MASSACHUSETTS
BAY
TRANSPORTATION
AUTHORITY

TECHNICAL SPECIFICATION
EE&QA-878

Orange Line No. 12 Car Traction Motor Overhaul

ISSUED: June 28, 2017

REVISIONS:

EQUIPMENT ENGINEERING & QUALITY ASSURANCE
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1.0 SCOPE

1.1 Project Objectives
The Massachusetts Bay Transportation Authority (MBTA), herein referred to as the Authority, seeks to completely overhaul Traction Motors used on the Orange Line No. 12 cars. These traction motors, 5GE1264A1, were original manufactured by General Electric. This traction motor is a part of the propulsion system and a subsystem of the truck assembly. This Authority’s overhaul seeks a qualified vendor, herein referred as Contractor, to overhaul the traction motors that will function as new once overhauled and installed in trucks for revenue operation.

1.2 Standard Features
The General Electric 5GE1264A1 motor is a self-ventilated, four poles, series wound, commutating pole direct current (DC) traction motor that converts electrical energy into mechanical energy to propel rapid transit cars.

1.3 General Requirements
The Authority intends to overhaul 5GE1264A1 motors. The overhaul will include the replacement of all bearings, hardware, carbon brushes, brush holder assemblies, leads, connectors, gasket, flash rings and all other parts detailed further in 5GE1264A1 Motor Parts List in the Appendix. The motors shall be overhauled per General Electric GEK-63192 documentation also in the Appendix. This document details the Traction Motor Inspection, Maintenance and Basic Overhaul Instructions. However EE&QA-806 Revision D specification supersedes the procedures outlined in GEK-63192 for the overhaul of the armatures. The Authority’s Motor Repair Record for the GE1264A1 Motor, MRS #: 83023005, shall be completely filled out and returned to the MBTA with every overhauled motor. All motor wires/leads shall be per EE&QA-606 specification in Appendix unless otherwise specified.

1.4 Terms of Payment and Delivery Schedule
The following are the proposed Payment Terms and Delivery Schedule.

1.4.1 Delivery Schedule
The following is a proposed project schedule.
8/1/2017 NTP – Upon Approval of Master Schedule and Project Management Plan.
9/1/2017 Proof of major component purchase order execution.
5/31/2018  Completion of motor overhaul program.

After the Authority receives proof that a purchase order had been issued for the major components the MBTA will proceed with the initial motor shipment for repair. The selected Contractor shall have the capacity to overhaul up to fourteen (14) motors every thirty (30) days. At minimum of twelve (12) overhaul motors shall be received by the Authority no more than thirty (30) days after they are shipped from the Wellington Car-house facility.

1.4.2 Method of Payment
The following shall constitute the method of payments of this contract:

A. The Authority shall make all payments to the Contractor in United States Dollars.

B. Payment for the Orange Line GE1264A1 Traction Motor Repair program will be made via check or wire transfer installments.

C. If an audit should disclose any invoices that exceed 100% of the invoice costs, this excess shall be returned to the Authority and shall be remitted to the Contractor at such time as those costs are incurred.

1.4.3 Schedule of Payment
The Contractor is required to submit a Bid Price based on the following Payment Schedule summarized below for the Orange Line GE1264A1 Traction Motor Overhaul program. These payments will take place over a time period of up to twenty (12) months from the Notice To Proceed (NTP).

- 5%  After NTP and approval of Master Schedule and Project Management plan
- 10% Proof of major components Purchase Order execution (payments can be made in parts).

The remaining payment schedule shall be made as the overhauled motors are delivered and accepted by the Authority. The payment amount shall be a percentage of the remaining 85% of the total cost to overhaul all the motors.
1.5 Delivery
The GE1264A1 traction motors for overhaul shall be shipped from and delivered to the Authority’s Wellington Car-house, Medford Massachusetts or any other location required by the Authority.

2.0 CONTRACTOR REQUIREMENTS

2.1 Contractor Qualifications
The selected Contractor shall have a minimum ten years of previous transit experience performing as the prime contractor, manufacture or remanufacture of direct current traction motors similar to those on the Authority’s Orange Line No. 12 subway cars. The Contractor shall provide service-proven overhauled direct current traction motors by using components that have functioned successful in revenue service since delivery. Additionally all upgraded/modified components must be selected with the understanding and guarantee to insure reliable revenue operation.

All sub-contractors for all the components shall have transit experience supplying similar equipment to those proposed. The Authority may require proof of this by submission of reliability data, equipment service time and location, modification information and maintenance records.

2.2 Contractor Responsibilities
The Contractor selected by the Authority shall adhere to all the requirements and specifications set forth by the Authority. Any deviations from the Authority’s requirements, as well as other proposals presented by the Contractor, must be submitted in writing to the MBTA for approval prior to proceeding. The Authority intends to take all suggestions regarding any item/components, material or method proposed by the selected Contractor into consideration. Authorization by the Authority does not waive the Contractor’s responsibility to comply with the requirements set forth in the Contract Documents nor should it change the agreed upon warranty.

2.3 MBTA Responsibilities
The MBTA will be responsible for removing the traction motors from the trucks on the Orange Line cars as well as palletize them for shipment. The Authority will perform Meg., resistance and dielectric testing for the main coils, inter-poles and armature prior to shipping the motors to the Contractor. These tests will also be performed after the overhaul motor is received from the Contractor and before it can be installed in a truck.
2.4 First Article of Inspection
The Contractor is required to have a First Article of Inspection (FAI) with the MBTA on their proposed overhaul and the function ability of the GE1264A1 traction motor. This shall be done after the first overhauled motors are received by the MBTA. If any concerns arise from the FAI the Contractor shall work with the Authority to rectify the issue in a timely manner before any motors are accepted for revenue service operation.

3.0 GENERAL PROCEDURE

The GE1264A1 motors shall be overhauled per the below recommendations:

3.1 Incoming Inspection
The Contractor is required to visually inspect the traction motor for obvious defects upon arrival at the repair facility and prior to testing.

3.2 Initial Testing
The Contractor shall measure and record the Resistance, Meg., and Dielectric for both the main coils as well as the interpoles. The Contractor shall also perform and record the Meg. test result of the armature. All these values shall be recorded on the Motor Repair Record sheet.

3.3 Disassembly, Cleaned and Baked
The motors shall be disassembled and all the parts send to a high pressure steam shower where they will be properly cleaned. Once cleaned the parts shall be baked in an oven to ensure that no residual moisture is left in the coils.

3.4 Insulation
The motors shall be coated with Elantas Electrical Insulation paint. Insulation paint shall be applied to the coils and inter-poles as well as the inside and outside of the shell, fan end cover and commutator end cover. All insulated parts shall be fully painted using a paint brush. Insulation shall not be applied using a spray system.

3.5 Repair
All the parts listed on the Motor Parts List in the Appendix shall be replaced with the OEM parts if not otherwise specified. The General Electric GEK-63192 (Traction Motor Inspection, Maintenance and Basic Overhaul Instructions) documentation in the Appendix shall be used as a reference for this overhaul. However EE&QA-806 Rev. D
specification supersedes the procedures outlined in GEK-63192 for the overhaul of the armatures. The MBTA’s Motor Repair Record for the GE1264A1 Motor, MRS #: 83023005 shall be completely filled out and returned to the MBTA with every overhauled motor.

Make sure all motor covers are cleaned and the mating surfaces are free of defects. All heli-coils shall be replaced. The mounting insert on the motor shell shall be inspected and if out of OEM specifications replaced. Mounting block shall be machined to drawing number 42202-1 and should have a tight fit with a 0.002” oversize. Motors shall be marked “REPAIR” in white color on the sides and bottom for easy identification.

3.6 Testing
Once overhauled and assembled the motor shall be tested statically and dynamically to ensure that it meets the OEM standards detailed in the GEK-63192 documentation. This test shall be performed twice; once with the motor spinning in clockwise direction and another in the counter clockwise direction. Once the test results are achieved and accepted the motor shall once again be inspected for the final time before it is packaged for shipment to the MBTA.

3.7 Materials
- All standard steel hardware shall be zinc plated.
- 1/0 wire shall be RSCC Exane only and length shall be 36” from shell (tip of gourmet) to connector.
- 1/0 AMP knife connectors.
- 4AWG wire shall be per RE-606 Technical Specification.
- Bearing grease shall be Texas Refinery Corporation’s Moly 880 Crown & Chassis (TRC #: 880) Lubricant.
- Elantas Electrical Insulation paint material 117235 (red color) shall be used to insulate the coils, inside of the shell plus the inside and outside of the end covers. Elantas Electrical Insulation paint material 129802 (black color) shall be used to insulate the outside of the shell. All insulated surfaces shall be 100% painted.

4.0 Warranty
The Contractor shall guarantee that all repaired traction motor shall function properly for at least eighteen (18) months after installation or 100,000 miles, whichever comes first.
If any motor fails before either guarantee milestones the Contractor shall be responsible for all the financial cost associated with repairing the failed motor.

5.0 Shipping
The Contractor as part of their proposal is to include the cost of shipping the motors both to and from the Authority’s Wellington Car-house Facility in Medford, MA. The armatures in the overhauled motors shall be locked in place prior to shipment per the directions outlined on Page 3 of the GEK-63192 documentation. Motors shall be firmly secured to shipping pallets so that they experience minimum movements during travel. Motors shall be packaged and shipped in such a way that it will remain dry during shipment as well as storage.
6.0 APPROVALS

Prepared By: [Signature]
Bruce J Shand - Engineer
Equipment Engineering & Quality Assurance

Date: 6/28/17

Approved By: [Signature]
Edward J Belanger – Superintendent
Subway Operations Main Repair Facility

Date: 06/29/2017

Approved By: [Signature]
Michael P Walsh – Deputy Director
Subway Maintenance Engineers

Date: 6/28/17

Approved By: [Signature]
Paul Flynn – Deputy Director
Subway Operations Main Repair Facility

Date: 7/18/17

Approved By: [Signature]
Joe Berry – Deputy Director
Heavy Rail Maintenance

Date: 6/28/17

Approved By: [Signature]
Steve Hicks – Chief Mechanical Officer
Rail Maintenance

Date: 6/29/17
7.0 REVISIONS
8.0 **APPENDIX**

Attachment 1 (pp 12): GE1264A1 Motor Repair Record Sheet.

Attachment 2 (pp 13-46): GEK-63192 - General Electric Type 1264A1 Traction Motor Documentations.

Attachment 3 (pp 47): 5GE1264A1 Motor Parts List.

Attachment 4 (pp 48): MBTA Drawing 42202-1


**MOTOR REPAIR RECORD**

WELLINGTON CARHOUSE

Motor Type: 1264 A1

Motor No.: ____________  Armature No.: ____________  Repair No.: ____________

**TAG # ____________**

MRS# 83023005

**Date of Last Rebuild:__/__/**

Class/Sub Class TMR 0A1

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**STRIP DATA**

**Cause of Failure:**

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**NAME __________________**  **Date Started:** / /

---

**ASSEMBLED DATA**

**REPAIRS MADE:**

---

**BEARINGS:** C.E. _______  F.E. _______

**Epoxy Dip:** _______  **Loctite:** _______

**COUPLING HUB:** Advance: _______  Cold: _______  **Hot:** _______

**New Armature No.: __________________**

**Date Completed:** / /  **Builder Name:** __________________

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**TEST DATA**

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<td>DIELECTRIC  μA</td>
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**RPM ____________ RPM**  **Readings Taken at Motor Temperature:**

**Tester: __________________**  **Torque:** 12
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These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

Verify numbers for parts, tools, or material by using the Renewal Parts or Tool Catalogs, or contact your General Electric representative for assistance. Do not order from this publication.
INTRODUCTION

SCOPE

This publication provides instructions for the inspection, maintenance and basic overhaul of the GE1264 Traction Motor. See Fig. 1.

When there are significant variations in the instructions for other forms, they are described on Model Difference Sheets (MDS) which are to be used in conjunction with this publication.

DESCRIPTION

The GE1264 is a self-ventilated, d-c traction motor which converts electrical energy into mechanical energy to propel rapid transit cars.

DATA

Model .................................. 5GE1264A1
Classification .......................... 4-pole, series wound, commutating pole, direct-current motor
Maximum Permissible Vibration ....... 0.002
Maximum Permissible Speed (rpm) .. 6400

Lubrication [oz.]
Coupling End .......................... 2.83
Commutator End .................... 2.0

Lubricant: Bearing Grease .......... GE-D6A2C5

CAUTION: Use only the recommended type of grease. Changing or mixing of different types of grease may result in bearing failure.

Seal Grease (See Caution Below) ...... D6A2C4

CAUTION: Use only at overhaul to seal bearing cavities and to coat running clearance surfaces specified in bearing assembly instructions.

Carbon Brushes
Type .................................... Duplex
Grade ................................... Speer 5410 or equivalent
Size [in.] ................................ 5/8 x 1-1/2 x 2
Minimum Brush Length (from top of carbon) [in.] . 3/4
Spring Pressure (with brush 7/16 above brushholder body) [lb.] 5 to 6

Brushholder
Clearance to Commutator [in.] ...... 0.050 - 0.070
Clamp-Capscrew Torque Value [lb.-ft.] .... 59-66

Commutator
Diameter: [in.] 
New .................................. 7-1/2
Minimum Permissible ................. 7-1/8
Side Mica (thickness) [in.] .......... 0.030
Undercutting: [in.]
Slot Width ........................... 0.033
Slot Depth .......................... 0.046

Dust Groove Dimensions [in.]
Width .................................. 0.23-0.26
Depth .................................. 0.135

Run-Out (Maximum After Resurfacing)
TIR [in.] ................................ 0.001
Maximum variation within any 20-bar group is 0.0004 in.
Maximum variation between any two adjacent bars is 0.0001 in.

Bearings

Coupling-End Diametral Clearance [in.] .... 0.0031 0.0002
Armature End-Play (in.) .............. 0.020 0.003
Coupling-End Bearing Runout (in.) .... 0.025
Commutator-End Bearing Runout (in.) . 0.002

Pole Bore
Exciting Pole Bore .................. 9.991 10.016
Commutating Pole Bore .............. 9.995 10.012

Resistance at 25 °C (ohms)

NOTE: Armature resistance to be measured between a 42 bar span starting with any bar and proceeding around commutator.

Armature ................................ 0.0157 0.0173

Exciting Field:
With Cables ......................... 0.0153 0.0169
Without Cables ...................... 0.0143 0.0159

Commutating Field:
With Cables ......................... 0.00765 0.00845
Without Cables ..................... 0.00685 0.00765
High-Potential Test
60 Hz, to ground and between fields for one minute.
All Windings:
New or Rewound
Armature/Coiled Frame (volts) .................. 3500
Reconditioned (volts) .......................... 2000

WARNING: Electric shock can cause serious or fatal injury. To avoid such injury, personnel should take and observe proper precautions during the High-Potential Testing.

Weight
Complete Motor (lb.) .............................. 881
Armature (lb.) ........................................ 294

TO LOCK THE ARMATURE:
1. REMOVE THE 9 O'CLOCK BOLT (FACING COMMUTATOR END) AND INSTALL LOCKING BOLT (1) WITH JAM NUT (2). TORQUE BOLT TO 12-14 FT.-LB., AND TIGHTEN THE JAM NUT TO LOCK ARMATURE AGAINST MOVEMENT.
2. PLACE DISASSEMBLED BOLT AND WASHER IN BAG AND ATTACH TO MOTOR.
3. ATTACH CAUTION TAG TO LOCKING BOLT.
4. PAINT LOCKING-BOLT HEAD YELLOW.

FIG. 2. ARMATURE LOCKING PROCEDURE, E-24800
Puller Tools:
Includes Coupling Hub Pullers For
Motor and Gear Unit ........... Part 41D731953G9
Brush Seater Stone (White) ....... Part 106X98
Commutator Grinder ............ Part 41C635781G1
Armature Lifting Tool ............ Part 41C681042-13
Brazing Machine
(For coil connections) .......... Part 41D780746-1
Dummy Bearing Caps:
Used For Checking Bearing Runout, Diametral
Clearance and Armature End-play.
Commutator End ............... Part 41D785838-3
Coupling End .................. Part 41D785838-1

LUBRICATION

Annually add 1 oz. of grease to the coupling-end bearing and add 1 oz. to the commutator-end bearing through the grease fitting.

CAUTION: Use only the recommended type grease. Changing or mixing of different types of grease may result in bearing failure.

INSPECTION

MONTHLY

1. Inspect exterior of motor, including air inlet screen and cables, for damage.
2. Brush or wipe clean the area around the brush inspection covers. Inspect covers for proper fit and make sure covers are not bent. Check cover latches for proper operation. Remove covers.
3. Wipe the flash ring clean.

Brushholders (Fig. 3)

Inspect the brushholders for damage. If damage is evident, refer to Brushholder Replacement and Clearance Adjustment section.

Brush Spring Pressure

Inspect brush springs for obvious failure or damage. Check brush spring pressure by comparing spring pressure with spring known to be good. Refer to DATA section for brush spring pressure value.

Brushes

Brush wear is determined by measuring actual brush length from the top of the carbon. Unlatch the brush spring lever (6), remove the brush and measure brush length. If brush is worn to, or near, minimum length listed in DATA section, replace all brushes.

If brushes will be replaced, see BASIC REPAIR ON CAR-MOUNTED EQUIPMENT section for instructions.

NOTE: Be sure that used brushes are of sufficient length to last until the next inspection.

CAUTION: When replacing brushes, use the recommended grade. Mixing of brush grades in the same motor or changing brushes to another grade is not recommended as this may seriously affect commutation, surface film, commutator and brush life.

WARNING: To avoid possible electric shock or injury from rotating equipment, do not remove or replace brushes while equipment is energized or rotating.

If brushes will not be replaced, the following brush inspection should be made:

1. Inspect all brushes to be sure they are not chipped or broken. Make sure brush shunts are not frayed or broken. Replace any brush which shows damage.

NOTE: Chipped, burned or rough-faced brushes may indicate a commutator problem.

2. When inserting brushes in their carbonways, make sure brushes slide freely and do not bind.

3. Check the brush shunts to be sure they are not twisted or out of position. Make sure all brush-shunt terminal connections and all brushholder cable connections are tight and spring levers are latched.

Commutator

Inspect the commutator for possible flashover damage. The commutator should be clean, smooth, glossy and free from high mica, high bars, flat spots and rough surfaces.

If the commutator needs to be resurfaced, refer to COMUTATOR RESURFACING (On Car) section.

Creepage Band

If the creepage band, Fig. 4 (35) is dirty, use a clean cloth dipped in an electrical cleaner such as Texize 826* or equivalent, and clean the creepage band.

*Texize Chemicals, Inc.
Inspect the band for cracks, pitting, thin spots and flashover damage. Make sure the band is tightly bonded to the commutator. If the band is not tightly bonded or if any of the above conditions exist, the band must be replaced.

Refer to REPAIR, “Creepage Band Replacement” section for instructions.

**ANNUALLY**

1. Include all items under INSPECTION, Monthly section plus the following:

2. Remove the brush inspection covers. Use clean, dry, compressed air and blow out the motor.

3. Raise or remove all brushes and check the brushholder-to-commutator clearance, Fig. 3. Use a fiber gauge, Fig. 5, to avoid damaging the brush-path surfaces of the commutator. Refer to DATA section for brushholder clearance dimension. If measured clearance does not correspond to values in DATA section, adjust clearance to proper dimension.

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**WARNING:** When using compressed air for cleaning purposes, an environment potentially hazardous to personnel in the immediate area is created. To prevent physical injury from flying debris, observe all Railroad and OSHA safety regulations.
Refer to BASIC REPAIR ON CAR-MOUNTED EQUIPMENT, Brushholder Replacement and Clearance Adjustment section for instructions.

4. Dip a clean lintless cloth in an electrical cleaner such as Texize 826 or equivalent, and wipe the dirt from the Teflon* brushholder sleeves, Fig. 3 (2).

NOTE: Never paint these sleeves. Periodically wipe them clean with a dry cloth or a cloth dipped in an approved, non-oily cleaning solvent.

*E.I. du Pont de Nemours Co.
BASIC REPAIR ON CAR-MOUNTED EQUIPMENT

BRUSH REPLACEMENT

1. Disconnect the brush-shunt terminal from the terminal screw on the brushholder and unlatch brushespring lever (6).

2. Lift the brushespring, remove the brush and blow out the carbonway with compressed air.

WARNING: When using compressed air for cleaning purposes, an environment potentially hazardous to personnel in the immediate area is created. To prevent physical injury by flying debris, observe all Railroad and OSHA safety regulations.

3. Lift the spring and insert a new brush in the carbonway. Make sure the brush slides freely in the carbonway. Latch spring lever (6).

NOTE: New brushes must be sanded to match the contour of the commutator surface. After sanding brushes, blow out the commutator chamber with dry, compressed air to remove carbon dust.

4. Connect the brush-shunt terminal under the brushholder terminal screw. Arrange the shunts to clear the opening in the brushholder body. Be sure shunts are not twisted.

CAUTION: When replacing brushes, use the GE recommended grade. Mixing of brush grades in the same motor or changing brushes to another grade is not recommended as this may seriously affect commutation, surface film, commutator and brush life.

BRUSHHOLDER REPLACEMENT AND CLEARANCE ADJUSTMENT (Fig. 4)

Brushholder Removal

1. To replace a brushholder(s) remove all brushes and wrap the commutator with heavy paper for protection.

2. Disconnect the cable from the brushholder(s) involved.

3. Remove bolt and washer (15) brushholder support (14) and lift the brushholder (13) out of the frame.

Installation

1. Position the brushholder in the frame with the brushholder studs resting in the clamp surfaces of the brushholder support (14).

2. Install brushholder clamp-bolt and washer (15) and tighten, but do not torque-bolt, until the brushholder-to-commutator clearance has been established.

Refer to following section for instructions to adjust brushholder clearance.

3. Check brushholder clearance after brushholder clamp-bolts have been tightened.

4. After brushholder clearance has been set, connect the brushholder cables and install the brushes.

Brushholder Clearance Adjustment

Refer to DATA section for Brushholder-to-Commutator clearance dimension and adjust brushholder(s) as follows:

1. Remove the protective wrapping from the commutator.

CAUTION: Do not allow brushholder(s) to touch, bump or rest on the commutator.
2. With brushes lifted or removed, insert a fiber gauge (equal in thickness to the clearance dimension) between the commutator and the brushholder.

Do not use a metallic gauge.

3. Loosen the brushholder clamp-bolt (15) and move the brushholder against the fiber gauge so the clearance-to-commutator is gauge thickness.

4. Tighten clamp-bolt (15). Check for proper clearance between the commutator and the brushholder and torque bolt (15) to 59-66 ft.-lb. Recheck the brushholder clearance gap.

5. Make sure all brushholder cables are connected and cable terminals are tight.

6. Install the brushes.

**COMMUTATOR RESURFACING (On Car)**

When visual inspection of the commutating surface reveals damage such as grooving, pitting or burns from minor flashover, the damage can often be repaired by performing resurfacing operations.

Refer to Fig. 6 for abnormal commutator surface conditions and the corrective resurfacing procedure involved.

**NOTE:** The cause of commutator surface damage should be determined and corrected prior to resurfacing.

<table>
<thead>
<tr>
<th>SURFACE CONDITION</th>
<th>REMEDIAL RESURFACING METHOD (ON CAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>THREADED (BRUSH PATH)</td>
<td>RAKE AND CLEAN SLOTS AND POLISH</td>
</tr>
<tr>
<td>GROOVED** (BRUSH PATH)</td>
<td>USE BRUSHSEATER STONE</td>
</tr>
<tr>
<td>BURNT AREAS OR FLAT SPOTS</td>
<td>FIXTURE GRIND* AND RAKE AND CLEAN SLOTS</td>
</tr>
<tr>
<td>HIGH BARE</td>
<td>AND POLISH</td>
</tr>
<tr>
<td>OUT OF ROUND</td>
<td><strong>DO NOT RESURFACE DIAMETER OF COMMUTATOR BELOW THE MINIMUM PERMISSIBLE DIAMETER LISTED IN DATA SECTION. MICA MUST NOT BE FLUSH WITH SURFACE OF COMMUTATOR AFTER GRINDING.</strong></td>
</tr>
<tr>
<td>COPPER DRAGGED (FEATHERED) LIGHT</td>
<td><strong>A COMMUTATOR WITH GROOVES WORN BY THE BRUSHES DOES NOT REQUIRE RESURFACING UNLESS:</strong></td>
</tr>
<tr>
<td>HEAVY</td>
<td>1. BRUSH BREAKAGE IS OCCURRING.</td>
</tr>
<tr>
<td></td>
<td>2. THE MICA IS FLUSH WITH THE BOTTOM OF THE BRUSH GROOVE. IF THE BRUSH-GROOVE DIAMETER IS LESS THAN THE MINIMUM PERMISSIBLE DIAMETER OF THE COMMUTATOR LISTED IN DATA SECTION, REPLACE THE COMMUTATOR.</td>
</tr>
</tbody>
</table>

**FIG. 6. ABNORMAL COMMUTATOR SURFACE CONDITIONS. E-21439A**

**WARNING:** During resurfacing operations, goggles and (when conditions warrant) a respirator should be worn to protect personnel from dust and flying particles.

**Preparation (Sanding, Hand Stoning or Fixture Grinding)**

1. Place the car over a maintenance pit and remove all electric power. Block the wheels of the truck located on end of car opposite truck containing motor to be worked on.

2. Jack up the truck containing motor to be worked on so armature can be rotated.

**WARNING:** Operating the motor from any power source presents potentially hazardous voltages within the motor and at motor connections. To prevent electrical shock, do not touch any electrically charged apparatus during resurfacing operations.

3. Open the traction motor leads and connect the motor to a d-c welding generator. See Fig. 7 for diagram of connections to run the motor from a welding set. By varying the output of the welding generator, the rpm of the motor can be controlled.

**WARNING:** For the safety of the personnel under the car during resurfacing operation, the following safety precautions must be adhered to:

1. Block the wheels to prevent the car from moving during the grinding operation. Make blocks positively secure.

2. A second person must be at the power control station ready to shut off power in case of an emergency during the grinding operation.

3. The grinding operator should wear goggles and a dust mask when resurfacing or blowing out the commutator.

**FIG. 7. DIAGRAM OF CONNECTIONS TO RUN TRACTION MOTOR FROM A WELDING SET. E-671A**
Sanding

If the commutator is dirty, blackened, or slightly rough, resurface it by sanding with 00 sandpaper or finer, as follows:

1. Attach the fine sandpaper to a wooden block shaped to fit the commutator, Fig. 8.

2. Run the motor at approximately 1500 rpm and hold block against commutator with a light, even pressure. Move the block back and forth longitudinally to clean the commutator.

3. Use clean, dry compressed air to remove dust and sand.

**WARNING:** When using compressed air for cleaning purposes, an environment potentially hazardous to personnel in the immediate area is created. To prevent physical injury by flying debris, observe all Railroad and OSHA safety regulations.

**CAUTION:** Never use emery cloth on a commutator. The abrasive particles not only scratch the surface, they are conductive. If they become lodged between the commutator segments a flashover will result.

Hand Stoning

If the commutator surface is mildly grooved, threaded, or burned, and only a small amount of copper has to be removed to correct the trouble, use a hand stone. Hand stoning will not correct an out-of-round commutator.

1. Use a fine-grade stone ground to fit the commutator, Fig. 9. It should also be of sufficient width to bridge any flat spots; otherwise, the stone will ride in and out of the flat and will not correct it.

2. Remove one brushholder for access to commutator.

3. Run the motor at approximately 1500 rpm.

**WARNING:** When using compressed air for cleaning purposes, an environment potentially hazardous to personnel in the immediate area is created. To prevent physical injury by flying debris, observe all Railroad and OSHA safety regulations.

Fixure Grinding (Fig. 10)

If the commutator is deeply grooved, threaded or out-of-round, resurface by fixture grinding.

Use Commutator Grinder Kit, Part 41C635781G1. The kit consists of a mounting bracket, grinder, and medium and finish-grade stones.

1. Inspect the grinder for cleanliness before installing. A dirty grinder may bind during the grinding operation. If the grinder is dirty, disassemble and clean it to remove accumulated dirt and copper. After the grinder is reassembled, lubricate the grinder-ways with graphite.

Install the grinder and resurface the commutator as follows:

2. Disconnect the brushholder cables and remove the lower, right hand brushholder. Use the same bolt and washer removed from the brushholder stud and bolt the bracket in place.
1. Retract the radial carriage slide fully and mount the grinder (without stones) on the bracket. Tighten bolts finger-tight.

2. Place a fiber strip (approximately 0.030 in.) on the commutator surface under the grinder.

3. Advance the radial carriage slide so it is resting lightly on the fiber strip. Traverse the carriage back and forth and check for variation in clearance. Readjust the position of the grinder on the bracket by rotation to obtain uniform clearance at both limits of travel.

4. Tighten mounting bolts securely.

5. Retract radial carriage slide and assemble grinder stones.

**NOTE:** For most applications, a medium-grade followed by a finish-grade stone is recommended. On heavily-grooved and worn commutators with deep flat spots, a coarse-grade stone can be used for roughing and the finish grade used for final grinding. If new stones will be used, they can be contoured on a carborundum wheel to fit approximately the curvature of the commutator.

6. Turn the feed control to back the stone away from the commutator before starting motor.

7. Apply power to the motor and gradually bring the speed up between 1000 and 1500 rpm.

8. Begin grinding by radially feeding the stones lightly against the commutator and then moving them back and forth longitudinally. More pressure can be applied as the stones become seated. Make four to six sweeps of traverse motion each time more pressure is applied with the radial feed. Do not take too deep a cut. This will result in dragging an excessive amount of copper over the edges of the commutator bars.

If possible, use some means of collecting the copper and abrasive dust thrown off by the grinding operation. For example, use a vacuum cleaning device with the cleaning orifice set just behind the trailing edge of the stones.

9. Grind the commutator until a uniformly smooth surface is obtained.

**NOTE:** Do not grind more copper from the commutator than absolutely necessary. Check depth of undercut during grinding operations to be sure a minimum of 1/64 in. undercut will be retained. If a satisfactory commutating surface cannot be ground without removing the minimum undercut, remove the motor from service and resurface the commutator.

10. Begin lightening the pressure of the stones near the end of the grinding operation.

11. Stop the motor. If a medium grade stone was used, change to a finish grade stone and repeat Steps 9, 10, 11 and 12.

12. Check commutator concentricity with a dial indicator for the following limits:

   a. Total indicated runout — 0.001 in.
   b. Variation of indicator runout within any group of 20 bars — 0.0004 in.
   c. Variation of indicator reading between any two adjacent bars — 0.0001 in.

   Continue grinding until these values are met.

13. Remove grinder assembly.

14. Scrape the slots between the bars to remove projecting mica fins or copper whiskers with a slot-raking tool, Fig. 11.

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**TABLE:**

<table>
<thead>
<tr>
<th>REF.</th>
<th>DESCRIPTION</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>GRINDER</td>
</tr>
<tr>
<td>2</td>
<td>STONE</td>
</tr>
<tr>
<td>3</td>
<td>STONE</td>
</tr>
<tr>
<td>4</td>
<td>BOLT</td>
</tr>
<tr>
<td>5</td>
<td>WASHER</td>
</tr>
<tr>
<td>6</td>
<td>BRACKET</td>
</tr>
</tbody>
</table>

**FIG. 10. COMMUTATOR GRINDER. E-24803**
17. Run the motor again at approximately 2000 rpm and polish the commutator with 00, or finer, sandpaper.

**CAUTION:** Never use emery cloth on a commutator. The abrasive particles not only scratch the surface, but are conductive and lodge between the commutator segments. A flashover may result.

 Blow dust from the commutator and interior of the motor with dry, compressed air. Hold the end of the hose about 1 or 2 in. from the commutator surface, and sweep longitudinally to blow away copper chips and loose mica.

**WARNING:** When using compressed air for cleaning purposes, an environment potentially hazardous to personnel in the immediate area is created. To prevent physical injury by flying debris, observe all Railroad and OSHA safety regulations.

18. Remove power and readjust the brushholder clearance to commutator to 0.050 – 0.070 in. Install new brushes.

19. Air Cure the Commutator. See following section for air curing instructions.

**Air Curing Commutator**

After the commutator has been resurfaced, it should be air cured as follows:

1. Rotate the armature slowly with the same source of power used for sanding, stoning or grinding.

2. Use a rubber air-hose with the metal nozzle removed and sweep the commutator surface with 70 psi air pressure.

3. Increase the motor speed to approximately 5300 rpm and blow air on the commutator until the sparking stops.

4. Increase the motor speed until full speed is reached (do not exceed 6400 rpm) and continue to blow air on the commutator until all sparking stops.

5. Stop the motor and disconnect the welding set.

6. Use a clean cloth and wipe off the brushholders, creepage band and accessible surfaces in the commutator chamber.

7. Make the necessary mechanical and electrical changes to place the motor and car back in service.

**COMMUTATOR MAINTENANCE**

See Allied Publication GEI-85167.

**SEPARATING MOTOR FROM GEAR UNIT**

Refer to car manufacturer's instructions to remove the truck from the car and to remove the wheel/axle/motor and gear unit assembly from the truck.

Refer to separate publication GEK-63191 for instructions to separate the motor from the gear unit.

**COUPLING HUB REMOVAL**

After the motor is separated from the gear unit, refer to the GAC9 Coupling Instruction Book, GEK-63194 for instructions to remove the coupling hub from the motor.
BASIC OVERHAUL

The following basic overhaul procedures include instructions to disassemble, repair, reassemble and test the motor.

Prior to disassembly of the motor, perform the following electrical tests to determine motor condition:

TEST BEFORE OVERHAUL

Perform a megohmmeter test on the motor then lift the brushes and meger the armature and field coils separately. A reading of 20 megohms or more normally indicates that the insulation is satisfactory. A reading less than 20 megohms indicates failure of insulation, accumulation of dirt or excess moisture.

MOTOR DISASSEMBLY

Refer to Fig. 4 for numbers in parentheses.

Armature Removal

1. Clean the outside of the motor and place it in a horizontal position on a bench. Remove cover (17).
2. Remove the brushes.
3. Either remove the brushholders or adjust them radially outward, away from the commutator.
4. Wrap the commutator with heavy paper or felt to protect it during armature removal and handling.
5. Remove inner circle of bolts (8) from end plate (10). Remove grease fittings (7) so bearing cap (4) will clear end plate (10) when armature is lifted out of the frame.
6. Turn the motor to a vertical position, coupling-end up, and block the magnet frame level so weight of motor does not rest on bearing cap (4).
7. Remove bolts (28) from framehead (27). Install two lubricated jack bolts in framehead and force framehead from fit in magnet frame. Lift the framehead off the shaft with bearing rollers intact.
8. Screw armature lifting tool, Fig. 12, Part 41C681042-13, on the coupling end of the armature shaft and screw a lifting eye, with locknut, into the tool. Tighten the locknut to lock the lifting eye.

CAUTION: Be sure grease fittings (7) are removed from bearing cap (4) before lifting armature out of frame.

Bearings

It is recommended that armature bearings be replaced at overhaul.

Coupling-End Bearing (Fig. 4)

1. Remove bolts (31) from bearing cap (32) and pry off cap and gasket (38). Remove bearing rollers.
2. Remove felt seal (39) from framehead bore.
3. Heat framehead to 100 C (212 F) and pry outer race from framehead fit.
4. Use puller tool, Fig. 13, Assy. 7 and pull inner race (30) and collar (33) from the shaft.

Commutator-End Bearing (Fig. 4)

1. Remove machine screws (34) and pry off bearing cap (4) and gasket (37).
2. Straighten the tabs of bearing lockwasher (6) and remove nut (5) from the shaft.
3. Install puller tool, Fig. 13, Assy. 1, and pull ball bearing (3) and bearing housing (2) off the shaft.
4. Press ball bearing (3) out of housing (2).
Brushholders (Removal) Fig. 4)

1. Disconnect the cables from the brushholders.

2. Remove bolt (15) and brushholder support (14) and lift brushholder (13) out of the frame. Remove all brushholders.

CLEANING

Any of the generally accepted methods of cleaning (vapor degreasing, use of a steam jenny, petroleum spirits or other commercial cleaning solvents) are recommended for cleaning motor parts. The method used should be governed largely by the facilities available, the extent to which the motor is disassembled, and the quantity of parts to be cleaned.

CAUTION: Do not use caustic soda solution on the armature or coiled frames as this will eventually lead to shorts and grounds. If cleaning solvents are used, observe cautions and warnings applying to them.
METHODS

Steam Cleaning

Steam cleaning is recommended for insulated and metal parts.
1. Use steam in combination with a commercial, non-caustic cleaner.
2. Suspend the part in a position accessible from all directions to a direct flow of steam from the hose.
3. Rinse all residue from parts with a mixture of clean steam and water.
4. Bake insulated parts for at least eight hours at 150°C (302°F) to remove all moisture.

Vapor Degreasing

Vapor degreasing is recommended for metal parts.
1. Bring the cleaning solution to a boil and allow the vapor line in the tank to rise to the condenser coils at the top of the tank.
2. Keep the vaporized cleaning solution at about 120°C (248°F).
3. Lower the part to be cleaned into the vapor-laden atmosphere so the vapor will condense on the part.
4. Remove the cleaned part from the degreaser. Drain and cool the part.

Cleaning Solvents

Cleaning solvents are recommended for metal parts.

WARNING: If commercial cleaning solvents are used, the precautions cited by the manufacturer regarding toxicity, flammability and ventilation must be strictly followed to prevent the possibility of serious or fatal injury to personnel.

CAUTION: Do not dip insulating materials into cleaning solvents.

NOTE: For insulated parts, use a quick-drying cleaning solvent which will not leave an oily deposit. Dip a clean, lintless cloth into the cleaner and wipe off the part or brush on solvent and wipe dry.

For anti-friction bearings and metal parts, use a cleaning solution which will leave an oil film on the finished surfaces. Kerosene, petroleum spirits, or other petroleum base cleaners are satisfactory.

Prior to reassembly, clean shaft tapers and pinion and bearing fits with a cleaner that does NOT leave an oily deposit.

BRUSHHOLDERS (CLEANING)

1. Clean the Teflon sleeves with a clean cloth dipped in Texize 826 or equivalent cleaner.
2. Blow the carbon deposits off of the brushholder body and clean by any method described above.

NOTE: If the brushholders are steam cleaned, bake them dry at 110°C (230°F).

INSPECTION AND TEST OF DISASSEMBLED MOTOR

Perform the following inspection and tests to determine the condition of the armature, coiled motor frame and brushholders.

After the inspection and test procedures have been completed and all defects or damage noted, refer to the REPAIR section for the correct repair procedure.

ARMATURE

1. Check the creepage band for thin spots (gray in color), cracks or lifting of the band.
2. Check the armature insulation and glass bands for damage, signs of burning or cracks.
3. Conduct a megohmmeter test (500 V) on the armature coils. A reading of 20 megohms or greater is acceptable.
4. Measure and record armature resistance.
5. Bar-to-bar resistance test:
   Test the armature for open or short-circuited armature coils as follows:
   a. Pass a regulated amount of d-c current through the armature coils.
   b. Read the voltage drop between the commutator segments with a millivolt meter. If the reading varies more than plus or minus 5 percent a defective coil is indicated.
6. High-potential test the armature to ground.

WARNING: Electric shock can cause serious injury or death. Strict safety precautions must be taken and observed by personnel conducting a high-potential test.
Apply a high-potential test of 2000 v, 60 Hz for one minute.

7. Check the commutator for threading, pitting, grooving, burned areas, flat spots, high bars and copper drag.

8. Check the commutator for “out-of-round.”

9. Check the diameter of the commutator. See DATA section.

MOTOR FRAME

1. Check the connection straps for loose connections and check the strap insulation for damage, signs of burning, cracks or discoloration.

2. Check the insulation on the coils for damage, signs of burning, cracks or discoloration.

3. Check the motor lead cables for damage, overheating and signs of deterioration.

4. Conduct a 500v megohmmeter test on the coils. A reading of 20 megohms or more is acceptable.

5. Measure and record commutating and exciting coil resistance.

6. High potential test the field coils to ground.

WARNING: Electric shock can cause serious injury or death. Strict safety precautions must be taken and observed by personnel conducting a high-potential test.

Apply a high-potential test of 2000 v, 60 Hz for one minute.

BRUSHHOLDERS

1. Inspect the brushholders and the brushholder insulators for flashover damage, cracks, and burned or pitted areas.

2. Check the brush springs to be sure they move freely and do not bind.

3. Insert a new brush in the carbonway and move it up and down in the carbonway to be sure it moves freely.

REPAIR

ARMATURE

Creepage Band Replacement

Materials and processing instructions for applying approximately 50 Teflon creepage bands, by the hot bond method, are available in a kit, Part 41A237905G1.

NOTE: The Teflon Band is NOT part of the above kit. Teflon creepage bands are available as Part 41A230144P39.

Application of a creepage band can best be performed in either a banding lathe or a winding lathe.

CAUTION: It is extremely important that the etched surface of the L-shaped Teflon tape be free of dirt, grease and other contamination which may prevent the tape from bonding to the underlay material.

Armature Insulation (Rewinding)

The armature must be rewound if the insulation is defective (coils are shorted or grounded), or if commutator replacement is required.

To rewind the armature, use a GE Co. rewind supply kit and the information supplied in the kit.

NOTE: After the armature is rewound, the armature coil leads must be TIG welded to the commutator risers.

Fan Replacement

1. If it is necessary to replace the fan, remove six socket-head bolts and washers, Fig. 4, (29), from fan, and remove fan from armature head.

2. Install a new fan and bolt it to the armature head with bolts and washers (29). Torque bolts to 30-36 ft.-lb.

NOTE: The dynamic balance of the fan must be within 0.03 oz.-in. before it is installed.

Commutator Tightening

After a long period of traction motor service, the mica insulation between commutator bars may relax and relieve commutator assembly pressure resulting in a loose commutator with high bars.
Commutator assembly pressure can be restored at overhaul by performing a commutator tightening procedure; however, it is necessary that spin seasoning and resurfacing operations be performed after the commutator is tightened.

Before proceeding to tighten a loose commutator, it must first be determined whether or not the brush surface diameter of the commutator will be larger than the minimum permissible diameter after the commutator is resurfaced.

If the brush surface diameter is calculated to be smaller (after resurfacing) than the minimum permissible diameter, listed in DATA section, the commutator must be replaced.

Commutator Tightening Procedure (Fig. 14)

1. Remove the tack weld from the commutator nut.

2. Use bottom tool Part 41C682230-1, and shaft adapter tool Part 41C682230P11, to support the coupling-end of the shaft and set the armature in a press.

Install commutator pressing ring/wrench assembly Part 41C688966G1 and press the commutator cap at 26 tons at the 5.25 in. pressing diameter shown on Fig. 14.

NOTE: Loosen the commutator nut to make sure the weld is broken and the nut is free, then tighten the nut as follows:

3. Tighten the commutator nut at 300 ft-lb. torque. Release pressure on the cap and remove tools.

4. Use bronze welding rod and tack weld the commutator nut to the commutator cap.

5. Spin season the commutator. See following section for instructions.

Spin Seasoning

A commutator seasoning cycle is required after pressing and tightening operations are performed. To season the commutator:

1. Dynamically balance the armature to within 3 grams on the coupling end and 3 grams on the commutator end. Refer to Fig. 4 for balance weight locations.

NOTE: Keyway must be filled with a half-key during balancing operations.

2. Place armature in a spin-seasoning stand.

3. Heat commutator to 165°C ± 10°C (311-347°F) at 6400 rpm.

4. Maintain temperature and speed for 30 minutes.

5. Cool to 50°C max (122°F) at 6400 rpm.

6. Repeat Steps 3, 4 and 5 for a total of 3 cycles.

7. True the commutator by diamond turning or grinding.

Commutator Resurfacing

Resurface the commutator at overhaul in a lathe by turning, or, grinding with a lathe-mounted grinding attachment or grind the commutator in a grinding machine.

The condition of the commutator and the amount of copper that must be removed will determine which method to use. Perform grinding operations if the commutator is threaded, grooved, has burned areas or is out-of-round. Turn the commutator in a lathe if the surface is badly worn, burned or scarred.

NOTE: Remove only the minimum stock necessary to resurface the commutator.

After the commutator is turned or ground, undercutting operations must be performed.

Commutator Diameter Check

NOTE: Prior to turning or grinding the commutator, be certain there is sufficient stock so the commutator will not be turned or ground below the minimum permissible diameter.

Refer to DATA section for Minimum Permissible Commutator Diameter dimension.
If the brush surface diameter will be less than the minimum permissible diameter after resurfacing operations are performed, the commutator must be replaced. Armature rewinding is necessary when the commutator is replaced.

**WARNING:** During resurfacing operations, eye protection and a respirator should be worn to protect personnel from dust and flying particles.

**Grinding**

1. Prior to grinding, true the shaft centers with respect to the bearing fits by scraping if necessary.

2. Place the armature in a lathe equipped with a grinding attachment or in a grinding machine. Check the concentricity of the bearing fits. TIR should not exceed 0.001 in.

3. Cover the armature windings to prevent entry of grinding dust and chips.

4. Grind the commutator and check runout with a dial indicator. Maximum commutator runout is 0.001 in.

5. Perform undercutting, raking and polishing operations.

**Turning**

If the surface of the commutator is badly worn, burned or scarred, turn the commutator in a lathe as follows:

1. True the shaft centers with respect to the bearing fits by scraping, if necessary. Place the armature in a lathe and check the concentricity of the bearing fits. TIR should not exceed 0.001 in.

2. Cover the windings to keep out chips.

3. Set the cutting tool for turning copper, and set lathe speed to give a commutator surface speed of 300 feet per minute. Refer to DATA section for dust groove dimensions.

4. Make clean, smooth cuts to remove just enough copper to renew the commutator surface. Do not allow the cutting tool to chatter.

5. After turning operations, check commutator runout with a dial indicator. Maximum runout is 0.001 in.

6. Perform undercutting, raking and polishing operations.

**Undercutting**

See Fig. 15 for diagram of proper undercut.

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**WARNING:** When using compressed air for cleaning purposes, an environment potentially hazardous to personnel in the immediate area is created. To prevent physical injury by flying debris, observe all Railroad and OSHA safety regulations.

**Raking**

Resurfacing usually leaves particles and slivers of copper hanging on the bar edges or lodged in the undercut slots. These must be removed before the motor is placed in service, or the particles may bridge the side mica and cause a flashover.
1. Brush out dirt and copper whiskers attached to the trailing edge of the bars with a stiff bristle brush; preferably one with nylon bristles. A new paint brush or stencil brush with the bristles cut short for added stiffness may also be satisfactory.

If stoning and undercutting have produced considerable dragging of copper from the edges of the bars, use a raking tool to remove the copper fins and ragged edges. Use the tool to rake the bar edges with the point inserted in the slot so that sides of the “V” rake the trailing edge of the bar. If the tool is ground with flat sides and used with moderate pressure as a raking tool, it will remove ragged copper fins and break the sharp edges of the bars. See Fig. 11 for an illustration of the tool. Another method of removing copper fins is to rake the slots with a piece of fiberboard approximately 0.045 in. thick.

2. After slots have been raked with fiberboard or a raking tool; sand the commutator with fine sandpaper (to remove small pieces of copper sticking from edges of slots) and polish the commutator.

Polishing

1. Polish the commutator with canvas, crocus cloth, fine (4/0) sandpaper, or 400A Triemite* paper.

Abrasive paper should be mounted on a wooden block curved to fit the surface of the commutator.

CAUTION: Never use emery cloth on a commutator. The abrasive particles not only scratch the surface, they are conductive and lodge between the commutator segments. A flashover may result.

2. Blow loose material off the commutator with dry, compressed air.

CAUTION: Use very little lubricant on brushholder clamp-bolts so lubricant does not drip on commutator.

WARNING: When using compressed air for cleaning purposes, an environment potentially hazardous to personnel in the immediate area is created. To prevent physical injury by flying debris, observe all Railroad and OSHA safety regulations.

3. Check commutator concentricity with a dial indicator. Refer to DATA section for runout limits.

4. Cover the commutator with heavy paper or felt to protect it from damage.

TEST AFTER REPAIR

Armature High-Potential Test

Apply test voltage between commutator (with all segments shorted) and the shaft.

Used Armature

Apply a high-potential test voltage of 2000 v, 60 Hz for one minute.

Rewound Armature

Apply a high-potential test voltage of 3500 v, 60 Hz for one minute.

WARNING: Electric shock can cause serious or fatal injury. To avoid such injury, personnel should take and observe proper precautions during the high-potential testing.

Armature Resistance Measurement

Refer to DATA section for Armature Resistance value and measure armature resistance.

INSULATION PROCESSING (VPI, ARMATURE)

After all armature repairs have been completed, see VACUUM PRESSURE IMPREGNATION section for further required processing of the armature.

LUBRICATION OF BOLTS

The threads and washer faces of bolts should be lubricated to obtain maximum benefit from applied torque when bolts are installed at reassembly.

NOTE: Threads and washer contact surfaces must be clean before lubricant is applied.

*Product of 3M Co.

**Product of Dow Corning Corp.

***Product of Acheson Colloids Co.
Where specific torque values are not listed in these instructions, refer to Fig. 16 for standard torque values for lubricated bolts.

MOTOR FRAME

Field Coil Replacement

Curing Of Field Coil Connection Insulation

**NOTE:** Coil connection insulation (varnish treated tape) must be cured by baking in an oven.

At Overhaul Or Motor Repair

If a field coil(s) "in the white" is installed, the coiled frame must be Vacuum Pressure Impregnated (VPI) twice.

During the VPI processing the coil connection insulation will be cured by baking.

Motor Repair

If a varnish treated supply coil(s) is installed during a motor repair and the coiled frame will not be VPI, the coil connection insulation must be cured by baking the coiled frame in an oven at 150 C (302 F) for two hours. Following this, the coil connections must be painted with GE Spec. No. A15B17B Red Glyptal varnish.

Brazing Coil Connections

**NOTE:** Exciting field coil connections are brazed. When replacing a field coil(s) use a brazing machine, Part 41D780746-1 to unbraze and braze coil connections.

**CAUTION:** Do NOT use a torch for brazing coil connections as excessive heat may damage coil insulation.

**Exciting Field Coils (Replacement)**

Exciting field coil connections are accessible from the coupling end of the frame (Fig. 17).

**To Replace One Coil**

1. Remove the insulation from the exciting coil connections of the coil to be replaced.

2. Use brazing tongs and unbraze the coil connections. Protect coil insulation with flowing air.

3. Heat the coiled frame in an oven at 150 C (302 F) for four hours to soften the varnish so pole bolts can be removed.

4. Position the hot coiled frame horizontally on a bench. Make sure the coil to be removed is located near the bottom of the frame circle so coil will not drop when the pole bolts are removed.

5. Remove pole bolts, Fig. 4 (23), and washers from exciting coil (25).

6. Pry the coil loose and slide coil out of frame.

**NOTE:** If more than one exciting coil will be replaced use a coiling arbor with 9 3/4 in. diameter magnetic discs, Fig. 18, to aid coil removal and installation.
Commutating Field Coils (Replacement)

The commutating coil connections, Fig. 17, are located on the commutator-end of the frame. For access to commutating coil connections and coils, use a coiling arbor.

To replace one or more commutating coils proceed as follows:

1. Place frame in horizontal position on a bench. On commutator-end of frame, unbraze connection of A.
1. Heat old coil in an oven to soften the varnish prior to removing the pole from old coil.

2. Block the hot coil in a press and remove the pole from the coil. Do not hammer directly on the pole or damage pole laminations.

3. Scrape the varnish from the pole. Do not use a grinder to remove varnish from laminations. Check for and remove all sharp edges from the pole.

4. Insert the pole in the new coil.

5. Clean the inside of the magnet frame. Make sure coil and pole contact surfaces are clean.

To Install Field Coils In Frame (Fig. 19)

1. Position coil(s) on the coiling arbor and reconnect the coil connection straps by brazing. Refer to Fig. 17 for connections.

2. Insulate coil connections with two tapings 1/2 lapped, of mica mat tape and one taping 1/2 lapped, of glass tape, Fig. 20.

Seal the joint between ferrules and cable insulation of small cables, Fig. 17 (33), with silicone rubber tape (27) at locations shown on view at B and C.

FIG. 18. VIEW OF COILING ARBOR AND EXCITING COILS, E-24808

lead and brushholder connection and AA lead and coil connection.

2. Remove A and AA leads from the frame.

3. Unbraz the F and FF leads from the exciting-field coil connections and pull leads out of the frame.

NOTE: If necessary, exciting field coils can also be replaced during this procedure. Preparation for replacement includes:

Removal of coil connection insulation (as required).

Unbrazing the coil connections of coils that will be replaced.

4. Heat the coiled frame in an oven at 150 C (302 F) for four hours to soften the varnish so pole bolts can be removed.

5. Remove hot coiled frame from oven and lower frame (coupling-end down) on a coiling arbor.

6. Remove pole bolts, Fig. 4 (20), and washers from ALL commutating coils and any exciting coils that will be replaced.

7. Pry coils loose from frame and lift frame off the coils.

8. Remove the insulation from the commutating coil connections of coils that will be replaced. Unbraz coil connections, as necessary. Protect insulation with flowing air.

To install used pole(s) in replacement field coil(s) proceed as follows:

FIG. 19. GE1264 FIELD COILS ON COILING ARBOR. E-24809
3. Lower the frame over the coils, Fig. 21. Make sure frame is positioned correctly to allow cables A and AA, F and FF to be connected AFTER the frame is VPI.

4. Line up all pole bolt holes with frame bolt holes.

5. Lubricate the threads and washer faces of all pole bolts.

6. Install commutating-pole bolts and torque to 45-50 ft.-lb. Install exciting-pole bolts and torque to 110-120 ft.-lb.

7. Lift the coiled frame off the coiling arbor.

8. Remove varnish from pole faces, to allow micrometer measurement to be made on bare metal, and measure the pole bores of all coils. Refer to DATA section for pole bore dimensions.

9. Refer to Test After Repair section (coiled frame) for instructions and perform tests listed.

Installing And Connecting Field-Coil Cables — After Frame VPI (Fig. 17)

NOTE: Install cables A and AA and F and FF AFTER the coiled frame has been VPI and flood-dipped to avoid stiff cables due to varnish penetration.

After the coiled frame is VPI:

1. Install and reconnect the field-coil cables by brazing.

2. Seal the joints between ferrules and cable insulation on all cables with silicone rubber tape (27) and RTV 108. Insulate the cable connections with two tapings 1/2 lapped of mica mat tape, and one taping 1/2 lapped of glass tape.


4. Bake the frame in an oven at 150 C (302 F) for two hours to cure the field coil cable-connection insulation.

INSULATION PROCESSING (VPI COILED FRAME)

After all field coil repairs have been completed, see section on Vacuum Pressure Impregnation (VPI) for further required processing of the coiled motor frame.
CAUTION: If field coil(s) are “in-the-white,” the coiled frame must be VPI twice. Bake after first VPI and cure before applying the second VPI.

TEST AFTER REPAIR (COILED FRAME)

IMPEDEANCE TEST OF COILED FRAME

Pass 24 amps (60 Hz current) separately, through the exciting (series) and commutating field and read the voltage drop, across each, excluding cables.

<table>
<thead>
<tr>
<th></th>
<th>Max.</th>
<th>Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exciting Field</td>
<td>17.6 v</td>
<td>16.1 v</td>
</tr>
<tr>
<td>Commutating Field</td>
<td>3.8 v</td>
<td>3.3 v</td>
</tr>
</tbody>
</table>

HIGH-POTENTIAL TEST

Frame With Used Coils

Apply a high-potential test voltage of 2000 v, 60 Hz for one minute.

Frame With All New Coils

Apply a high-potential test voltage of 3500 v, 60 Hz for one minute.

WARNING: Electric shock can cause serious or fatal injury. To avoid such injury, personnel should take and observe proper precautions during the high-potential testing.

RESISTANCE MEASUREMENT

Refer to DATA for values and measure the resistance of the exciting and commutating fields.

BRUSHHOLDERS

Teflon Sleeve Replacement

1. Remove the damped Teflon sleeve from the brushholder stud. To remove sleeve, heat the brushholder in an oven to 150 C (302 F) then peel or cut sleeve from the stud.

2. Thoroughly clean the surface of the stud and remove any carbon or dirt build-up.

3. Heat a new Teflon sleeve in a 150 C oven for 15 minutes.

4. Use asbestos gloves and immediately assemble the hot sleeve on the stud.

Brushholder Stud Replacement

To replace brushholder studs:

1. Support the brushholder body on blocks and press both studs out of the body.

2. Heat the body in the area of the stud holes to 200 C (392 F) and quickly assemble the new studs in the brush holder body by hand so the bottom of the stud is flush with the bottom of the brushholder body.

CAUTION: Do not press studs into brushholder body.

3. Use flowing air to cool the assembly.

4. Assemble new Teflon sleeves on studs per instructions in preceding section.

VARNISH TREATMENTS

VACUUM PRESSURE IMPREGNATION (VPI)

Armature and Motor Frame

After all repairs have been completed on the armature and the coiled motor frame, the armature and frame must be vacuum pressure impregnated in GE-702C polyester varnish.

Following the VPI processing, the armature must be given a varnish immersion treatment and the coiled frame must be flood dipped in varnish.

The VPI process must be performed in a vacuum impregnating tank with a nitrogen/dry air atmosphere. Do not attempt to VPI unless all proper materials and equipment are available. Maintain all VPI temperatures +2-1/2 degrees C.

Varnish (VPI)

The GE-702C polyester varnish used in the (VPI) process is catalyzed and normally stable but it can set-up quite rapidly if vigilant care is not taken to avoid overheating. Overheating of the varnish can be avoided by making sure:
1. The item to be impregnated is within the specified temperature limits.

2. The cooling-water is circulating through the holding tank and the tank agitator is operating at the time the hot varnish is returned to the holding tank.

Varnish viscosity limits are shown on Fig. 22 as a function of temperature. GE-775 viscosity reducer is used to maintain viscosity within the limits shown. Five gallons of reducer, per drum of varnish, is usually required to control viscosity.

Gel Time

Gel time of the varnish should be within the limits shown on Fig. 23 as measured with a Sunshine Gel Meter at 115-116°C (239-240.8°F), boiling butanol. If gel time falls below the minimum, GE-776 inhibitor solution should be added at the rate of 3 pints per 100 gallons. Gel time may be increased by adding uncatalyzed GE-702C varnish if normal make-up varnish is needed.

1. Preparation for Impregnation

NOTE: Machined surfaces from which varnish will be removed after impregnation should be coated with black varnish, GE-271. Threads should be coated with GE-RTV-108 Silicone Sealant to prevent varnish build-up. For tapped holes, use dummy bolts with O-rings under heads or RTV Sealant.

2. Impregnation

a. Pre-bake and repair per previous instructions.
b. Allow parts to cool below 60°C, but not below 40°C, to avoid jelling of varnish.

c. Place parts in the vacuum tank and seal the tank. When processing the armature, place it in the tank with the commutator end up.

d. Start the vacuum and hold below 3000 microns for ten minutes. Record the final vacuum. If final pressure is above 3000 microns, DO NOT continue until adequate vacuum is obtained.

e. Stop the vacuum and transfer varnish from the holding tank until the desired level is obtained. A layer of foam will form on the surface of the varnish. If at all possible, let the varnish level come four inches over the desired height and continue. If not possible, when foam reaches the desired level, knock down with a small amount of nitrogen and pump additional varnish to replace the foam. If at this point the vacuum is less than 20 inches mercury (in. Hg) the cycle is not acceptable. Transfer the varnish back into the holding tank and repeat Steps d and e. If the cycle is acceptable, continue.

f. Open the nitrogen line and bring to 0 pressure. (Do not use air below 0 pressure.) Continue to pressurize the tank with nitrogen or dry air to maximum obtainable, but not over 100 psig. Hold above 70 psig for a minimum of 25 minutes.

g. Release the pressure by venting to atmosphere and transfer the varnish to the holding tank. Be sure the cooling water and agitation is on in the holding tank.

h. Remove the parts from the tank.

i. Motor Frame — Bake at 150°C for six hours.

j. Armature — The armature should be roll-baked at 140°C for seven hours. Baking must start within 30 minutes after removal from VPI tank and rolling should be at a rate of 1/3 to three revolutions per minute.

NOTE: After the VPI process has been completed, the following processes are required:

Armature Assembly — Refer to VARNISH TREATMENT OF THE ARMATURE AFTER VPI section.

Motor Frame — Refer to the FLOOD DIPPING MOTOR FRAME AFTER VPI section.

NOTE: Do not clean previously protected cables, terminals, machined surfaces, threads and tapped holes before varnish treating the armature and flood dipping the motor frame.

VARNISH TREATMENT OF ARMATURE AFTER VPI

The following immersion process must be performed on the armature assembly after the VPI process.

1. Preheat the armature in an oven at 140°C for at least five hours.

2. The temperature of the armature must not be less than 90°C, or above 120°C before immersing. Immerse the armature in a vertical position (commutator end up) in the varnish (GE Spec. No. A15B53A) for at least one minute.

NOTE: One minute is the minimum time to insure adequate varnish penetration.

3. Lift the armature out of the varnish and spin until the excess varnish is removed. Clean the shaft with Xylene (GE Spec. No. D5B9).

4. Bake at 140°C in an oven for at least eight hours.

FLOOD DIPPING MOTOR FRAME AFTER VPI

The following process must be performed on the motor frame after the VPI process.

1. The material to be used is a red-pigmented, alkyd-base insulating varnish, (GE 8001, Spec. GE A15B17B). Refer to Fig. 24 for varnish viscosity chart.

2. Prior to use, the tank must be agitated for a minimum of 15 minutes and checked to be sure the pigment is uniformly dispersed.

3. Preheat the frame so that when it is dipped, its temperature will be between 40°C and 80°C.

4. Dip the frame in the tank (pinion end down) far enough to submerge the coils and connections and hold for at least 15 seconds.

5. Remove the frame from the varnish and allow the excess varnish to drain for at least 15 minutes in the vertical position.

6. Bake in the vertical position in an oven at 150°C for a minimum of 30 minutes.
NOTE: WHEN NECESSARY, USE SOLVESO NO. 100 TO THIN VARNISH.
GE NO. 8001 VARNISH NO. 3 ZAHN CUP

![Graph of Varnish Viscosity Chart for Dipping Coiled Frame]

FIG. 24. VARNISH VISCOITY CHART FOR DIPPING COILED FRAME. E-24812

7. Install, connect and insulate the field coil cables. See Installing and Connecting Field Coil Cables after Frame VPI section for instructions.

8. Clean black varnish from protected machined surfaces and clean drilled and tapped holes. Remove silicone tape from cable ends and terminals.

ARMATURE BALANCING
Refer to Fig. 4 for balance weight locations. Dynamically balance the armature within 3 grams on the coupling end and 3 grams on the commutator end by adding balance weights on the commutator cap and the armature head at the balancing radius.

NOTE: Keyway must be filled with a half-key during balancing operations.

MOTOR REASSEMBLY
Refer to Fig. 4.

BRUSHHOLDERS
1. Use bolt (15) and attach brushholder support (14) to frame mount. Position the brushholder studs in the support clamp and move the brushholder radially outward as far as possible.

2. Tighten bolt (15) lightly; do not torque. Install all brushholders.

3. Connect the brushholder cables to the brushholders. Refer to connection diagram, Fig. 17.

BEARINGS

NOTE: Two types of grease are used at bearing reassembly; GE Spec. D6A2C5 is used to lubricate the bearings, and GE Spec. D6A2C4 is used to seal the bearing cavities and to coat running clearance surfaces.

CAUTION: To avoid bearing distress, use only the types of grease specified for lubricating and sealing bearings. Do NOT substitute one type of grease for another or intermix grease types.

Commutator-End Bearing (Fig. 25)

1. Clean the shaft bearing-fit and remove any nicks or burrs from fit surfaces.

2. Use seal grease, GE Spec. D6A2C4, and coat the inner surface of bearing housing (2) and the running-clearance surfaces of the bearing housing, collar (40) and the shaft as shown in Fig. 25.

3. Use 1.2 oz. of bearing grease, GE Spec. D6A2C5, and fill all voids in bearing (3).

4. Heat bearing housing (2) to 100 C (212 F) and install cold ball bearing (3) into bearing housing (2) with bearing seal facing inward.

NOTE: The bearing may be pressed into the bearing housing bore with an arbor press.

CAUTION: Avoid cocking outer race in bore of housing. Press bearing on face of outer race only.

5. Use a 0.002 in. feeler gage and make sure the outer bearing race is seated on the bottom of the housing bore.

6. Heat the bearing housing assembly to 100 C (212 F) and install it on the shaft. Make sure inner race is tight against the shaft shoulder.
7. Install bearing lockwasher (6) and bearing nut (5) on end of shaft. Tighten the nut and secure it with a washer tab.

8. Place 0.8 oz. of bearing grease in cavity of bearing cap (4).

9. Install gasket (37) on bearing housing (2) and attach bearing cap to bearing housing with machine screws (34).

10. Rotate bearing housing assembly to be sure it turns freely on the shaft without binding.

**CAUTION:** Do not heat bearing assembly over 110°C (230°F) as damage to grease may occur resulting in premature bearing failure.

**CAUTION:** To avoid damage to commutator-end grease fittings (7), install grease plugs. Then install fittings after armature is lowered into frame.

**Coupling-End Bearing (Fig. 26)**

1. Clean the shaft bearing and collar fits. Remove any nicks or burrs from fit surfaces.

2. If a new roller bearing (30) will be installed, heat inner race to 120°C (248°F) and shrink it on the shaft tight against the shaft shoulder. Use a 0.002 in. feeler gauge to make sure inner race is tight against shoulder.

3. Heat collar (33) to 120-140°C (248-284°F) and shrink it on the shaft tight against the bearing inner race. Check collar location with a feeler gauge.

5. Pack 0.84 oz. of bearing grease, GE Spec. D6A2C5, in the cavity of framehead (27). Heat framehead to 100 C (212 F) and install cold outer-bearing race and rollers of bearing (30) in hot framehead bore, tight against bottom of bore. Use a feeler gauge and make sure outer race is seated on bottom of bore.

6. Use 1.15 oz. of bearing grease and fill all voids in roller cage of bearing (30).

7. Coat the running clearance surfaces of framehead (27) and the shaft with seal grease, GE Spec. D6A2C4, and slide the framehead on the shaft.


9. Place gasket (38) on framehead (27). Use bolts and lockwashers (31) and bolt bearing cap (32) to the framehead. Torque bolts (31) to 21-24 ft.-lb.

ARMATURE (Fig. 4)

1. Bolt end plate (10) to commutator-end of magnet frame with bolts (8) and torque bolts to 11 to 13 ft.-lb.

2. Turn the frame to a vertical, commutator-end down, position. Block the frame level with clearance for commutator-end guide studs when the armature is installed.

3. Wrap the commutator with heavy paper. Screw armature lifting tool, Part 41C681042-13, Fig. 12, on the coupling end of the shaft and screw a lifting eye, with locknut, into the tool. Tighten locknut to lock the lifting eye.

4. Install two guide studs in commutator-end bearing housing (2).

5. Install a guide stud in the framehead fit on coupling-end of the magnet frame.

6. Lift the armature and lower it into the magnet frame. Avoid bumping the commutator, brushholders or, field coils.

7. Make sure the radial position of the commutator-end grease fitting tapped holes matches location shown on Fig. 27. Align the commutator-end guide stud with the bolt hole in end plate, Fig. 4 (10), and start the bearing housing into the frame opening.

8. Make sure coupling-end grease fittings will be in correct radial position. Align frame head with guide stud and lower the armature.
TRACTION MOTOR, TYPE GE1264, GEK-63192

NOTE:
LIFTING INSTRUCTIONS
1. LIFT ASSEMBLED PROPELLION PACKAGE USING GEAR UNIT AND MOTOR VERTICAL SUSPENSION BRACKETS AND GEAR UNIT LIFTING LUG.
2. LIFT MOTOR BY USING THE HORIZONTAL AND VERTICAL MOTOR SUSPENSION BRACKETS AND A SLING AROUND THE SHAFT AT THE COUPLING HUB.
3. LIFT GEAR UNIT USING THE LIFTING LUG, SUSPENSION BRACKET AND SAFETY NOSE.

IMPORTANT:
The electrical equipment should be located in a space which — provides sufficient accessibility for brush inspection, allows removal of all the brushes and pivotail fasteners, allows maintenance personnel to comply to the GE maintenance instruction special requirements.

NOTE:
1. LIFT GE1264AT MOTOR/GEA73A1 GEAR UNIT OUTLINE, E.24815

FIG. 27. GE1264AT MOTOR/GEA73A1 GEAR UNIT OUTLINE, E.24815
9. On the coupling end; install bolts, Fig. 4 (28), and lockwashers and alternately tighten bolts to draw framehead (27) evenly into frame fit. Torque framehead bolts (28) to 110-120 ft.-lb. Remove guide stud from frame.

10. Remove guide stud from commutator-end bearing housing. Install bolts (8) through end plate (10) into bearing housing (2). Torque bolts (8) to 11-13 ft.-lb.

11. Turn the motor to a horizontal position. Rotate the armature by hand to be sure it turns freely.

COMMUTATOR-END BEARING RUNOUT (Fig. 4)

1. Block up the commutator-end of the motor about four in. above horizontal.

2. Remove grease fittings (7).

3. Remove bolts (8) from inner and outer bolt circles.

4. Remove end plate (10), machine screws (34) and bearing cap (4).

5. Install a dummy bearing cap to clamp the bearing, Part 41D785838-3, and secure the cap with machine screws (34). Install end plate (10) and torque bolts (8) to 11-13 ft.-lb.

6. Force the armature toward the pinion-end of the motor.

7. Mount a dial indicator on the shaft, Fig. 28. Set the pointer of the indicator against the face of the outer bearing-race.

8. Rotate the armature and read bearing runout. If runout exceeds value listed in DATA section, check for dirt or burrs in bearing housing fit.

9. Remove dummy bearing cap. Install gasket (37), bearing cap (4), machine screws (34), end plate (10) and bolts (8). Torque bolts (8) to 11-13 ft.-lb.

10. Install grease fittings (7) and torque fittings to 21 ft.-lb.

COUPLING-END BEARING

Runout Check (Fig. 4)

1. Remove bolts (31) from bearing cap (32) and remove bearing cap. Block up the coupling-end of the motor about 4 in. above horizontal.
motor and set the pointer of the indicator against the face of the outer bearing-race.

4. Rotate the armature and read bearing runout. Refer to DATA section for maximum coupling-end runout value. If runout exceeds value listed, check for burrs or dirt on the framehead-to-frame fit and/or, improper seating of bearing in the framehead fit.

NOTE: Leave dial indicator in position and check armature end-play. See following section for instructions to check end-play.

ARMATURE END-PLAY

With the dial indicator mounted on the coupling-end of the shaft and the pointer touching the face of the outer bearing race:

1. Pry the armature, toward coupling-end, as far as free travel allows. Zero the dial indicator.

2. Pry armature toward commutator and check shaft travel on dial of indicator. End-play limits are listed in DATA section.

NOTE: Do NOT install bearing cap (32) before checking the diametral clearance of the coupling-end bearing.

Diametral Clearance Check (Coupling-End Bearing)

1. Position the motor with the shaft horizontally.

2. Use a feeler gauge and check the clearance between each bearing roller and the inner race, at the top of the bearing. Place the feeler gauge between the top roller and the inner race, Fig. 30. The clearance between rollers and race should measure between 0.0002 and 0.0031 in. Try various gauge thicknesses until clearance can be determined by the feel of the gauge as gauge is slowly pulled from between roller and inner race.

3. Remove dummy bearing cap.

4. Install gasket (38) on framehead and install bearing cap (32). Bolt bearing cap in place with bolts (31) and torque bolts to 21-24 ft.-lb.

MOTOR RESISTANCE MEASUREMENT

Measure resistance at 25 C.

<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armature</td>
<td>0.0157</td>
<td>0.0173</td>
</tr>
<tr>
<td>Exciting Field:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Cables</td>
<td>0.0153</td>
<td>0.0169</td>
</tr>
<tr>
<td>Without Cables</td>
<td>0.0143</td>
<td>0.0159</td>
</tr>
<tr>
<td>Commutating Field:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Cables</td>
<td>0.00765</td>
<td>0.00845</td>
</tr>
<tr>
<td>Without Cables</td>
<td>0.00685</td>
<td>0.00765</td>
</tr>
</tbody>
</table>

BRUSHHOLDER CLEARANCE ADJUSTMENT

Refer to BASIC REPAIR ON CAR-MOUNTED EQUIPMENT, Brushholder Replacement and Clearance Adjustment section for instruction and adjust clearance on all brushholders.

BRUSHES

Refer to DATA section for recommended brush grade and install a new set of brushes.

NOTE: New brushes must be sanded to match the contour of the commutator surface. After sanding brushes, blow out the commutator chamber with dry, compressed air to remove carbon dust.

WARNING: When using compressed air for cleaning purposes, an environment potentially hazardous to personnel in the immediate area is created. To prevent physical injury by flying debris, observe all Railroad and OSHA safety regulations.

CAUTION: When replacing brushes, use GE recommended grade. Mixing of brush grades in the same motor or changing brushes to another grade is not recommended as this will seriously affect commutation, surface film, commutator and brush life.
COVERS

Before installing the brush inspection covers, make sure all brush spring levers are latched and brushholder connections are tight.

TEST

Refer to Fig. 31 for motor connection diagram.

RUNNING TESTS

No Load Saturation (Speed Check)

With brushes down and seated, pass the following currents through the exciting field (series only). Hold speed constant at 1000 rpm and read terminal volts.

**WARNING:** Electric shock can cause serious or fatal injury. To avoid such injury, personnel should observe all safety rules throughout the following tests.

<table>
<thead>
<tr>
<th>Amps</th>
<th>Volts</th>
<th>Max.</th>
<th>Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 500</td>
<td></td>
<td>151.8</td>
<td>147.8</td>
</tr>
<tr>
<td>2. 250</td>
<td></td>
<td>127.1</td>
<td>123.5</td>
</tr>
<tr>
<td>3. 0</td>
<td></td>
<td>2.51</td>
<td>0.6</td>
</tr>
<tr>
<td>4. 100</td>
<td></td>
<td>77.4</td>
<td>73.2</td>
</tr>
<tr>
<td>5. 250</td>
<td></td>
<td>126.5</td>
<td>122.4</td>
</tr>
<tr>
<td>6. 375</td>
<td></td>
<td>141.9</td>
<td>137.7</td>
</tr>
</tbody>
</table>

**NOTE:** The voltage for falling 250 amps, 2, must exceed that for rising 250 amps.

High Voltage Run (Open Circuit)
(To Show Up Shorts in Armature)

Air cure the commutator at 5300 rpm with 130 amps in the exciting field (approximately 500 v). Use dry, compressed air and a rubber hose with the nozzle removed. See “Air Curing Commutator” section for instructions.

**WARNING:** When using compressed air for cleaning purposes, an environment potentially hazardous to personnel in the immediate area is created. To prevent physical injury by flying debris, observe all Railroad and OSHA safety regulations.

Drive motor at 5830 rpm for 10 minutes with the exciting field separately excited at 300 amps. This excitation will produce approximately 815 armature volts. Do NOT read this voltage.

**CAUTION:** Never exceed 100 C total temperature on bearings.

Reduce speed to 1000 rpm and thoroughly blow out both ends of the test machine with dry compressed air.

Overspeed Test

Drive motor at 6400 rpm for two minutes. Check commutator for roughness with a fiber rod and check for noisy bearings with a listening rod.

Vibration Test

Record maximum vibration on the CE and PE with a vibration indicator at 5300 rpm.

- P.E. vibration (in.) ...................... 0.002
- C.E. vibration (in.) ...................... 0.002

Commutator Runout

Stop the motor. Check commutator runout (maximum runout - 0.001 in.). Attach an indicator to the frame with a flat tipped pointer against the commutator. Slowly rotate armature by hand and measure runout in all brush paths. Maximum runout in any brush path is 0.001 in. TIR. Rate of change is 0.0004 within any group of 20 bars and 0.0001 in. between adjacent bars.

High-Potential Test

While machine is hot, test all windings to ground and between fields.
Volts (60 Hz for one minute)

New windings: 3500
Repaired or Reconditioned windings: 2000

**WARNING:** Electric shock can cause serious or fatal injury. To avoid such injury, personnel should take and observe proper precautions during the High-Potential Testing.

**MOTOR COUPLING HUB ASSEMBLY**

Refer to GAC9 coupling instruction book GEK-63194 for instructions to assemble the coupling hub on the motor shaft.

**MOTOR TO GEAR-UNIT ASSEMBLY**

Refer to separate publication GEK-63191 for instructions to join the motor to the gear unit.

**NOTES:**
<table>
<thead>
<tr>
<th>OEM Part #</th>
<th>Description</th>
<th>Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>N170P25028</td>
<td>Armature (Fan to Armature) 3/8&quot;-16 x 1-3/4&quot; Long Grade 5 Hex Socket Head Bolt.</td>
<td>6</td>
</tr>
<tr>
<td>41B537660P1</td>
<td>Armature (Fan to Armature) 0.42&quot; I.D. Flat Washer - Special.</td>
<td>6</td>
</tr>
<tr>
<td>41A23883P1</td>
<td>Armature Lubricant Collar.</td>
<td>1</td>
</tr>
<tr>
<td>8864951P54</td>
<td>Fan End Roller Bearing - FAE NU212E.M1C3.</td>
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<tr>
<td>8864950P77</td>
<td>Commutator End Single Shield Ball Bearing - SKF #: 6307ZJEM.</td>
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<tr>
<td>N22P23016B</td>
<td>Commutator End Cap &amp; End Plate Mounting 5/16&quot;-18 x 1&quot; Long Grade 5 Hex Head Bolt.</td>
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</tr>
<tr>
<td>N22P33036</td>
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<tr>
<td>N22P33032</td>
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<tr>
<td>N22P25012B</td>
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<tr>
<td>N22P25024B</td>
<td>Flash Ring Mounting Grade 5 Hex Head Bolt - 3/8&quot;-16 x 1 1/2&quot; Long</td>
<td>4</td>
</tr>
<tr>
<td>N22P33024</td>
<td>Frame Head 5/8&quot;-11 x 2-1/2&quot; Long Grade 5 Hex Head Bolt.</td>
<td>7</td>
</tr>
<tr>
<td>N/A</td>
<td>5/8&quot; x 1 1/2&quot; x 2&quot; Long Duplex Speer 5410 or Equivalent Carbon Brush.</td>
<td>8</td>
</tr>
<tr>
<td>427C431G1</td>
<td>Brush Holder Assembly.</td>
<td>4</td>
</tr>
<tr>
<td>302702P2</td>
<td>Lead Cable Bushings.</td>
<td>4</td>
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<tr>
<td>8811148P1</td>
<td>Collar Bearing Retaining Ring.</td>
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<tr>
<td>41A238186P1</td>
<td>1.68&quot; Long Motor End Hub Mounting Coupling Key.</td>
<td>1</td>
</tr>
<tr>
<td>41A238184P1</td>
<td>1 3/16&quot;-24 Motor End Hub Mounting Coupling Nut - (Special).</td>
<td>1</td>
</tr>
<tr>
<td>494A352P12</td>
<td>Motor End Oil Coupling Seal.</td>
<td>1</td>
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<tr>
<td>41B535345P1</td>
<td>Sleeve Housing Coupling.</td>
<td>1</td>
</tr>
<tr>
<td>41A238183P1</td>
<td>Motor End Hub Mounting 1-1/4&quot; I.D. Coupling Lock Washer - Special.</td>
<td>1</td>
</tr>
<tr>
<td>N2800P1</td>
<td>Fan &amp; Commutator Ends Bearing Grease Fitting.</td>
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<tr>
<td>41B535657G1</td>
<td>Flash Ring.</td>
<td>1</td>
</tr>
<tr>
<td>41A232391P1</td>
<td>1/64&quot; Thick Commutator End Bearing Cap Mounting Gasket.</td>
<td>1</td>
</tr>
<tr>
<td>41A23242P1</td>
<td>1/4&quot; Thick Fan End Bearing Cap Mounting Gasket.</td>
<td>1</td>
</tr>
<tr>
<td>N/A</td>
<td>Heat Shrink Tubing For Lead Ends.</td>
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</tr>
<tr>
<td>41B53578G1</td>
<td>Commutator End Bearing Housing (If required after inspection).</td>
<td>1</td>
</tr>
<tr>
<td>N/A</td>
<td>Lead Clamp Assembly (If required after inspection).</td>
<td>1</td>
</tr>
<tr>
<td>N/A</td>
<td>Lead Clamp 1/2&quot;-13 x 1.0&quot; Long Grade 5 Hex Head Bolt.</td>
<td>1</td>
</tr>
<tr>
<td>N/A</td>
<td>Lead Clamp 3/8&quot; Plain Flat Washer.</td>
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</tr>
<tr>
<td>N/A</td>
<td>Lead Clamp 3/8&quot;-16 Grade 5 Elastic Hex Head Lock Nut.</td>
<td>2</td>
</tr>
<tr>
<td>N/A</td>
<td>Lead Clamp 1/2&quot; I.D. Spring Lock Washer.</td>
<td>1</td>
</tr>
<tr>
<td>8864959P8</td>
<td>Commutator End Bearing Lock Nut.</td>
<td>1</td>
</tr>
<tr>
<td>494A407P1</td>
<td>Commutator End Plate.</td>
<td>1</td>
</tr>
<tr>
<td>N170P26040B</td>
<td>B.H. Support Mounting 7/16&quot;-20 x 2-1/2&quot; Long Grade 5 Hex Socket Head Bolt.</td>
<td>4</td>
</tr>
<tr>
<td>N51P21010B</td>
<td>Bearing Cap 1-4&quot;-18 x 5/8&quot; Long Mounting Grade 5 Flat Head Screw.</td>
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<tr>
<td>41A238580P2</td>
<td>Felt Seal.</td>
<td>1</td>
</tr>
<tr>
<td>493A800G2</td>
<td>Brush Holder Mounting Support (Two Halves).</td>
<td>4</td>
</tr>
<tr>
<td>N/A</td>
<td>1/0 Amp Terminal Connector</td>
<td>4</td>
</tr>
<tr>
<td>N402P14B</td>
<td>Bearing Support Mounting 7/16&quot; I.D. Plain Washer.</td>
<td>4</td>
</tr>
<tr>
<td>41A231459P1</td>
<td>Commutator End Bearing Cap &amp; End Plate 0.344&quot; I.D. Mounting Flat Washer - Special.</td>
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</tr>
<tr>
<td>886495P108</td>
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</tr>
<tr>
<td>186V513P1</td>
<td>Coil Mounting 0.718&quot; Flat Washer - Special.</td>
<td>16</td>
</tr>
<tr>
<td>186V513P1</td>
<td>Frame Head 0.718&quot; I.D. Flat Washer - Special.</td>
<td>7</td>
</tr>
<tr>
<td>41B537660P1</td>
<td>Fan End Bearing Cap Mounting 0.42&quot; I.D. Flat washer - Special</td>
<td>4</td>
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<tr>
<td>41B537660P1</td>
<td>Flash Ring Mounting 0.42&quot; I.D. Flat washer - Special</td>
<td>4</td>
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<td>41A238580P2</td>
<td>Felt Seal.</td>
<td>1</td>
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<tr>
<td>493A800G2</td>
<td>Brush Holder Mounting Support (Two Halves).</td>
<td>4</td>
</tr>
<tr>
<td>N/A</td>
<td>1/0 Amp Terminal Connector</td>
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<tr>
<td>493A800G2</td>
<td>Brush Holder Mounting Support (Two Halves).</td>
<td>4</td>
</tr>
<tr>
<td>N/A</td>
<td>1/0 Amp Terminal Connector</td>
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TECHNICAL SPECIFICATION
EE&QA-806

REQUIREMENT FOR THE OVERHAUL OF TRACTION MOTOR ARMATURES

ISSUED:  February 01, 2010

REVISIONS:  February 21, 2017

VEHICLE PROCUREMENT & QUALITY ASSURANCE
<table>
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<th>APPROVALS</th>
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<tbody>
<tr>
<td>Prepared By:</td>
<td>2/22/17</td>
</tr>
<tr>
<td>Bruce J Shand - Engineer</td>
<td></td>
</tr>
<tr>
<td>Equipment Engineering &amp; Quality Assurance</td>
<td></td>
</tr>
<tr>
<td>Approved By:</td>
<td>02/22/2017</td>
</tr>
<tr>
<td>Ed Belanger – Superintendent</td>
<td></td>
</tr>
<tr>
<td>Subway Operations Main Repair Facility</td>
<td></td>
</tr>
<tr>
<td>Approved By:</td>
<td>2/22/17</td>
</tr>
<tr>
<td>Paul Flynn – Deputy Director</td>
<td></td>
</tr>
<tr>
<td>Subway Operations Main Repair Facility</td>
<td></td>
</tr>
<tr>
<td>Approved By:</td>
<td>3/22/2017</td>
</tr>
<tr>
<td>Steven Hicks – Chief Mechanical Officer</td>
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<tr>
<td>Rail Maintenance</td>
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<td>Inspection</td>
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<td>3.4.6.2</td>
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<td>Armature Rewinding</td>
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<td>Armature Shaft Repair</td>
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<td>3.4.6.5</td>
<td>Fan Repair</td>
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<td>Commutator Press and Tighten</td>
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<td>Commutator Spin Seasoning</td>
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<td>3.4.6.8</td>
<td>Commutator V-Ring Creepage Band Replacement</td>
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<td>Armature Vacuum Pressure Impregnation</td>
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<td>Armature Balancing</td>
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<td>3.4.7</td>
<td>Reassembly</td>
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<td>3.4.8</td>
<td>Final Inspection and Test</td>
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<td>Polarization Index Test</td>
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<td>3.4.8.4</td>
<td>Dielectric Test</td>
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<td>3.4.8.5</td>
<td>Armature Winding Tests</td>
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<td>3.4.8.6</td>
<td>Post-Test Inspection</td>
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<td>3.5</td>
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<td>Armature Shaft Replacement</td>
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<td>4.1.2</td>
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1.0 SCOPE AND DESCRIPTION OF WORK

1.1 SCOPE

This specification establishes the general procedures and processes and the Contractor requirements for the overhaul of traction motor armatures.

1.2 DESCRIPTION OF WORK

All work listed and summarized in Section 1.2.1 as Basic Work is required on each traction motor armature turned over to the Contractor for overhaul. It shall be the responsibility of the Contractor to determine what part of the Extra Work listed in Section 1.2.2, plus any additional work not listed, will be necessary to completely overhaul and repair the armature and restore it to an as-new condition. The funds reserved for Extra Work are not guaranteed to be paid to the Contractor without the Extra Work being performed.

1.2.1 Basic Work

The Basic Work shall consist of the following:

<table>
<thead>
<tr>
<th>Item</th>
<th>Summary Description</th>
<th>Reference Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Contractor to pick up armature upon notification at the Subway Main Repair Facility- 80 Broadway, Everett MA 02149</td>
<td>5.2</td>
</tr>
<tr>
<td>2</td>
<td>Incoming Inspection and Test</td>
<td>3.4.2</td>
</tr>
<tr>
<td></td>
<td>Inspect and test armature for obvious defects. Log defects and missing parts on the Incoming Inspection Report (Appendix C, 10.1)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Disassembly</td>
<td>3.4.3</td>
</tr>
<tr>
<td></td>
<td>Disassemble armature to extent necessary</td>
<td></td>
</tr>
</tbody>
</table>
### SUBJECT: REQUIREMENT FOR THE OVERHAUL OF TRACTION MOTOR ARMATURES

<table>
<thead>
<tr>
<th>Step</th>
<th>Task</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Armature Cleaning</td>
<td>3.4.4</td>
</tr>
<tr>
<td></td>
<td>Clean as necessary and oven dry.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Inspection and Test</td>
<td>3.4.5</td>
</tr>
<tr>
<td></td>
<td>Thoroughly inspect armature for mechanical defects and faults. Check all parts, including core, fan, armature shaft, etc. for damage, distortion, straightness, wear and proper dimensions. Log all defects on the Incoming Inspection Report (Appendix C, 10.1).</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Commutator Replacement</td>
<td>3.4.6.2</td>
</tr>
<tr>
<td>7</td>
<td>Armature Rewind</td>
<td>3.4.6.3</td>
</tr>
<tr>
<td>8</td>
<td>Replace Core Laminations</td>
<td>3.4.6.3.g.2</td>
</tr>
<tr>
<td>9</td>
<td>Reassembly</td>
<td>3.4.7</td>
</tr>
<tr>
<td></td>
<td>Reassemble armature as required.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Final Inspection and Test</td>
<td>3.4.8</td>
</tr>
<tr>
<td></td>
<td>Thoroughly test and inspect completed motor armatures for proper operation and acceptance by the Authority. Log test results on the Final Test Report (Appendix C, 10.2).</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Preparation for Shipment</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>Prepare repaired and tested motor armatures for shipment to the Authority.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contractor to ship repaired motor armatures to the Authority.</td>
<td>5.2</td>
</tr>
</tbody>
</table>
1.2.2 Extra Work

In addition to performing the Basic Work outlined in Section 1.2.1 on each motor armature, the Contractor shall be responsible for determining the need for any and all additional repair work required to completely rebuild and remanufacture the motor armatures to an essentially as-new condition. Such additional work, or Extra Work, shall be approved by the Authority prior to commencement of said work. If the Contractor proceeds with any Extra Work without Authority approval, the Contractor shall assume all costs for performing such work. Examples of such Extra Work are as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Summary Description</th>
<th>Reference Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Replace Armature Shaft as needed</td>
<td>3.5.1</td>
</tr>
<tr>
<td>2</td>
<td>Replace Fan</td>
<td>3.4.6.5.b</td>
</tr>
</tbody>
</table>

2.0 APPLICABLE DOCUMENTS AND DRAWINGS

The following documents and drawings of the issue in effect on the date of signing of the Contract form a part of this Specification to the extent specified herein. In the event of conflict between the documents and drawings referenced herein and the contents of this Specification, the contents of this Specification shall be considered a superseding requirement unless stated otherwise by the Authority. Any conflicts within or between the documents and drawings referenced herein shall be promptly brought to the attention of the Authority for its resolution.

2.1 DOCUMENTS

2.1.1 Institute of Electrical and Electronics Engineers, Inc. Documents


2.1.2 General Electric Company Publications


Publication GEK-63192 dated April, 1978; "Inspection, Maintenance and Basic Overhaul Instructions, Traction Motor, Type GE1264"

2.1.3 Westinghouse Electric Corporation Publications

Instruction Book 5786-19 dated January, 1941; "Parallel Accelerator Control and Type 1432-D Motor for Boston Elevated Railway Co."

Publication I.B.20907; "Inspection and Maintenance of Control and Rotating Apparatus for Massachusetts Bay Transportation Authority South Shore Cars," Section 2.1 (Type 1460-B1 Traction Motors)

3.0 REQUIREMENTS

3.1 GENERAL REQUIREMENTS

3.1.1 Intent and Purpose of Specification

The intent of this Specification is to establish a minimum acceptable quality standard for the overhaul of traction motor armatures, but not to rule out better or more economical materials or techniques, if such exists. If the Contractor wishes to use different materials or procedures, he shall apply, in writing, to the Authority's Manager of Equipment Engineering and Quality Assurance for approval. If it is determined that it is in the best interest of the Authority, written approval for such alternates will be issued. Without such written approval, the Contractor shall not deviate from this Specification. Such written approval will be appended to this Specification and made an integral part thereof.

3.1.2 Contractor's Responsibilities

The Contractor shall be responsible for performing Basic Work on each motor armature in accordance with the requirements included in Section 3.4 and for
performing any additional repairs that may be necessary, but not specifically included therein, as part of that Basic Work. Such work will restore the armature to an as-new condition.

In addition, the Contractor shall be responsible for identifying and, following approval by the Authority, performing as Extra Work additional tasks such as shaft replacement. Such work shall be in accordance with the requirements included in Section 3.5.

The Contractor shall be responsible for furnishing the various procedures, forms and data sheets required. Forms are included but not limited to those in Appendix C. If an alternative form is used, the format of the substitute form shall be submitted and approved by the Authority.

Unless otherwise specified herein or in any contractual documents, the Contractor shall complete all work required on each armature and return within fifteen (15) business days after receipt of a notice to pick up said armature. All “notice(s) to pick up” will be conveyed via email. Each armature delivered to the Authority shall be subjected to an incoming inspection; any deviation from the specification shall result in the armature(s) being returned to the vendor. The vendor shall have five (5) days to correct any problems found during the Authority’s incoming inspection process. Travel time to and from the vendor facility will not be included in the five (5) day restriction.

3.1.3 Reports

The Contractor shall submit the following reports to the Authority that are cumulatively updated to include but not limited to all inspections, checklists, repair actions, including warranty repairs, which occurred within the reporting period:

a. a summary report of cumulative frequency rates and unit costs for each type of overhaul action for each type of armature processed shall be submitted every six months.

b. a detailed report of cumulative repair work performed and costs thereof on individual armatures processed sorted by serial number, shall be submitted with each shipment of repaired armatures.
c. a cumulative listing of all purchased and/or Contractor manufactured repair and replacement parts (reference Section 3.1.6) shall be submitted every six months.

d. a status listing of all required data submittals, including drawings, specifications, analyses, and procedures shall be submitted.

e. the original copy of the Incoming Inspection Report for each armature returned to the Authority (Appendix C, 10.1 or an approved substitute).

f. the original copy of the Final Test Report (Appendix C, 10.2 or an approved substitute) for each armature returned to the Authority.

g. the original copy of the Armature Rewind Quality Control Checklist (Appendix C, 10.3 or an approved substitute) for each armature returned to the Authority.

h. the original copy of the VPI Process QC Sheet (Appendix C, 10.4 or an approved substitute) for each armature returned to the Authority.

i. the original copy of the Machining, Balancing and Undercutting Quality Control Checklist (Appendix C, 10.5 or an approved substitute) for each armature returned to the Authority.

j. the original copy of the Balance Report (Appendix C, 10.6 or an approved substitute) for each armature returned to the Authority.

k. a detailed list of all insulation materials and compounds that are required as well as copies of the MSDS sheets at the time the contract is awarded and in the event that a material substitution is required.

3.1.4 Guarantees

All work performed and all parts and materials shall be unconditionally guaranteed by the Contractor for a period of 18 months after the motor in which the armature is installed is placed in service, or for 24 months following receipt of the repaired armature by the Authority, whichever comes first. The Contractor shall accept the Authority's records with respect to the date that the motor was placed in service.
If at any time during the guarantee period the armature fails or is defective, in the opinion of the Authority, the Contractor shall pick up the armature and, in the presence of an Authority representative if deemed necessary by the Authority, disassemble, inspect and test the armature at his shop to determine the cause of failure or defect. The Authority may, at its discretion, perform such disassembly, inspection and test in its own shops in the presence of a Contractor representative.

If, in the opinion of the Authority, the failure or defect is due to the fault of the Contractor, either by negligence, oversight, inadequate or incomplete repair, inadequate or inferior parts, materials, procedures and processes, or poor workmanship, the Contractor shall perform all necessary replacement and repairs as determined by the Authority at no additional cost to the Authority.

The Contractor shall also reimburse the Authority for all direct and indirect labor costs incurred in removing the failed or defective armature from the vehicle and from the motor in which it was installed. This reimbursement shall be in the amount of $946, based on current Authority costs of removing and replacing a motor on a car ($373) and then removing and replacing the armature ($573).

**The contractor will be assessed a charge of $100 per business day for any armature not returned to the Authority as specified in Section 3.1.2**

If the Contractor establishes to the complete satisfaction of the Authority that the cause of the failure or defect was not due to the fault of the Contractor as above, no reimbursement for direct and indirect labor costs shall be assessed and the Authority may authorize the Contractor to perform the necessary repairs as determined by the Authority. If the Contractor performs such repairs, the costs there of shall be in accordance with the Price Schedule submitted with his proposal at the time of bidding. In either case, the work, parts and materials shall be re-guaranteed by the contractor as above.

### 3.1.5 Procedures and Instructions

Any work performed on Authority motor armatures shall be in accordance with the Original Equipment Manufacturers (OEM) requirements for that armature, unless otherwise noted herein, and in accordance with additional requirements of this Specification.

It shall be the responsibility and obligation of the Contractor to promptly inform


| **SUBJECT:** REQUIREMENT FOR THE OVERHAUL OF TRACTION MOTOR ARMATURES |
|-----------------------|------------------|
| Date: February 01, 2010 | Revised: February 21, 2017 | Revision: D |

the Authority if any of the procedures, instructions or requirements contained herein are incomplete, inadequate, unclear, improper, or deleterious to the equipment or if they affect personnel safety.

If requested by the Authority the Contractor shall prepare a separate comprehensive Armature Repair Procedure for any or all motor armatures covered by this Specification and Contract, in a format as approved by the Authority. All procedures shall be submitted to the Authority's Manager of Equipment Engineering and Quality Assurance for approval. The procedure shall be in accordance with Original Equipment Manufacturer and Authority requirements and shall include all information and steps required to properly overhaul, repair and rebuild the armature in question containing, at a minimum, all applicable manufacturing processes and procedures, assembly drawings, coil construction drawings, insulation details, materials and parts listings, and test procedures, except for proprietary information, which shall be made available to the Authority on an as-needed basis but will not be reproduced by the Authority except for internal evaluation.

Once approved, the Contractor shall not make any change in the procedure or implement any procedure not covered therein or in this Specification unless written approval and permission is granted by the Authority's Manager of Equipment Engineering and Quality Assurance.

Failure to submit these procedures, data and drawings in a timely manner may constitute grounds for cancellation of the contract.

All approvals shall be made in writing by the Authority's Manager of Equipment Engineering and Quality Assurance. All such requests for approval and all data submittals, data sheets, reports, etc. shall be forwarded to:

Massachusetts Bay Transportation Authority  
Manager of Equipment Engineering and Quality Assurance  
Subway Operations- Main Repair Facility  
80 Broadway  
Everett, Massachusetts 02149

### 3.1.6 Repair and Replacement Parts

All repair and replacement parts required in the repair of equipment covered in
this Specification shall meet or exceed the specifications and shall be purchased by the Contractor only from the Original Equipment Manufacturer. If repair or replacement parts are either purchased from another manufacturer or supplier or manufactured by the Contractor, prior written approval from the Authority's Manager of Equipment Engineering and Quality Assurance must be obtained. The approval request will only be considered after complete drawings and specifications of the alternate parts offered are submitted, together with a complete analysis of how the necessary drawings and specifications were derived from the Original Equipment Manufacturer's parts. All such drawings, specifications, and analyses shall be first reviewed, approved, and signed by the Contractor's qualified engineer. Documents and data that have not been so approved shall be rejected by the Authority. The process of approvals shall not affect delivery of repaired units and the Authority will not be responsible for delays in the process.

All missing parts and all repair and replacement parts shall be provided and installed by the Contractor as Extra Work at an additional cost to the Authority, except for any minor parts and consumable items, such as balance weights and fasteners, which shall be provided as part of the Basic Work, at no additional cost to the Authority.

All discrepant parts replaced at additional cost to the Authority shall be tagged by the Contractor, including armature serial number, job number, etc., and returned to the Authority, as requested, at no extra expense to the Authority.

All parts replaced or repaired shall be appropriately logged on the Small Parts Quality Control Checklist (Appendix C, 10.7 or an approved substitute)

The costs for such replacement parts shall be as listed by the Contractor in the Price Schedule submitted with his proposal at the time of bidding. The costs for any part not listed therein shall be borne by the Contractor as part of the Basic Work.

3.1.7 Workmanship and Materials
3.1.7.1 General

Workmanship and materials shall, in every respect, be of high-grade and quality and in accordance with the best modern industry practice. Whenever the Specification or any directions of the Authority are vague or in doubt as to what is
permissible, or fail to note the quality of any construction or work, the requirement of best quality shall be followed. Materials shall be new, except as otherwise specifically stated herein. Materials and workmanship shall be free from defects of any kind.

3.1.7.2 Qualifications of Personnel

All work under this Contract shall be performed by fully trained and qualified personnel. Those personnel engaged in special processes (e.g. welding, non-destructive testing, etc.) shall be certified as appropriate. Proof of certification shall be supplied if requested by the Authority.

3.1.7.3 Materials and Supplies

All materials and supplies required shall be provided by the Contractor, at his expense. It is the responsibility of the Contractor to provide insulation materials and compounds that are Service Proven and that have been fully qualified and rated as Class H, or better, per the requirements of the Institute of Electrical and Electronics Engineers, Inc. Suggested materials and supplies are listed in this Specification where appropriate, but it shall remain the responsibility of the Contractor to select such materials and supplies in accordance with the above requirements. A full listing, with manufacturers data sheets and thermal rating certification data as required, of all materials and supplies used by the Contractor to perform the work herein shall be forwarded to the Authority for information and/or approval prior to the commencement of any work.

3.1.8 Shop Equipment

The Contractor shall possess motor armature repair and test equipment available for use on this contract and shall employ personnel thoroughly trained and skilled in their use. Due to the high performance required of traction motors, the following additional specialty equipment not usually found in an industrial motor repair facility shall be provided at the Contractor's facility.

a. Automatic T.I.G. (Tungsten Inert Gas) welding equipment for welding armature conductors to commutator risers

b. Commutator and core pressing and tightening tooling
c. Automatic commutator undercutting equipment

d. Voltage surge tester

e. V.P.I. (Vacuum Pressure Impregnation) equipment

f. Armature banding equipment

g. Commutator heating and spin seasoning equipment

h. Armature balancing equipment

Specific equipment requirements are presented in the following sections.

3.1.8.1  Insulating Varnish Control

Gel time and viscosity of insulating varnish shall be checked at least once per week. Inhibitor solutions and viscosity reducers shall be added in the amounts as recommended by the varnish manufacturer to bring gel time and viscosity within the limits prescribed by the varnish manufacturer.

A sample of the varnish shall be taken and analyzed by the varnish manufacturer for proper formulation at least once per month. Any additives recommended by the varnish manufacturer shall be added to maintain the proper formulation. The Contractor shall prepare and maintain periodic reports on these checks and analyses. A copy of this report, including a listing of armature and stator assemblies impregnated with the varnish during the period covered by the report shall be submitted to the Authority every three months. A copy of the VPI Process QC Sheet (Appendix C, 10.4 or equivalent) shall be submitted with each armature returned to the Authority.

3.1.8.2  Baking Ovens

Baking ovens shall be of the circulating type with accurate temperature control and shall be capable of achieving and sustaining the temperatures specified herein for the times stated. If not specified, the drying cycle shall be of sufficient duration to insure that the armature attains the highest possible insulation resistance. The maximum temperature shall not exceed that imposed by the limitations of the insulation system (temperature classification).
3.1.8.3  T.I.G. Welding Equipment

T.I.G. (Tungsten Inert Gas) welding shall be accomplished with Linde Company, or approved equal, heli-arc welding equipment using Argon gas. Operators shall be thoroughly trained and experienced in T.I.G. welding traction motor commutators, and machines and equipment specifically designed for that purpose shall be utilized. Power supplies shall include an adjustable millisecond timer switch and an adjustable current limiting device.

3.1.8.4  Spin Seasoning Equipment

Spin seasoning equipment shall be as manufactured by CAM Industries of Hanover, Pennsylvania, or approved equal. It shall be designed for use on high speed traction motor armatures and capable of handling the complete armature. It shall be capable of reaching and maintaining armature rotational speeds up to 6,500 RPM and commutator temperatures up to 170°C(338°F) and shall include an insulated commutator heating chamber that protects the armature windings and banding from direct heating. The equipment shall include variable heat and speed controls capable of maintaining control over the set speeds and temperatures.

3.1.8.5  Armature Banding Machines

Banding machines shall be as manufactured by CAM Industries of Hanover, Pennsylvania, or approved equal, and shall insure uniformity of banding tape tension in banding applications.

3.1.8.6  Measuring and Test Equipment

Procedures shall be established to verify that all tools, gauges, instruments, and other inspection, measuring and test equipment used in tests, processes, and activities affecting quality are controlled, calibrated, and adjusted at specific periods, against standards traceable to the National Bureau of Standards, to maintain accuracy within necessary limits. Records of such control, calibration and adjustments shall be maintained by the Contractor and all equipment, as applicable, shall be clearly marked to indicate current calibration status. All such procedures and records shall be furnished to the authority upon request.
3.1.8.7 Tooling and Fixtures

All tooling, fixtures and gauges required for the work herein shall be designed and manufactured, or otherwise provided, by the Contractor. The Contractor shall provide the Authority with drawings of such items for information and/or approval, as requested by the Authority if, in the opinion of the Authority, such items may be of use in its maintenance activities.

3.2 DESCRIPTION AND GENERAL DATA

This Specification may cover any and all of the following traction motors currently in use, or contemplated for use, on Authority vehicles:

Motors Manufactured by General Electric Company

<table>
<thead>
<tr>
<th>Type</th>
<th>Used On</th>
</tr>
</thead>
<tbody>
<tr>
<td>5GE1264A1</td>
<td>No. 4 E.B.R.T. Cars or No. 12 M.L.R.T. Cars</td>
</tr>
</tbody>
</table>

Motors Manufactured by Westinghouse Electric Corporation

<table>
<thead>
<tr>
<th>Type</th>
<th>Used On</th>
</tr>
</thead>
<tbody>
<tr>
<td>1432-D</td>
<td>P.C.C. Cars</td>
</tr>
<tr>
<td>1460-B</td>
<td>No. 1 S.S.R.T. Cars</td>
</tr>
<tr>
<td>1460-B1</td>
<td>No. 2 S.S.R.T. Cars</td>
</tr>
<tr>
<td>1463-E1</td>
<td>No. 7 Surface Rail Cars</td>
</tr>
</tbody>
</table>

Appendix A includes a data sheet on these motors and contains currently available Original Equipment Manufacturer's information. Missing data, or revised data, necessary for the repair of armatures shall be obtained by the Contractor and forwarded to the Authority to revise the data sheets.

3.3 HANDLING PRECAUTIONS

Proper handling of all motor armatures is necessary to avoid damage and shall be done in accordance with the following guidelines:

a. Lift armatures by the use of a lifting nut screwed onto the end of the shaft or with the use of slings. Use a spreader to hold the two slings apart to prevent undue pressure from being applied to the armature. Do not lift more than one armature at a time.
b. When turning an armature from the vertical to the horizontal position, and vice-versa, take precautions to prevent the weight of the armature from being momentarily transferred to the armature shaft extensions causing the armature to be gouged or bent.

c. Armatures may be turned by using a lifting nut on one end and a single sling on the other, with an independent hoist for each.

d. Do not roll armatures across the shop floor.

e. Rest armatures on a fixture that supports the two ends of the shaft.

3.4  BASIC WORK

3.4.1  General

The Contractor shall be responsible for performing all work listed in Section 1.2.1 as Basic Work in accordance with the procedures contained herein. In addition, it shall be the responsibility of the contractor to determine the need for any additional, or Extra Work, required to rebuild the motor armature to an as-new condition. Extra Work requirements are included in Section 3.5 of this Specification.

3.4.2  Incoming Inspection and Test

Each motor armature shall receive a preliminary visual inspection as necessary to determine the following:

a) Additional work requirements beyond Basic Work to insure complete repair of the armature.

b) Existing pre-repair condition of the armature to compare the condition after repairs prior to shipping back to the Authority.

c) Assemble data for failure analysis, if any.

d) Warranty responsibility determination as applicable.

Upon receipt of the armature, the Contractor shall log, in black ink, the condition
of the armature and preliminary inspection results in the Incoming Inspection Report (Appendix C, 10.1 or an approved substitute).

The Inspection Report shall include pertinent information such as the armature serial number, the contract number, the Contractor's Job Number, the general condition of the armature and a listing of missing and or broken parts. Additional items, including actual work performed, shall be logged on the Incoming Inspection Report as the work progresses.

Visually check the overall condition of the armature, including commutator, armature windings, armature shaft, banding, etc.

### 3.4.3 Disassembly

a. Disassemble the armature assembly by removing the fan and any other parts prior to any cleaning and inspection of the armature and its components.

**CAUTION:** TAKE EXTREME CARE TO AVOID DAMAGING THE MICA INSULATION.

b. Carefully remove the creepage band and string banding from the mica V-ring extension.

### 3.4.4 Cleaning

Clean the armature in accordance with the following:

a. Clean carbon and dirt from the mica V-ring with a dry rag or fiber brush.

b. Remove any paint or varnish from the ends of the commutator bars by scraping.

c. Blow out armature with clean, dry compressed air at 50 psig.

d. Wash the armature by steam cleaning with high pressure stain in an Authority approved mild detergent.

e. Clean the armature with a soft bristle brush. Carefully clean the commutator
slots with a stiff nylon brush, removing all traces of dirt.

f. Re-wash the armature as in part (d) above and rinse thoroughly with steam and hot water to remove all traces of cleaning compound.

g. Thoroughly dry the armature in a vacuum tank or in a circulating-type oven at 150°C (300°F) for eight hours.

3.4.5 Inspection

3.4.5.1 General Requirements

After cleaning and drying, the armature shall be thoroughly inspected to more completely determine its condition and the extent of repairs required. All mechanical dimensions, shall be carefully checked and measured and compared against the Original Equipment Manufacturers data sheets and drawings as appropriate. Items of Extra Work required shall be determined by the Contractor at this time and specifically brought to the attention of the Authority for approval.

The Contractor is responsible for performing all necessary inspections to completely determine the condition of the armature. All results and any defects and discrepancies shall be logged in black ink on the Incoming Inspection Report.

3.4.5.2 Inspection

Inspect the armature assembly, observing the following.

a. Inspect the outside surface of the armature assembly for evidence of scraping and damage.

b. If applicable, inspect the fan for any cracks, excessive abrasion, warpage, wear and any other damage and deformation. If in doubt, check for cracks by an Authority approved Dye Penetrant Inspection method. Damaged fans shall be repaired, or replaced as Extra Work.

c. Inspect the mica V-ring for damage.

d. Inspect the armature shaft observing the following:
(1) Inspect the bearing surfaces for nicks, scoring or deep wear patterns. The surface finish must be 16 micro inches R.M.S. or better.

(2) Measure the diameters of the commutator and non-commutator end bearing surfaces. They shall be within the bearing manufacturer's recommendations for shaft bearing seat diameter limits for heavy load and shock load conditions.

(3) If applicable, inspect the coupling seat for damage. Check the taper fit with an Authority approved gauge.

(4) Support the armature on the bearing journals and measure the shaft run out with a 0.0001 inch per division dial indicator. The Full Indicator Run out (F.I.R.) relative to the bearing journals shall be within the following limits:

<table>
<thead>
<tr>
<th>Surface</th>
<th>F.I.R. (Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coupling Seat</td>
<td>0.001 Inch</td>
</tr>
<tr>
<td>Bearing</td>
<td>0.001 Inch</td>
</tr>
<tr>
<td>Spline Pitch Diameter</td>
<td>0.002 Inch</td>
</tr>
</tbody>
</table>

(5) Support the armature assembly between centers and indicate both bearing journal surfaces with a 0.0001 inch per division dial indicator. The Full Indicator Run out (F.I.R.) shall not exceed 0.0005 inch. If this run out is exceeded, scrape the shaft centers and re-indicate the bearing journal surface until the F.I.R. is as required.

(6) If applicable, check for shaft spline wear by measuring across two precision ground pins placed between diametrically opposite teeth. Measure the wear on individual tooth pairs by moving both pins around the spline, one tooth at a time, and measuring the diameter for each pair. Check the spline for general condition and other dimensions.

**NOTE:** The spline teeth must be completely clean with no dirt, fretting dust or grease on them, and all burrs and rolled-over edges must be removed, to insure accurate measurements.

(7) If applicable, gauge and chase any internal and external threads.
3.4.6 Repair or Replacement

3.4.6.1 General Requirements

The following repair or replacement work shall be performed as part of the Basic Work unless specifically identified as Extra Work. All parts that do not pass inspection and are damaged beyond economical repair shall be replaced. Any work of a minor nature not specifically covered here or in Section 3.5 shall be accomplished as Basic Work.

All work performed and any parts replaced shall be logged in black ink on the appropriate report.

The following materials and supplies and manufacturers thereof are suggested for use in the repair of the armatures. All materials and supplies shall be approved by the Authority prior to the awarding of the contract and in the event of a change of material being used during the life of the contract and shall meet or exceed the requirements of Section 3.1.7.3.

Some work requirements already required as part of the Basic Work of Section 3.4.6.2 are repeated for emphasis and for sequence of operations in Section 3.4.6.3. The prices quoted for shall not include charges for accomplishing these steps more than once per completed armature.

| TABLE 3-1 |
| ARMATURE REPAIR MATERIALS |

Nomex 414 paper tape, various thicknesses and widths (E.I. Dupont deNemours & Company, Wilmington, Delaware)

B-Stage Nomex 410 Sheet, Class 200ºC, epoxy resin coated on both sides (Type EI-10L07-02, Electrolock, Inc., Shagrin Falls, Ohio; Type LN-508E, Lectromat, Inc., Mars, Pennsylvania)

Type F FEP-Kapton Film Tape, 0.0015 inch thick, (Type 150F019, E.I. Dupont deNemours & Company, Wilmington, Delaware)
Type H Kapton Film, 0.002 inch thick (E.I. Dupont deNemours & Company, Wilmington, Delaware)

Type H Kapton adhesive tape with Acrylic thermosetting adhesive, 0.0025 inch thick (Type P-224, Permacel, New Brunswick, New Jersey)

Woven glass tape, Medium Weave, (Pittsburgh Electrical Insulation Corp. (Hesgon Company), Munhall, Pennsylvania; Essex Magnet Wire and Insulation Division, Fort Wayne, Indiana)

Fiberglass acrylic adhesive tape, 0.005 inch thick (Type P-213, Permacel, New Brunswick, New Jersey)

Open weave fiberglass cloth, treated with polyester resin and cured, 0.030 inch thick (P.E.I. 800-M, Pittsburgh Electrical Insulation Corp., Munhall, Pennsylvania)

Glass sleeving, Class H (no silicone resins permitted)


Edging tape with nylon rod edge restraint, (Glass Band Edging Tape, Pittsburgh Electrical Insulation Corp., Munhall, Pa.)

Heat Shrinkable Mylar Tape, 0.003 inch thick, 0.75 inch wide (E. I. Dupont deNemours & Company, Wilmington, Delaware)

Thermosetting, 2 component, polyester compound (GE-3285, General Electric Co., Insulating Materials Dept., Schenectady, N.Y.)

Polyester impregnated glass cord, 1/16 inch diameter (Jonathan Temple and Co., Hackensack, N.J.)

Thermopoxy brushing compound (Sterling U-953 with C-12A catalyst, Reichhold, Chemicals Inc., Sewickley, Pa.)

R.T.V. Silastic adhesive/sealant (Type 899, Dow Corning Corp., Midland, Mich.)

Thermosetting Epoxy Varnish (Sterling U-475-EH Thermopoxy Varnish, Reichhold Chemicals, Inc., Sewickley, Pa.)


Xylene Cleaner (G.E. Specification D5B9, General Electric Company)

Polyester impregnated fiberglass sheet, 1/16 inch thick, 1/8 inch thick (Glastic Corp. Cleveland, Ohio)

Abrasive paper (Federal Specification P-P-101, Grit No. 320)

Primer (No. E42GP22, Federal Standard 595, Color No. 34151, mixed equal parts by volume with catalyst reducer, Sherwin-Williams Co., Los Angeles, California, or equivalent)

Glyptal insulating paint (GE1201, General Electric Co., Insulating Materials Dept., Schenectady, N.Y.)

### 3.4.6.2 Commutator Replacement

Replace the commutator with a new commutator, in accordance with the following procedures:

a. Strip and clean the armature in accordance with the procedures of Sections 3.4.6.3.b and 3.4.6.3.c.

b. Inspect and test the armature core in accordance with the requirements of Section 3.4.6.3.d through 3.4.6.3.f. Replace any defective laminations in accordance with the requirements of Section 3.4.6.3.g.

c. Remove the commutator from the armature shaft using a hydraulic puller, or the equivalent, being extremely careful not to damage the shaft.
d. New commutators shall meet the following requirements:

1. Commutators shall be approved by the Authority.
2. All mica rings, sleeves and splittings shall be new.
3. All commutator bars shall be new and diameter shall be at 
   new.
4. Commutators shall be completely spin/temperature seasoned and 
   cycled in accordance with an Authority approved procedure prior to 
   installation.
5. Commutators shall be electrically tested in accordance with the 
   requirements of Section 3.4.6.3.h.
6. The commutator assembly shall be pre-balanced as an assembly to 
   within one ounce-inch.
7. The maximum accumulated error due to commutator bar and mica 
   thickness variations shall not exceed 0.004 inch bar-to-bar.
8. When dividing the commutator into eight sectors, or groups of bars, 
   the maximum accumulated error due to commutator bar and mica 
   thickness variations, as measured at the outside diameter of the 
   commutator, shall not exceed 0.015 inch.
9. Bare metal surfaces of the commutator shell shall be primed and then 
   painted with a Glyptal insulating paint.
10. The commutator bar centered over the keyway in the commutator 
    shell, if applicable, shall be permanently identified with a period (.) 
    stamped on the end of the bar facing the V-ring.
11. The skew allowance at the centerline of the commutator shell 
    keyway, or the armature axial centerline, and the centerline of the 
    above identified bar shall be 0.015 inch maximum over the length of 
    the entire bar.
12. The centerline of the commutator keyway and the centerline of the
above identified bar shall be indexed radially within 0.0075 inch at the lateral centerline of the commutator brush surface. This indexing is independent of the skew allowance above.

e. Heat the commutator at 150ºC (302ºF) for two to three hours.

f. Lightly coat the appropriate shaft diameters with a suitable lubricant.

CAUTION: IF APPLICABLE, THE RADIAL INDEXING OF THE CENTERLINE OF THE COMMUTATOR BAR IDENTIFIED PER SECTION 3.4.6.3.d(10) ABOVE, OR THE CENTERLINE OF THE COMMUTATOR SLOT, WHICHEVER IS APPLICABLE FOR THE PARTICULAR ARMATURE DESIGN AND THE CORE SLOT IDENTIFIED PER SECTION 3.4.6.3.g(16) SHALL BE WITHIN THE TOLERANCE SPECIFIED BY THE ORIGINAL EQUIPMENT MANUFACTURER.

g. Press the new commutator onto the armature shaft, aligning the keyway slot in the commutator shell with the key in the armature shaft, if applicable. Check the alignment of the commutator to insure that it lines up with the core slots in accordance with Original Equipment Manufacturer's requirements. Apply a minimum of 40 tons of pressing force to the commutator shell and insure that the commutator is fully seated against the armature core pressure plate.

h. Press and tighten the commutator in accordance with the OEM procedure.

i. Rewind the armature in accordance with the procedures of Section 3.4.6.3

3.4.6.3 Armature Rewinding

Rewind the armature in accordance with the following procedure.

Replacement of shafts shall be at additional cost to the Authority. Replacement of minor parts such as pressure plates, collars, spacers, keys, etc. shall be included in the rewind cost.

NOTE: While the intent is to standardize on insulation methods and materials
and on rewinding techniques, it is recognized that these instructions may not apply to all armatures. The Contractor shall modify these general instructions as appropriate to specific armatures, as approved by the Authority. In addition, variations to these general procedures may be permitted, with Authority approval, to allow the use of proven techniques and materials.

a. Armature and equalizer coils shall be designed and manufactured as approved by the Authority in accordance with the following general requirements:

(1) Armature and equalizer coils shall be in strict accordance with the latest design of the Original Equipment Manufacturer (OEM), including dimensions of conductor size, number of conductors, conductor orientation, insulation, twisting and forming.

The orientation of armature coils in the core slot shall not be changed from the OEM design unless the Contractor produces a written verification from the OEM, including appropriate technical analysis, that changing the conductor orientation would improve the design and operating characteristics of the motor and would be of benefit to the Authority.

Insulating materials used shall be updated to the present state of the art as approved by the Authority.

(2) Finished armature coils shall be a snug fit into the core slot.

(3) Conductors shall be of an electrolytic tough pitch copper suitably heat treated and annealed after forming to withstand the shock and vibration loads experienced on rail vehicle traction motors without failure. Lead ends shall be twisted and swage formed to fit the commutator riser slots.

(4) Armature and equalizer coil conductors shall be insulated over the entire length of the conductor with one layer, 1/2 lapped, of 0.0015 inch thick FEP-Kapton type F film tape, thermally sealed after wrapping to form an integral insulation.
(5) Uninsulated armature coils shall be shaped by hot pressing after
stacking the insulated coil conductors.

(6) Equalizer coils shall be covered with glass sleeving centered on the
coil. If space does not permit this, glass sleeving shall be applied to
every other equalizer coil, with Authority approval.

(7) Armature coils shall have filler strips of B-Stage Nomex added
between all conductors at the knuckle end.

(8) Armature coil leads shall each be insulated with one layer, 2/3 lapped
to result in three layers, of 0.002 x 3/8 inch type H Kapton film tape
followed by one layer, 1/2 lapped, of 0.005 x 3/8 inch woven glass
tape. The insulations shall begin no more than 1/8 inch from the
commutator riser and shall extend to a point 1 1/2 inches from the slot
where it shall tie in to the adjacent lead.

(9) Armature coils shall have a ground insulation of one layer, 1/2 lapped,
of 0.002 x 3/8 inch type H Kapton film tape applied over the full
length of the coil.

(10) Armature coils shall have a pre-shaped slot wrapper of 0.002 inch
thick Nomex paper, 2 1/2 wraps with the overlap on the side, applied
to the slot portion of the coil and extending at least 3/4 inch beyond
each end of the slot.

(11) Armature coils shall have an overall insulation of one layer, 1/2
lapped, of 0.005 x 3/4 inch woven glass tape applied over the full
length of the coil.

(12) Armature coils should not be Vacuum Pressure Impregnated at this
time. The VPI process shall be performed when the armature is
completely wound and welded

(13) Finished coils shall be hot die pressed and formed such that the coil
leads line up with the appropriate commutator slots in accordance
with the armature throw requirements.
(14) Each finished armature coil shall be subjected to a high potential test, per the requirements of Section 4.2.2, with 1,000 volts A.C., R.M.S., 60 Hertz, applied between adjacent conductors to insure that they are free of electrical faults. There shall be no breakdown indicated.

(15) Each finished armature coil shall be subjected to a high-potential ground test, per the requirements of Section 4.2.2 at 3,000 volts A.C., R.M.S., 60 Hertz for 60 seconds. There shall be no breakdown indicated. The test voltage shall be applied between a slot-sized die and the coil with the slot section under pressure within the die.

(16) Each finished equalizer coil shall be subjected to a high-potential ground test, per the requirements of Section 4.2.2., at 1,000 volts A.C. R.M.S., 60 Hertz, for 60 seconds. There shall be no breakdown indicated. Each coil shall be wrapped with metal foil, to within 3/16 inch of the coil end with the test voltage applied between the coil and the metal foil.

(17) Each finished armature and equalizer coil shall be 100 percent inspected for dimension, defects and quality of workmanship.

(18) All coils shall be of first-class quality and shall be manufactured by fully qualified personnel.

(19) All conductors shall be individually glass sleeved up to the commutator riser.

b. Remove the armature windings and insulation observing the following procedure:

(1) Remove the fan.

**CAUTION**: AN ABSOLUTE MINIMUM OF COMMUTATOR RISER MATERIAL SHALL BE REMOVED. BE CAREFUL TO NOT BEND OR DAMAGE RISERS.

(2) Place the armature in a lathe and machine the T.I.G. welded face of the commutator risers just enough to release the welded ends of the coils.
from the risers. If the coil ends are soldered into the riser slots, carefully heat the area to remove the coils without damage to the commutator.

(3) Carefully remove the coil banding and coil wedges.

(4) Cut the coils in back of the risers and at the front and rear ends of the core using a 1/8 inch cut-off tool or a rotating carbide tip cutter. The cut shall be made at a distance between 1/8 and 3/8 inch outboard of components.

**CAUTION:** THE FOLLOWING TEMPERATURES SHALL NOT BE EXCEEDED IN THE STRIPPING OPERATION:

```
CORE      -    250ºC (482ºF)
COMMUTATOR - 200ºC (392ºF)
AS MEASURED ON THE BRUSH SURFACE
```

(5) Remove the armature and equalizer coils and all associated insulation, varnish and compounds.

**NOTE:** Coils and wedges in core slots shall be removed by mechanical means ("Thumm" method) or by high pressure water spray. The commutator shall be protected by a hood. When the high pressure water method is used, the armature must be baked in an oven for six hours at 150ºC (302ºF) following stripping.

**CAUTION:** USE EXTREME CARE TO AVOID BENDING COMMUTATOR RISERS AND CRACKING OF MICA SEGMENTS.

(6) Remove the cut-off leads from the commutator risers.

(7) Straighten any bent risers and clean out riser slots as necessary.

(8) Remove all balance weights from the commutator and non-commutator end of the armature.
(9) Remove the commutator creepage band without damaging the mica V-ring.

c. Thoroughly clean the stripped armature observing the following:

(1) Clean off all insulation, varnish and compounds still remaining on the core and coil supports.

**CAUTION:** TAKE EXTREME CARE TO AVOID DAMAGING THE MICA INSULATION.

(2) Carefully remove the old creepage band and string banding from the mica V-ring extension.

(3) Clean any carbon and dirt from the mica rings with a dry rag or a fiber brush.

(4) Remove any paint or varnish from the ends of the commutator bars by scraping.

**CAUTION:** USE EXTREME CARE TO PROTECT THE SHAFT BEARING SURFACES AND THE COMMUTATOR FROM DAMAGE FROM BLASTING.

(5) Thoroughly clean the armature by shell blasting, or by an Authority approved method, to remove all deposits of old varnish and compounds. Mask off any areas that are not required to be cleaned or that would otherwise be damaged.

(6) Clean the armature of all debris with dry compressed air. Inspect for and remove any copper chips from behind the risers.

d. Replace all armature core laminations. No part of the core laminations will be reused.

(1) Remove the commutator from the armature shaft using a hydraulic puller, or the equivalent, being extremely careful not to damage the shaft.

(2) Disassemble the core, inspecting the shaft and pressure plate for
damage. Replace any defective parts.

**CAUTION:** ON SOME ARMATURES, A NUMBER OF END LAMINATIONS AT EACH END OF THE CORE ARE SPOT WELDED TOGETHER. IF THIS IS THE CASE, THE SPOT WELDS SHALL BE LOCATED MIDWAY BETWEEN EACH TOOTH AND POSITIONED 0.3 TO 0.7 INCHES FROM THE OUTSIDE DIAMETER OF THE LAMINATION. THE SIZE OF THE SPOT WELD SHALL BE 0.18 TO 0.25 INCHES IN DIAMETER.

**CAUTION:** LAMINATIONS SHALL BE STACKED WITH BURRS, IF ANY, IN THE SAME DIRECTION. BURRS SHALL BE AVOIDED TO THE MAXIMUM EXTENT PRACTICABLE. IF PRESENT, THEY SHALL NOT EXCEED 10 PERCENT OF THE LAMINATION THICKNESS, OR 0.002 INCH, WHICHEVER IS LESS.

(3) Assemble the coil support and the knuckle end laminations on a mandrel, with a key, if applicable, to line up the inside diameter.

(4) Line up the slots using at least four tight fitting steel drifts.

(5) Place the assembly in a press. Apply 40 tons, press and release twice. Reapply the force and check the length of the core. Add or subtract center laminations as necessary to obtain the proper core length.

(6) Reapply 40 tons of force and re-measure the core length. Correct as necessary.

(7) Release the pressing force, assemble the commutator end pressure place onto the mandrel and reapply the 40 tons of pressing force.

(8) Bolt the assembly in an axial direction using clamping plates and bolts.

(9) Remove the pressing force, remove the assembly from the press and remove the keyed mandrel.
(10) Heat the assembly in an oven for four hours at 200ºC (392ºF).

(11) Install the armature shaft into the core from the end opposite the commutator (knuckle end). Replace the shaft key if it was damaged during shaft removal, if applicable.

(12) Place the assembly, while hot, in a press and apply a force of 40 tons. Hold the pressing force until seizure occurs.

(13) Remove the assembly from the press. Remove the drifts and temporary clamping bolts and plates.

(14) Inspect and install the commutator in accordance with OEM Procedures.

(15) After replacing laminations, commutators and shaft, check the shaft for straightness in accordance with the procedures in Section 3.4.5.2.f

(16) Identify the core slot over the core keyway, if applicable, or, for skewed slots, that slot which, at the commutator end of the core, is over the keyway, with an "X" marked on the core outside diameter with an indelible black marker, on each side of the slot, at the center of the core. Do not stamp the core.

(17) Mark the armature serial number on the core outside diameter with 1/4 inch high legible letters with an indelible black marker. Do not stamp the core.

(18) Measure the skew alignment of the identified core slot with respect to the commutator end and non-commutator end shaft bearing journals. The maximum allowable skew deviation is 0.020 inch from the nominal slot skew.

(19) After all repairs to the core are completed and before winding the armature, repeat the core loss test in accordance with the procedures of Section 4.2.5.

e. Test the commutator observing the following procedure:
(1) Perform a commutator-to-ground dielectric test at 4,000 volts A.C. R.M.S., 60 Hertz, in accordance with the procedure of Section 4.2.2.

(2) Perform a bar-to-bar dielectric test on every bar by applying 200 volts A.C., R.M.S., 60 Hertz, between adjacent bars for ten seconds.

Any commutator that does not withstand these voltages for the time indicated without breakdown shall be replaced in accordance with the procedures of Section 3.4.6.2

f. Clean the armature assembly of all debris with dry compressed air. Inspect for and remove any metal chips and other debris from behind the commutator risers.

g. If applicable, install the equalizer coil support insulation, observing the following general procedure:

**CAUTION:** TAKE EXTREME CARE TO PREVENT DAMAGING THE MICA BEHIND THE RISERS.

(1) Seal the gap between the commutator bars and the mica ring at the riser end with a continuous bead of R.T.V. Silastic adhesive/sealant.

(2) If applicable, fill the cavity under the equalizers in the back of the commutator risers with 3/8 inch wide Class H polyester resin impregnated, thermosetting, non woven fiberglass banding tape at 225 pounds tension. Fill to a level even with the bottom of the equalizer slot to provide even support for the equalizer coils.

(3) Fit one layer of 0.010 inch thick B-Stage Nomex paper sheet into the equalizer coil pocket in the commutator shell in back of the commutator risers, covering all vertical and horizontal surfaces except for the back of the commutator riser. The sheet shall be sized such that it can be folded over the completed equalizer windings after their installation. Use scissor cuts as necessary to fit the strip properly. Hold the strip in place with a few turns of glass adhesive tape.

(4) Fit a second layer of 0.010 inch thick B-Stage Nomex paper tape into
the pocket, overlapping the joint and all scissor cuts on the radial portion. Secure as above.

(5) Using layers of woven glass tape, build up the equalizer coil support, as necessary to a point where the coils will be properly supported.

h. If applicable, install the armature equalizer coils observing the following general procedure:

CAUTION: MAKE SURE THAT EACH EQUALIZER COIL HAS A SINGLE LENGTH OF GLASS SLEEVING INSTALLED OVER ITS ENTIRE LENGTH. IF SPACE DOES NOT PERMIT THIS, GLASS SLEEVING SHALL BE APPLIED TO EVERY OTHER EQUALIZER COIL, WITH AUTHORITY APPROVAL.

CAUTION: USE EXTREME CARE TO PREVENT NICKING AND DAMAGING THE COILS, INSULATION AND RISERS.


(1) Apply a thin layer of thermosetting, 2-component, polyester compound, or approved equal, over the equalizer coil support.

(2) Install the equalizer coils into the armature in accordance with the requirements of the Original Equipment Manufacturer. Place the bottom lead of the coil in the commutator risers and continue around the commutator until all bottom leads are in place.

(3) Keep the bottom coil legs adjacent to each other forming a neat tight diamond. Gently bend the top conductor out of the way to enable the application of insulation.
CAUTION: THE DRIFTS AND MALLETS SHALL BE USED DISCREETLY. THERE SHALL BE NO SHARP EDGES ON TOOLS. PROTECT THE EDGES OF THE DRIFTS WITH SEVERAL LAYERS OF TAPE TO MINIMIZE DAMAGE TO COILS AND INSULATION. THE MALLET SURFACES MUST BE SMOOTH AND ALL TOOLS MUST BE KEPT IN GOOD REPAIR.

(4) Punch down the bottom leads into the commutator riser slot with a steel drift.

(5) Apply a layer of thermosetting, 2-component, polyester compound over the bottom coil legs and fill the cavities between adjacent bottom coil legs and the risers.

NOTE: Use masking strips to prevent the compound from running into the riser slots.

(6) Hold down the bottom coil legs with a half-lapped layer of 0.007 x 3/4 inch woven glass tape.

(7) Apply two layers of 0.010 inch thick B-stage Nomex insulating strips over the bottom coil leads and glass tape. Stagger the overlap of the layers making sure that the tape is wide enough to cover the bottom leads from the inside of the knuckle to the riser. Cut to fit, if necessary. Secure in place with 0.0025 inch thick Kapton acrylic adhesive tape.

(8) Apply two half-lapped layers of 0.002 inch thick Type H Kapton film tape in back of the commutator risers over the bottom legs and the Nomex paper sheet. Secure the end of 0.0025 inch thick Kapton acrylic adhesive tape.

(9) Apply a thin layer of thermosetting, 2-component polyester compound over the insulation.

(10) Shape and place the top lead of the equalizer coils into the position over the insulation and insert into the proper commutator riser slots.
Line up the diamond of the bottom and top leads of the coils as the winding progresses. Keep the layers neat and tight without overlapping.

(11) Punch down the top leads into the commutator riser slot with a steel drift.

(12) Fill the equalizer coil area, including the cavities at the knuckles and the top of the windings with a thermosetting 2-component, polyester compound.

(13) Tightly wrap layers of 0.003 inch thick heat shrinkable Mylar tape over the equalizer coil area and compound and bake the armature in an oven until the B-stage Nomex sheets, the banding tape and the compound has been cured, for four hours at 150°C (302°F), or at a temperature and time as recommended by the insulation material manufacturers.

(14) Remove the assembly from the oven and remove the Mylar tape.

(15) Fill in any voids in back of the equalizer winding knuckle to the core with woven glass tape. Build up to the level of the top of the equalizer windings.

(16) Apply two layers of 0.010 inch thick Nomex paper tape over the equalizer windings and glass tape filler.

(17) Tightly apply two half-lapped layers of 0.002 inch thick Kapton Type H film tape over the equalizer windings and Nomex sheet. Secure the end with 0.0025 inch thick Kapton acrylic adhesive tape.

(18) Apply half-lapped layers of 0.007 x 3/4 inch woven glass tape over the Kapton film until the build-up is of the same diameter as the commutator shell coil support.

(19) Test the equalizer windings and commutator for open circuits and shorts.
i. Build up the insulating pad on the commutator and non-commutator end coil supports observing the following procedure:

(1) Apply 0.005 inch thick fiberglass acrylic adhesive tape over the coil support.

**CAUTION:** THE INSULATION BUILD-UP SHALL BE OF UNIFORM THICKNESS.

(2) After about four to five inches of tape has been applied, wind in 0.010 inch thick Nomex paper tape along with the glass adhesive tape, overlapping the glass tape over the Nomex as the application progresses. Butt lap each layer to achieve a uniform thickness.

(3) Extend the tapes over the edge of the non-commutator end coil support between 3/16 and 1/4 inch.

(4) If the build-up of the Nomex-glass adhesive tape layers will be 1/16 inch or more, intertwine 0.030 inch thick open-weave treated fiberglass cloth with the Nomex and glass adhesive tape. Butt lap each layer as above.

(5) Continue applying the insulation until the coil support pad is built up to the same diameter as the bottom of the armature core slots.

(6) Trim the pad overhang on the non-commutator coil support to remove rough and frayed edges. The overhang shall be about 3/16 inch.

j. Install the armature coils observing the following procedure:

**CAUTION:** MAKE SURE THAT THE U-PIECES ARE PROPERLY FOLDED AND SEATED TO PREVENT INTERFERENCE WITH THE WEDGES, BUT YET PROVIDE INSULATION ON THE SIDE OF THE SLOT BY EXTENDING UP TO THE WEDGE.

(1) Insert U-pieces (cuffs), made from the appropriate thickness of Nomex paper tape, into each slot in the end laminations at both ends of
the core. The U-pieces shall butt against the center laminations and extend approximately 0.25 inches out from the core.

(2) Insert bottom insulating strips, made from 0.005 inch thick Nomex paper tape, into the bottom of each slot. The strips shall be as wide as the flat portion of the bottom of the slot and one inch longer than the straight portion of the coil. Center the strip axially such that it extends at both ends of the core.

CAUTION: POSITION THE COILS SUCH THAT AN EQUAL LENGTH OF THE COIL STRAIGHT PORTION EXTENDS FROM EACH END OF THE CORE. IN ADDITION, THE OUTSIDE EDGE OF THE KNUCKLE SHALL BE PROPERLY LOCATED FROM THE END OF THE CORE SUCH THAT IT WILL NOT INTERFERE WITH THE FAN OR ANY OTHER ITEMS.

CAUTION: THE DRIFTS AND MALLETS SHALL BE USED DISCREETLY. THERE SHALL BE NO SHARP EDGES ON TOOLS. PROTECT THE EDGES OF THE DRIFTS WITH SEVERAL LAYERS OF TAPE TO MINIMIZE DAMAGE TO COILS AND INSULATION. THE MALLET SURFACES MUST BE SMOOTH AND ALL TOOLS MUST BE KEPT IN GOOD REPAIR.

(3) Insert the bottom leg of the first coil (coil number 1) into the appropriate core slot (slot number 1) and insert the coil bottom leg leads into the appropriate commutator riser slots. Pound the coil into the bottom of the slot with a drift and mallet and punch down the leads into the commutator riser slots.

(4) Check to insure that the centerline of coil number 1 is in line with the appropriate commutator bar. Check the throw of the coil and leads.

(5) Place the bottom leg of the next coil (coil number 2) into core slot number 2 and insert the bottom leg leads into the proper commutator bar riser slots.
CAUTION: CHECK THE POSITION OF THE BOTTOM COIL LAY, STRAIGHT PORTION EXTENSIONS, ANGLE OF DIAMONDS, COIL LEAD LAY IN COMMUTATOR RISERS AND KNUCKLE CROWDING AS THE WINDING PROGRESSES. SPACE COILS AS REQUIRED TO OBTAIN UNIFORMITY. IT MAY BE NECESSARY TO DRIFT THE COILS SLIGHTLY TO INSURE CORRECT POSITIONING AND TO PREVENT CROWDING WITH ADJACENT COILS.

(6) Insert the remaining coils, proceeding counter-clockwise looking at the commutator end of the armature. Insert the bottom legs of the coils into the proper core slots and insert the bottom leg leads into the proper commutator bar riser slots. Use a drift and mallet with care to locate and to nest coils, coil leads and diamonds with proceeding coils. Using a drift and mallet, pound the coil into the bottom of the core slot and punch down all bottom leads into the commutator bar riser slots.

NOTE: It may be necessary to slightly open the riser slots with a thin knife to facilitate insertion of coil leads.

CAUTION: THE SPACERS SHALL NOT PROTRUDE ABOVE THE TOP SURFACE OF THE COIL LEG.

(7) Insert coil radius spacers made from appropriate thicknesses of polyester impregnated fiberglass sheet between the full length of the diamond portion of the bottom legs at each end of each coil. Use different thicknesses of spacers to insure that the coils are properly supported from adjacent coils and to insure a tight assembly.

(8) Continue around the armature until all bottom coil legs and leads and all coil spacers are in place.

(9) When all bottom coil leads are in place, insert bare copper fillers in the riser slots, if required for a tight fit.. Punch down all fillers and all bottom coil leads in the riser slots.

(10) Fill the area behind the commutator risers to where the bottom leg
leads enter the diamond section of the coil with a thermosetting, 2-component polyester compound.

**NOTE:** Use masking strips to prevent the compound from running into the riser slots.

(11) Prepare front and rear coil insulating pads of 0.010 inch Nomex paper sheet of the proper widths. The front pad shall fit between the core and the commutator risers and the rear pad shall fit between the core and the inside of the knuckle (the pin diameter location).

(12) Layer wrap the front and rear coil insulating pads between the bottom and top diamonds of the coil. The insulating pads shall be built up to a thickness that will properly support the top legs of the coils in the diamond areas. If the pad thickness will be greater than 0.030 inch, insert 0.030 inch open-weave fiberglass cloth of the proper width between the layers of Nomex. Hold the pads in place with 0.005 inch thick glass acrylic adhesive tape.

(13) Insert coil separator strips of appropriate thickness Nomex paper sheet on top of each of the coil bottom legs in each of the core slots. These separator strips shall be as wide as the finished coil width and extend 1/2 inch beyond each end of the core.

**CAUTION:** ANY voids between the bottom surface of the coil top leg and the insulating pads shall be fully filled with strips of Nomex paper sheet of various thicknesses and widths to insure a solid support for the coil top legs.

(14) Insert the top leg of the first coil (coil number 1) into the appropriate core slot and insert the top leg coil leads into the appropriate commutator riser slots.

**NOTE:** Since the top leg of the coil is inserted over a tooth edge, it may be necessary to stretch the coil slightly beyond the normal pitch needed in the slot by gentle hand persuasion. If this persuasion is insufficient, the rear
knuckle may be gently drifted with a drift and mallet.

(15) When the coil is properly located, pound the top coil leg into the core slot with a drift and mallet and punch down the leads into the commutator riser slots.

**CAUTION:** THE SPACERS SHALL NOT PROTRUDE ABOVE THE TOP SURFACE OF THE COIL LEG.

(16) Insert coil radius spacers made from appropriate, thicknesses of polyester impregnated fiberglass sheet between the full length of the diamond portion of the top legs at each end of each coil. Use different thicknesses of spacers to insure that the coils are properly supported from adjacent coils and to insure a tight assembly.

**CAUTION:** CHECK THE POSITION OF THE BOTTOM COIL LAY, STRAIGHT PORTION EXTENSIONS, ANGLE OF DIAMONDS, COIL LEAD LAY IN COMMUTATOR RISERS AND KNUCKLE CROWDING AS THE WINDING PROGRESSES. SPACE COILS AS REQUIRED TO OBTAIN UNIFORMITY. IT MAY BE NECESSARY TO DRIFT THE COILS SLIGHTLY TO INSURE CORRECT POSITIONING AND TO PREVENT CROWDING WITH ADJACENT COILS.

(17) Proceeding counter-clockwise around the armature, insert the top legs of the remaining coils into the core slots and the top leg coil leads into the appropriate commutator riser slots until nearly all coils are in place. Pound the top coil legs into the core slots with a drift and mallet and punch the leads down into the commutator riser slots.

**NOTE:** If the radial surfaces of adjacent coil knuckles contact, place flat horseshoe-shaped pieces of 0.007 inch thick Nomex between the coils at the knuckle.
(18) Starting at slot number 1, insure that all coils are firmly seated by pounding each coil along its length with a drift and mallet. Additionally, punch the coil leads down into the commutator risers to insure that they are firmly sealed.

**NOTE**: If the coil leads are loose in the commutator riser slots, copper shims of the appropriate thickness, and of the full width and depth of the riser slot, may be used to tighten the leads.

(19) Insure that the coil knuckle ends are seated firmly on the coil support insulation.

(20) Hy-pot ground test the commutator and armature windings to the armature shaft as per the procedure of Section 4.2.2 at 3,000 volts A.C., R.M.S., 60 Hertz, for 60 seconds. There shall be no breakdown indicated.

(21) Oscillograph surge comparison test the armature windings in accordance with the requirements of Section 4.2.3 to insure that the windings are free of electrical faults.

k. Install temporary banding to pull the armature coils up tight to final position prior to machining off coil extensions and T.I.G. welding, observing the following procedure or, as an alternate, an Authority approved steel wire and re-roll method:

(1) Place fiber or steel filler strips in the core slots on top of the straight portion of the winding. These shall be rectangular in cross section with a width slightly less than the slot width, a height that will extend 3/16 inch above the core and a length equal to the core length. Tap the filler strips to insure that the coils are firmly seated in the slot. Temporarily hold them in place with string, tape or some other suitable banding.

(2) Apply two layers of Mylar tape, or equivalent, over both end coil extensions to prevent the temporary banding tape from adhering to the insulation.
(3) Preheat the armature at 150°C (302°F) for three hours.

**CAUTION:** APPLY THE TEMPORARY BANDING WHILE THE ARMATURE IS STILL HOT.

(4) Place the armature in an appropriate banding machine with a tensioning mechanism capable of maintaining the proper banding tension at all times.

**CAUTION:** DO NOT RELAX THE BANDING TENSION AT ANY TIME DURING THE APPLICATION OF THE TEMPORARY BANDING.

(5) Apply the temporary band using a tension of 400 pounds for 3/4 inch wide tape or 550 pounds for 1 inch wide tape. During banding, the coil extensions and filler strips may be pounded with a fiber mallet to seat high spots. The mallet surface shall be smooth and in good repair and the pounding operation shall not damage the insulation.

(6) Start the tape over the non-commutator end coil extension. Run off one turn and then start the overlap, adjusting the tension after 1 1/2 turns.

(7) Apply a minimum five layers of banding tape at full tension over the non-commutator end coil extension, with each layer half-lapped.

(8) Continue the banding onto the core, applying a minimum of five layers of banding tape at full tension over the core and filler strips, with each layer half-lapped.

(9) Continue the banding onto the commutator end coil extensions. Apply a minimum five layers of banding tape at full tension, with each layer half-lapped.

(10) Secure the end of the banding tape. Remove the armature from the banding machine and allow it to cool.
| l. | Perform a Commutator Press and Tighten Operation in accordance with the procedures specified in Section 3.4.6.6. |
| m. | Install the slot wedges observing the following procedure: |
|   | (1) Slot wedges shall be new and shall be made of N.E.M.A. Grade G11 glass laminate. Wedges shall be of a length and cross section as recommended by the Original Equipment Manufacturer. |
|   | (2) Remove the core slot filler strips by progressively opening the temporary glass banding over the core. |
|   | (3) Trim the slot U-pieces (cuffs) near the core surface with a sharp knife or scissors to a height where they will fully overlap when folded. |
|   | (4) Fold the tops of the U-pieces (cuffs) over the coil, making sure that they are fully overlapped. |
|   | **CAUTION:** THE SLOT WEDGES SHALL SLIDE FREELY IN THE CORE SLOTS BEFORE THE TOP FILLER STRIPS ARE INSTALLED BUT SHALL BE SUFFICIENTLY TIGHT TO FULLY CONFORM TO THE WEDGE GROOVE. |
|   | (5) Install top filler strips of a sufficient thickness of Nomex paper tape or polyester impregnated fiberglass sheet to force the coils tight in the direction of the slot depth when the wedges are installed. The strips shall be 0.020 inch narrower than the slot width to allow for sliding and approximately 3/8 inch longer than the core length on each end of the core. |
|   | (6) Apply several turns of glass adhesive tape around the top filler strip extensions and the coils outside the core to hold the insulation in position. |
|   | **CAUTION:** ALL SLOT WEDGES MUST BE TIGHT AND PROPERLY LINED UP IN THE SLOTS. |
(7) Starting with the commutator end of the core, drive the slot wedges in from both ends of the core, with the wedge lead-in slope pointing to the centerline of the core.

n. Machine off the coil leads flush with the face of the riser with a lathe. Mask off the top of the riser area and the ventilation area near the core to prevent chips from entering the connection areas.

o. Test the armature prior to T.I.G. welding the conductors to the risers observing the following procedure:

1. Hy-pot ground test the commutator and windings to the armature shaft per the requirements of Section 4.2.2 at 3,000 volts A.C., R.M.S., 60 Hertz, for 60 seconds. There shall be no breakdown indicated.

2. The windings shall be oscillograph surge comparison tested in accordance with the requirements of Section 4.2.3 to insure that the windings are free of electrical faults.

Any armatures that do not pass these tests shall be rejected.

p. T.I.G. weld the coil leads to the commutator riser in accordance with the following procedure, or an Authority approved procedure:

1. The coil leads must be clean and not tinned.

2. Remove all heavy burrs from the machined areas.

3. Place the armature in a vertical position. Welding shall be accomplished with the commutator risers in a horizontal position.

4. If applicable, install water cooled heat-sinks at the inside diameter of commutator riser and on the brush track adjacent to the riser. Set the water flow.

5. Position the carbon ground and attach the machine ground to fixture arm. Set up for 3/32 inch electrode and No. 4 shielding cup, set shielding gas at 15 C.F.H. and set the machine range setting at medium and D.C. straight polarity.
CAUTION: A CONTINUOUS WELD IS NOT PERMITTED.

(6) The welding shall be performed in a series of small spots, or puddles, so that the entire lead is welded to the commutator. The desired penetration is 0.030 inch. The spots, or puddles, shall be small enough to prevent welding adjacent bars together.

CAUTION: BE SURE TO WELD ONLY ON JOINTS WHICH ARE DIRECTLY BELOW THE CARBON GROUND. FAILURE TO DO SO MAY RESULT IN DAMAGE TO COMMUTATOR AND COILS.

(7) Starting with the inside row, weld only one lead per slot and skip five slots between welds.

(8) Next, weld the lead in the slots midway between the previously welded leads. Continue to divide the spacing and weld until the inside row is completed.

(9) Move to the second row and weld, using the same weld sequencing as with the first row. Progress with the same procedure, row by row until complete.

CAUTION: AT NO TIME SHALL THE TEMPERATURE RISE OF THE COMMUTATOR BE SUCH AS TO DAMAGE EITHER THE MICA, RESINS, BARS, ETC.; NOR SHALL ANY PART OF THE RISER BE ANNEALED.

(10) Maintain a continuous check of the temperature of commutator. If there is a noticeable increase in temperature, rotate the commutator 180 degrees and continue welding. If the temperature continues to rise, stop welding and let the assembly cool.

(11) Wire brush the risers to remove light welding smut.

(12) Perform a commutator bar-to-bar test on the armature following T.I.G. welding in accordance with the requirements of Section 4.2.4 to insure a proper joint.

(13) Oscillograph surge comparison test the armature following T.I.G.
welding in accordance with the requirements of Section 4.2.3.

(14) Any armature not passing these tests shall be rejected.

q. Vacuum Pressure Impregnate the armature in accordance with the requirements of Section 3.4.6.9.

r. Remove the temporary banding and Mylar tape and apply permanent banding to the armature assembly in accordance with the following procedure:

**CAUTION**: Steel banding to the proper diameter and tension shall be applied to the non-commutator end of the Type 5GE1264A1 traction motor.

**NOTE**: Banding tape shall be stored in a frost-free freezer compartment at a temperature as recommended by the tape manufacturer. Storage time shall not exceed six months. Materials should be allowed to warm to room temperature before package is opened to avoid moisture condensation. Partially used rolls should be resealed in a polyethylene bag and placed in cold storage.

(1) Insure that the armature coils are fully pulled down and seated.

(2) Pre-heat the armature to 150ºC (300ºF) for four hours prior to starting the banding operation.

(3) Fill area behind the commutator risers to where the top coil leg leads enter the diamond area of the coil with a thermosetting, 2-component polyester compound.

**CAUTION**: APPLY THE PERMANENT BANDING WITHIN ONE-QUARTER HOUR AFTER REMOVAL FROM THE OVEN. AT NO TIME DURING BANDING SHALL THE ARMATURE CORE FALL BELOW 110ºC (250ºF).
(4) Place the armature in an appropriate banding machine with a tensioning mechanism capable of maintaining the proper banding tension at all times.

(5) Place beaded edge restraints on the area to be banded. The bead edges shall be accurately positioned such that the edge of the glass band will present a nearly perpendicular appearance to the axis of the armature. The beaded edge restraint adjacent to the core shall be fitted up against the slot wedges. The beaded edge restraint adjacent to the commutator shall be applied over the riser by 1/4 inch. The length of the edge restraints shall be such that the ends are as closely butting as possible. Terminate the edge restraint and pull tight with the aid of acrylic adhesive glass tape, smoothing out all wrinkles.

**CAUTION:** DO NOT ALLOW BANDING TAPE TO CONTACT THE COMMUTATOR RISER AREA WITHOUT THE BEADED EDGE RESTRAINT BEING IN POSITION. THE SHARP EDGES OF THE COMMUTATOR RISER WILL CAUSE THE TAPE TO TEAR WHEN UNDER TENSION.

**CAUTION:** DO NOT RELAX THE BANDING TENSION AT ANY TIME DURING APPLICATION OF BANDING.

**CAUTION:** THE BANDING AND EDGING SHALL NOT EXCEED THE CORE OUTSIDE DIAMETER.

(6) The minimum number of turns of banding tape required on each end of the armature shall exceed that required by the Original Equipment Manufacturer. The banding shall be able to resist the bursting force present at 2 1/2 times the rated speed of the motor.

**CAUTION:** BAND THE NON-COMMUTATOR END OF THE ARMATURE FIRST.

(7) Band the armature with 0.015 inch thick Class H polyester resin impregnated, thermosetting non-woven fiberglass banding tape of the appropriate width. Apply the required number of layers of banding tape, evenly distributed across the band width. Apply the first turn at
200 pound tension commencing at the core end of the band. The second turn shall be placed over the first at a slight angle to prevent slippage. After full tension has been attained, the tape shall be wrapped evenly, uniformly and smoothly at the proper tension across the width of the band. The height shall be kept level. The application tension shall be as follows:

<table>
<thead>
<tr>
<th>Tape Width (Inches)</th>
<th>Application Tension (Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8</td>
<td>225</td>
</tr>
<tr>
<td>3/4</td>
<td>400</td>
</tr>
<tr>
<td>1</td>
<td>500</td>
</tr>
</tbody>
</table>

(8) If the surfaces of the coils do not present an even surface, start banding in the low area and level the surface as the tape is being applied. Low areas shall be filled with small pieces of banding tape to level the bands. This will prevent overloading and breaking the outside strands of tape.

(9) A near uniform cross section shall be maintained and thin flange-like edges shall be avoided. The wind angle shall be maintained as close to perpendicular to the armature shaft center line as possible and the banding tape shall not be allowed to bunch or crawl up the edges of the welting.

(10) Terminate the band by heating the tape with a flat iron, soldering iron or industrial hot air gun while maintaining tension.

(11) Trim all excess tape, loose fibers and strands from core and end turns.

(12) Tightly wrap a few layers of heat shrinkable thick Mylar tape over the banded areas and secure with fiberglass adhesive tape.

(13) Fully cure the banding by baking the armature for five hours at 150°C (302°F) after the armature has reached oven temperature, or at a temperature and time recommended by the banding tape manufacturer to fully cure the banding.
(14) After curing the banding, remove the Mylar film from the banding areas while the armature is still warm.

s. Insure that the core slot situated over the keyway is identified in accordance with the requirements of Section 3.4.6.3.g(16).

t. Vacuum Pressure Impregnate the armature and apply a varnish immersion treatment to the armature in accordance with the procedures specified in Sections 3.4.6.9 and 3.4.6.10 respectively.

u. Insure that the armature serial number is stamped on the end of the shaft and in the shaft coupling keyway in 1/8 inch high legible letters. Mark the armature serial number and the core keyway location, if applicable, on the non-commutator end band in accordance with the requirements of Sections 3.4.6.10.h and 3.4.6.10.i.

v. Apply the epoxy or Teflon V-Ring creepage band in accordance with the OEM procedures.

w. Verify the commutator surface in accordance with the procedures specified in Section 3.4.6.2.

x. Balance the armature assembly in accordance with the procedures specified in Section 3.4.6.11.

y. Spin season the commutator in accordance with the procedures specified in Section 3.4.6.7.

z. Test the armature in accordance with the procedures specified in Section 3.4.8, except that the Polarization Index shall be 3.0 or greater. Any armatures that do not pass these tests shall be rejected.

aa. Wrap the commutator with a suitable protective material such as heavy multi-layered paper or felt.

### 3.4.6.4 Armature Shaft Repair

Repair the armature shaft observing the following:
a. Hand-dress and repair any light nicks, scores and damages areas that can be effectively repaired.

b. If the shaft is slightly bent and can be straightened without damage to the armature and windings, mount the armature on wooden blocks under the bearing journals and press midway between the journals to bring the shaft F.I.R. within limits. If the shaft cannot be straightened, or if the bearing journals, coupling taper seat or spline, if applicable, are severely damaged or undersize, replace the shaft as Extra Work in accordance with the procedures of Section 3.5.2.

c. If the coupling seat can be restored to the proper taper fit without exceeding the dimensional tolerances of the Original Equipment Manufacturer, restore the surface by resurfacing and grinding.

d. All external and internal threads shall be chased and cleaned. Hydraulic assist holes and passages, if any, shall be cleaned.

e. Polish the bearing journals and coupling taper seat with crocus cloth or steel wool. The surface finish shall be 16 micro inches RMS or better.

f. Scrape the shaft centers as necessary to achieve the requirements of Section 3.4.5.2.f.

g. Insure that the armature serial number is present and legible on the end of the shaft and in the shaft coupling keyway, if applicable. Restamp as necessary using 1/8 inch high letters. Missing serial numbers shall be assigned by the Authority. Any other number on the shaft shall be ground off.

3.4.6.5 Fan Repair

If inspection revealed a defective or damaged fan, repair or replace it observing the following:

(a) Radial cracks, up to 3/4 inch in length, and dents on the fan surface shall be repaired, as approved by the Authority. Cracks shall be welded providing the cracks did not originate from aging, improper heat treatment or chemical composition of the material.
(b) If a damaged fan cannot be economically repaired, it shall be replaced with a new fan, as extra work.

(c) New and repaired fans shall be dynamically balanced in accordance with the requirements of Section 3.4.6.11.

3.4.6.6 Commutator Press and Tighten

Perform a Commutator Press and Tighten Operation on each armature as part of the Basic Work in accordance with the following procedure:

CAUTION: THE FOLLOWING TEMPERATURES SHALL NOT BE EXCEEDED:

- CORE: 200°C (392°F)
- COMMUTATOR: 200°C (392°F) AS MEASURED ON THE BRUSH SURFACE

a. Place the armature in an oven and heat it to 150°C (302°F). Measure the commutator temperature with a pyrometer.

NOTE: If the temperature has dropped to below 125°C (257°F) just before the Commutator Press and Tighten Operation, reheat the armature so that the commutator temperature during the operation will be between 125°C (257°F) and 150°C (302°F).

NOTE: If the armature is to be rewound, the Commutator Press and Tighten Operation is to be done immediately following the installation of the temporary banding per Section 3.4.6.3.n.

b. Place the armature in a vertical position on a press platform.

c. Remove the tack welds, on the V-ring and nut, if any.

d. Place appropriate tightening tools on the commutator V-ring nut.

e. Apply a force to the commutator V-ring. Actual tonnage to be in accordance with Original Equipment Manufacturer's requirements.
f. Tighten the commutator V-ring nut and check its movement using a scribe line as an index. Actual torque to be in accordance with Original Equipment Manufacturer's requirements.

g. If the nut moves more than 10 degrees circumferentially, repeat steps a through f.
   NOTE: If the V-ring nut does not move at all, loosen it and re-tighten it to insure that it is not seized or locked in place.

h. If the V-ring nut moves 10 degrees or more circumferentially on the second heat, press and tighten cycle, replace the commutator in accordance with the requirements of Section 3.5.3 to prevent undue stress from being exerted on the armature coils behind the riser area.

i. If the V-ring nut has moved, spin season the commutator in accordance with the procedures of Section 3.4.6.7.

3.4.6.7 Commutator Spin Seasoning

The commutator shall be spin seasoned, without fan installed, in accordance with the following procedure (refer to Table 3.2 for spin seasoning speeds) and as approved by the Authority:

**WARNING:** PLACE A HEAVY-DUTY PROTECTIVE SHIELD OVER THE ARMATURE IN THE EVENT OF A COMMUTATOR OR COIL FAILURE.

<table>
<thead>
<tr>
<th>Armature Manufacturer</th>
<th>Basic Speed (RPM)</th>
<th>Running Speed (RPM)</th>
<th>Heating Speed (RPM)</th>
<th>Maximum Speed (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE</td>
<td>1264</td>
<td>6,400</td>
<td>3,600</td>
<td>6,400</td>
</tr>
<tr>
<td>Westinghouse</td>
<td>1432</td>
<td>5,000</td>
<td>3,600</td>
<td>5,000</td>
</tr>
<tr>
<td>Westinghouse</td>
<td>1460</td>
<td>6,500</td>
<td>3,600</td>
<td>6,500</td>
</tr>
</tbody>
</table>

**NOTE:** If not shown above, the contractor shall contact the armature
manufacturer or the commutator manufacturer to determine the correct speeds. The contractor shall forward this information to the Authority when is has been obtained.

**CAUTION:** THE FOLLOWING TEMPERATURES SHALL NOT BE EXCEEDED:

- CORE - 200°C (392°F)
- COMMUTATOR - 200°C (392°F) AS MEASURED ON THE SURFACE

**CAUTION:** THE ARMATURE SHOULD BE PROPERLY BALANCED PRIOR TO THE SPIN SEASONING OPERATION.

a. Place the armature in an Authority approved spin seasoning machine and support it by bearings applied to its bearing journals.

b. Measure the concentricity of the commutator in each brush track while slowly turning the armature. Full Indicator Run out (F.I.R.) at slow roll shall comply with the following requirements. Record the measured run outs for each brush track.

Support the armature on its bearing journals and check the commutator with a 0.0001 inch per division dial indicator in accordance with the following requirements:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Run out (Maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Indicator Run out</td>
<td>0.0005 Inch</td>
</tr>
<tr>
<td>Bar-to-Bar Variation</td>
<td>0.0002 Inch</td>
</tr>
<tr>
<td>Variation within any 20-bar group</td>
<td>0.0004 Inch</td>
</tr>
</tbody>
</table>

In addition, there shall be no more than one high spot and one low spot per revolution.

c. Measure and record the commutator diameter.
d. Operate the armature at its "Running Speed" at a temperature between 40ºC and 50ºC (104ºF to 122ºF) for 30 minutes.

e. Heat the commutator to 155ºC to 165ºC (311ºF to 329ºF) while operating the armature at its "Heating Speed".

f. Maintain the temperature at 155ºC to 165ºC (311ºF to 329ºF) for 30 minutes, while operating the armature at its "Heating Speed."

g. While operating the armature at its "Running Speed", turn off the heat and cool the commutator with compressed air to a temperature between 40ºC and 50ºC (104ºF and 122ºF).

h. Turn off the compressed air and continue operating the armature at the "Running Speed" for 15 minutes.

i. Repeat Steps e through h two more times for a total of three cycles. On the last cycle, operate the armature at its "Running Speed" and check for high bars and commutator eccentricity. The commutator should be smooth by feel.

j. Press and tighten commutator in accordance with the requirement of Section 3.4.6.6. If the V-ring nut moves more than 10 degrees circumferentially, replace the commutator in accordance with the requirements of Section 3.4.6.2, as approved by the Authority.

k. Tack weld the V-ring nut to the V-ring.

l. Measure and record commutator concentricity as in Step b above. If the specified limits are not met, replace the commutator in accordance with the requirements of Section 3.4.6.2.

m. Scribe or engrave, in 1/8 inch high characters, on the V-ring nut the date that the spin seasoning operation was completed. Eliminate old markings, if any.

3.4.6.8 Commutator V-Ring Creepage Band Replacement

Replace the Commutator V-Ring Creepage Band with a thermopoxy band in accordance with the following procedure:
a. Place the armature in an appropriate rotating device such as a banding machine or lathe.

**CAUTION:** TAKE EXTREME CARE TO AVOID DAMAGING THE MICA INSULATION.

b. Carefully remove the old creepage band and string banding from the mica V-ring extension if not already done.

c. Clean the mica with fine abrasive paper, Grit No. 320 or equivalent.

d. Clean any carbon dust or other particles from the mica V-ring and remove any paint or varnish from the ends of the commutator bars.

e. Seal the gap between the commutator bars and the mica V-ring with a continuous bead of R.T.V. Silastic adhesive/sealant.

f. Coat the mica V-ring with a solventless epoxy varnish.

**CAUTION:** THE GLASS CORD SHOULD BE KEPT UNDER TENSION AT ALL TIMES.

g. Place 1/16 inch polyester impregnated glass cord (string band) onto the mica surface by rotating the armature in a direction away from the winder. Apply the first turn of the cord on the V-ring extension directly against the commutator bars with a short start section of cord extending at right angles toward the outer part of the V-ring extension. Run the cord in several parallel turns over the short section to lock the first turn in place and cut off the excess of the short section. Continue running parallel turns, using 20 to 30 pounds tension up to a short distance from the end of the mica. Place a loop of cord on the banding with the closed end extending past the mica. Continue applying the parallel turns over the loop until the end of the mica is reached. Cut the cord and insert the end through the loop. Pull the loop and cord under the last few turns to lock the cord tightly in place.

h. Coat the string band with a thermosetting epoxy varnish using a brush and bake at 150°C (300°F) for 4 hours minimum.

i. Remove the armature from oven and allow to cool to 65°C to 95°C (150°F to 200°F), then place in a rotating device.
j. Lightly sand the string band surface with abrasive paper, Grit No. 320 or equivalent, in order to roughen the surface for better adhesion of thermopoxy and also to remove any excess epoxy.

**CAUTION:** THE THERMOPOXY COMPOUND SHALL BE MIXED IN SUFFICIENT QUANTITY FOR APPLICATION TO ONE ARMATURE. EACH MIXTURE SHALL BE MADE IN NEW CONTAINERS, UTILIZING NEW APPLICATORS, AND SHALL BE MIXED IMMEDIATELY PRIOR TO EACH APPLICATION.

k. Mix the thermopoxy compound, 100 parts by weight of Sterling U-953 Neutral thermopoxy resin with 14 parts by weight of C-12A catalyst.

l. With armature rotating at approximately 120 R.P.M. (or at a speed fast enough to prevent the thermopoxy from running off the bottom of the band) apply the thermopoxy compound to the band surface, using a brush. When a uniform buildup is achieved (1/32 inch minimum) stop brushing and continue rotating the armature until the thermopoxy cures.

**NOTE:** The thermopoxy surface shall be fully cured and shall have a smooth, shiny, glasslike surface totally devoid of high spots, voids and depressions. It shall fully cover the glass cord and shall seal the edges of the commutator bars at a point below the bar mica level.

m. Remove the armature from the rotating device and allow it to cool.

3.4.6.9  Armature Vacuum Pressure Impregnation

After all repairs on the armature have been completed, it shall be Vacuum Pressure Impregnated in an approved solvent-less Class H polyester varnish in accordance with the following procedure:

**CAUTION:** USE CLEAN, DRY AIR ONLY.

a. Thoroughly clean the armature assembly by removing dust and all other foreign particles. Use low air pressure when blow cleaning, full air system pressure may wedge particles in inaccessible places.
b. Coat all machines surfaces, bearing surfaces and other areas where varnish must be later removed with a masking varnish or a release agent. Plug any threaded holes in the ends of the shaft with a silicone sealant or dummy bolts with 0-rings to keep varnish out of the threads.

c. Vacuum-Pressure Impregnate the armature assembly with solventless polyester varnish observing the following:

(1) Preheat the armature assembly by placing it in a baking oven for 6 hours at a temperature between 170ºC and 180ºC (338ºF and 356ºF).

**CAUTION:** THE ARMATURE TEMPERATURE SHALL NOT BE ALLOWED TO FALL BELOW 40ºC (104ºF), TO AVOID GELLING OF VARNISH.

(2) Remove the armature assembly from the baking oven and allow it to cool down to a temperature between 40ºC and 60ºC (104ºF and 140ºF).

(3) Place the armature assembly in a vacuum chamber in a vertical position with the commutator end up.

**CAUTION:** IF THE FINAL PRESSURE IS ABOVE 3,000 MICRONS, DO NOT CONTINUE UNTIL AN ADEQUATE VACUUM IS OBTAINED.

(4) Subject the armature assembly to a dry vacuum of 3,000 microns (3.0 millimeters) of mercury, or less, for not less than 30 minutes. Record the vacuum readings at the beginning and end of the dry vacuum cycle.

(5) While still under vacuum, transfer the varnish from the holding tank to the work tank until the commutator risers are covered. The varnish level shall not exceed 1/4 inch above the face of the risers.

(6) After the varnish has been admitted to the tank, hold the tank vacuum at 3,000 microns, or less, for 30 minutes or until all bubbling of the varnish has ceased and the varnish surface is calm, whichever is longer.
(7) Break the vacuum with dry nitrogen gas or clean, dry air to about 20 inches of mercury.

(8) When 20 inches of mercury is obtained, shut off the nitrogen or air supply and open the work tank bleed valve to bring it to zero pressure. Close the bleed valve.

(9) Pressurize the work tank with nitrogen or dry air to between 90 and 100 psig. Hold the pressure for a minimum of one hour.

(10) Release the work tank pressure and transfer the varnish into the holding tank.

(11) Allow excess varnish to drain from assembly for 10 minutes.

(12) Remove the armature from the work tank, place it in a horizontal position and wipe off the shaft and balance grooves in rear coil support, with a rag dampened with Xylene solvent.

**CAUTION:** THE ROLL-BAKING OPERATION AT TEMPERATURE MUST COMMENCE WITHIN 20 MINUTES FROM THE TIME THE VARNISH WAS RETURNED TO THE STORAGE TANK.

(13) Place the armature in a "rotisserie" and roll-bake it at a rate sufficient to prevent the varnish from running for a minimum of two hours at a temp. of 150°C to 160°C (302°F to 320°F), until the varnish semi-cures.

**CAUTION:** USE EXTREME CARE TO AVOID DAMAGING THE VARNISH COATING AND THE GLASS BANDING.

(14) Clean any excess build-up of varnish from the armature core and banding with a scraper or squeegee after the armature has been roll-baked for about 45 minutes.

(15) Remove the armature from the rotisserie unit, turn it vertical with commutator up and place it in a pre-heated baking oven.

(16) Bake the armature to a fully cured state for a minimum of six additional hours at a temperature of 150°C to 160°C (302°F to 320°F), or at a
temperature and time as recommended by the varnish manufacturer.

3.4.6.10 Armature Varnish Immersion Treatment

Following the Vacuum Pressure Impregnation process, apply an epoxy varnish immersion treatment to the armature, observing the following:

**CAUTION:** DO NOT CLEAN PREVIOUSLY PROTECTED MACHINED SURFACES AND THREADS BEFORE VARNISH TREATING.

a. Preheat the armature assembly in a baking oven in a vertical position, at a temperature of 140°C (284°F) for at least five hours.

**NOTE:** The preheat step may be combined with step 3.4.6.9.c(16) above.

b. Remove the armature assembly from the baking oven and allow it to cool to a temperature between 40°C and 60°C (104°F and 140°F).

c. Immerse the armature assembly in a vertical position, commutator end up, in an approved thermosetting epoxy varnish for about 20 minutes.

d. Lift the armature assembly out of the varnish and spin it until the excess varnish is removed.

e. Roll-bake the armature to a fully cured condition for a minimum of six hours at a temperature of 150°C to 160°C (302°F to 320°F).

f. Remove the armature from the oven and allow it to cool. Strip and remove the masking varnish film, release agents, sealants and dummy bolts. Clean the shaft with Xylene.

g. Check the tops of the commutator riser slots to see if the fiberglass band is completely sealing the space behind the risers. If sealing is not complete, seal by filling only the slot space beneath the band with R.T.V. Silastic adhesive/sealant. Clean any varnish from commutator slots.

h. Mark the armature serial number on the non-commutator band in one inch high letters using an indelible black marker.
i. If applicable, mark the core keyway location with an "X" on the non-commutator band using an indelible black marker (refer to Section 3.5.1.g(16)).

3.4.6.11 Armature Balancing

After all repair work has been completed, each armature and fan shall be separately dynamically balanced at a rotational speed as recommended by the balancing machine manufacturer (approximately 1,000 R.P.M.) in accordance with the following procedure:

**NOTE:** Static balancing is not acceptable.

a. Insure that the fan, whether repaired or not, was separately dynamically balanced. The maximum permitted fan dynamic unbalance is 0.03 ounce-inch. Fan balance shall be effected by milling the correct amount of material from the inboard shroud of the fan. Any screws or balance weights on the fan shall be removed prior to balancing the fan.

b. The armature, without fan attached, shall be supported on its bearing journals and balanced in an Authority approved balancing machine.

**NOTE:** Armatures with shaft keyways shall be filled with half-keys during the balancing operation.

**CAUTION:** BALANCING THE ARMATURE BY ADDING SCREWS OR WEIGHTS TO THE FAN, WHEN ATTACHED, IS STRICTLY PROHIBITED, UNLESS SPECIFICALLY REQUIRED BY THE ORIGINAL EQUIPMENT MANUFACTURER AND APPROVED IN WRITING BY THE AUTHORITY.

c. Remove all existing balance weights, if not already done.

d. Balance the armature at the Commutator End and the Non-Commutator End by adding balance weights to the areas specified by the Original Equipment Manufacturer. The maximum permitted dynamic unbalance allowed is:
Commutator End: 0.4 ounce-inch, or 1 gram
Non Commutator End: 0.5 ounce-inch, or 2 grams

e. Any areas where balance weights are welded in, such as inside the commutator cap or the armature head, shall be thoroughly cleaned, primed and finish painted.

f. The original balance report shall be supplied to the Authority with the finished armature.

3.4.7 Reassembly

Assemble the fan to the armature using new fasteners.

3.4.8 Final Inspection and Test

This section specifies the acceptance testing and inspection to be conducted by the Contractor on each motor armature to determine its suitability for delivery to the Authority. Only those armatures that meet all the requirements established herein shall be accepted by the Authority; any discrepancies shall be cause for rejection.

The tests shall be conducted in accordance with the procedures contained herein and test results shall be recorded in black ink on the Final Test Report (Appendix C, 10.2). The originals of completed Final Test Report shall be directly forwarded to the Authority's Manager of Equipment Engineering and Quality Assurance and a copy shall accompany the armature when delivered to the Authority.

3.4.8.1 Pre-Test Inspection

Prior to the start of the tests, each armature shall be examined for completeness of work, cleanliness and finish conditions.

3.4.8.2 Insulation Resistance Test

Measure armature insulation resistance with a megohm meter. Test all bars to the shaft at 1,000 volts D.C. for 60 seconds. The resistance measured, corrected to 25°C (75°F), must be ten megohms minimum.
3.4.8.3 Polarization Index Test

Perform a Polarization Index Test at 1,000 volts D.C. in accordance with the procedure of Section 4.2.1. The Polarization Index shall be 2.0 or greater.

3.4.8.4 Dielectric Test

Perform a high-potential commutator-to-ground dielectric test, at 2500 volts A.C., R.M.S., 60 Hertz, in accordance with the procedure of Section 4.2.2.

3.4.8.5 Armature Winding Tests

Oscillograph surge comparison test the armature windings in accordance with the requirements of Section 4.2.3 to insure that the windings are free of electrical faults.
Measure the bar-to-bar resistance in accordance with the procedure of Section 4.2.4.

3.4.8.6 Post-Test Inspection

Re-examine each armature prior to shipping. Insure that all data requirements have been completed and recorded and that all values are within specified values. Any deviations from the limits specified shall be cause for rejection.
Wrap the commutator with a suitable protective material such as heavy multi-layered paper or felt.

3.5 EXTRA WORK

As part of the Basic Work required on all armatures, the Contractor shall determine what additional work, or Extra Work, is required to completely rebuild and remanufacture the traction motor armatures to an essentially as-new condition. Such Extra Work shall be approved by the Authority prior to commencement of the work. The work shall be performed in accordance with the requirements and procedures established herein. Procedures for Extra Work that are not included or complete herein shall be approved by the Authority. Additional work will be authorized on a case by case basis with the cost not to exceed that charged to other United States Transit Properties for similar work. The cost of the shaft replacement will not exceed 20% of the contract price for basic work.
3.5.1 Armature Shaft Replacement

If inspection revealed any damage to the armature shaft, coupling tapered seat, bearing journals or splines that cannot be repaired by hand dress or polish, replace the shaft in accordance with the following procedure:

**CAUTION:** THE FIXTURE SHALL GRIP AND SUPPORT THE ARMATURE ASSEMBLY ON THE COMMUTATOR SHELL AND ON THE COIL SUPPORT ON THE OPPOSITE END AND SHALL NOT DAMAGE THE ASSEMBLY.

a. Place the armature assembly in a fixture suitable for maintaining the proper alignment of the armature coils, core and commutator when the shaft is removed.

b. Press the shaft out of the armature assembly from the commutator end. Use hydraulic assists if applicable.

c. Lightly coat the appropriate diameters of the shaft with a suitable lubricant.

d. Replacement shafts shall be made from A.I.S.I. A-4140 steel, heat treated to 28 to 32 HRC, and shall be machined in accordance with the Original Equipment Manufacturer's dimensions for a new shaft.

e. Insert and press in the new shaft from the end opposite of the commutator. Replace any spacer rings, if required. Replace the shaft key if it was damaged during removal of the shaft, if applicable.

f. Stamp the armature serial number on the end of the shaft, in the location prescribed by the Original Equipment Manufacturer, and in the shaft coupling keyway, if applicable, in 1/8 inch high legible letters. The serial number shall be the same as on the removed shaft and shall be of the form "S/N xxxxxx."

g. Inspect the commutator in accordance with the requirements of Section, 3.4.6.7 and 3.4.6.8

h. Re-balance the armature assembly in accordance with the requirements of Section 3.4.6.11.
4.0 QUALITY ASSURANCE PROVISIONS

4.1 QUALITY ASSURANCE PROGRAM

4.1.1 General Requirements

The Contractor shall be responsible for providing a quality product to the Authority under this contract.

The Contractor must be certified to one or more of the following Quality Assurance standards at the time of the award and maintain such certification for the duration of the contract:

ISO 9001:2008
AAR M-1003

To this end, the Contractor shall plan, establish and execute a one of the required Quality Assurance Programs, which shall be maintained throughout the duration of the Contract. The elements of the Quality Assurance Program shall be imposed on all elements of the Contractor's organization and on all manufacturers, vendors, suppliers and subcontractors that perform work or supply parts and materials under this Contract.

4.1.2 Quality Assurance Program Certification

The Contractor shall submit a copy of their Quality Assurance Program Certification for this Contract to the Authority as part of their proposal for review and approval.

Contractor will submit one of the following:

Association of American Railroads (AAR) Quality Assurance Program Certificate
ISO 9001:2008 Certification from a Certification Body that is accredited by the ANSI-ASQ National Accreditation Board (ANAB)
4.1.3 Organization

The organization of the Contractor's Quality Assurance Program shall be clearly defined. Quality assurance personnel shall have sufficient, well-defined responsibility and organizational freedom to identify and evaluate quality problems, to initiate, recommend or provide solutions, to verify implementation of solutions, and to control further processing, delivery or installation of a nonconforming or deficient item until proper disposition has been obtained. The personnel or organization responsible for the implementation and administration of the Quality Assurance Program shall insure that schedules and costs do not compromise quality and shall have direct contact with the Contractor's management at a level where appropriate action can be taken. Management responsibility for the Quality Assurance System shall be set forth on the Contractor's policy and organization chart and the responsibility for the Quality Assurance Program shall be so placed that schedules and costs will not compromise quality.

4.1.4 Procedures Manual

Prior to the commencement of any work under this Contract, the Contractor shall prepare and submit to the Authority for approval three copies of a detailed Quality Assurance and Procedures Manual which the Contractor shall utilize and follow for execution of all phases of work under this Contract. The manual shall encompass all phases of the Contractor's Quality Assurance Program and shall include, but not be limited to: control of procurement, control of subcontractors, receiving inspection, production and process control, in-process inspection, functional testing, discrepancy control, measuring and test equipment calibration/certification, drawing control, configuration control, quality assurance records, shipping inspection and other quality specifications to meet the requirements of the Contract. In addition, all implementing and referenced manuals, personnel qualification and work methods, work instructions, quality control methods, work forms and data sheets, acceptance/rejection criteria, material listings, sources of supply for parts and material, codes, standards, manufacturing process and test procedures shall be included. This manual shall be updated and revised as necessary throughout the duration of the Contract.

4.1.5 Drug and Alcohol Free Workplace Requirement

The Contractor, Contractor's employees, vendors, visitors, and volunteers are to
be free of the effect of drugs, alcohol, controlled substances or other prohibitive substances when they are on MBTA property or performing MBTA business. In addition, all referenced parties are prohibited from using, possessing, selling or distributing any drugs, alcohol, controlled substances or other prohibited substances when they are on MBTA property or performing MBTA business. It is the responsibility of the Contractor to advise its employees of this requirement and to ensure that its employees meet this "fitness for duty" standard. Violators of this policy will not be allowed to remain on MBTA property or to continue conducting business for or with the MBTA. The Contractor will submit to the Authority within thirty (30) days of a Drug and Alcohol violation, a written report documenting the actions taken with regard to any of its employees who violate this policy. The Contractor will accept all liability arising from violation of this policy by his/her employees.

4.2 TEST METHODS AND PROCEDURES

The following test methods and procedures shall be applicable to the extent necessary to determine the condition of the armature. The Contractor shall have in his possession all test equipment sufficient for performing these tests and shall keep such equipment fully calibrated.

4.2.1 Polarization Index Test

Perform the Polarization Index Test in accordance with the following procedure:

a. Measure insulation resistance for a ten minute period with a megohmmeter.

b. Record the resistance reading after one minute and after ten minutes.

c. Divide the ten minute resistance reading by the one minute reading. The ratio thus obtained is the Polarization Index.

4.2.2 Alternating Current High-Potential Test

Perform a high-potential commutator-to-ground dielectric test, observing the following procedures:

CAUTION: THIS IS A DESTRUCTIVE TEST. THE UNIT UNDER TEST
SHALL HAVE A MINIMUM INSULATION RESISTANCE VALUE OF FIVE MEGOHMS BEFORE PROCEEDING.

a. Wrap the commutator surface with several turns of bare, clean copper wire.

b. Connect one lead of the tester to the copper wire and the other end to the motor shaft.

**CAUTION:** THE TEST VOLTAGE SHOULD NEVER BE APPLIED TO THE UNIT UNDER TEST BY SWITCHING FROM OFF TO FULL TEST VOLTAGE OR FROM FULL TEST VOLTAGE TO OFF IN ONE STEP.

c. Energize the tester and slowly increase the voltage from zero to the full test voltage, at about 150 volts per second. Maintain the test voltage for 60 seconds. Then gradually reduce the voltage to zero, at about 150 volts per second.

d. There shall be no disruptive discharges or breakdowns indicated. Leakage current shall not exceed 10 microamperes after the full test voltage being applied for 60 seconds.

### 4.2.3 Oscillograph Surge Comparison Test

Oscillograph surge comparison tests shall be performed as indicated to insure that the armature is free of any commutator bar-to-bar and coil turn-to-turn electrical faults. The tests shall be conducted in accordance with the procedures specified by the test equipment manufacturer for the application and as approved by the Authority. The applied bar-to-bar test voltage shall be 400 volts. Alternative test methods to achieve the same results shall be approved by the Authority.

### 4.2.4 Bar-to-Bar Resistance Test

Bar-to-bar resistance measurements shall be conducted with a low-resistance, high-current micro ohmmeter or a "Ductor" test set as supplied by James G. Biddle Co., Plymouth Meeting, Pennsylvania. The readings shall not vary more than 5 percent from each other.
4.2.5 Core Loss Test

Perform the core loss test using a Lexeco Inc. model 1081B Core Loss Tester, or an Authority approved equal. The tester shall incorporate instrumentation and computer programming that will print out the core condition along with the numerical values of pertinent test parameters and the part number and serial number of the unit under test. The original of the print-out shall be attached to the Final Inspection and Inspection Report.

The Lexeco Tester will define the maximum watts/pound lose when the core parameters are entered. Follow the Lexeco recommendations.

If such a core loss tester is not available, the contractor may, with Authority approval, use the following alternate test methods, the detailed procedures of which shall be approved by the Authority.


(1) Place an appropriate number of turns of insulated wire through the armature ventilation core slots to attain a flux density of approximately 80 kilo lines per square inch within the armature core. The wire should be sized for a nominal current level of 20 amperes and a voltage of 220 volts A.C.

(2) Connect the cable turns to a current regulated power supply with an output voltage of 220 volts A.C. at 60 Hz.

**CAUTION**: THE CURRENT SHOULD BE APPLIED CAUTIOUSLY AT THE START AND THE CORE QUICKLY CHECKED BY FEEL FOR SIGNS OF OVERHEATING.

(3) Adjust the power supply to achieve a current flow through the cable turns of approximately 15 amperes at 220 volts A.C. at 60 Hertz.

(4) Change or adjust the number of cable turns through the core ventilation slots as required to obtain an average core temperature of 27ºC to 38ºC (80ºF to 100ºF).
NOTE: If the average core temperature is too low, remove two turns at time and recheck the average temperature. If the temperature is too high, add two turns at a time and recheck the average temperature.

(5) Apply the current for a minimum of 40 minutes, checking frequently for any hot spot indications with the palm of the hand or with an infra-red detector.

(6) At the end of the time period, check for hot spots in the core with an infra-red detector. Hot spot temperatures shall not be more than 15°C (60°F) above the average core temperature. If the hot spot temperatures exceed this value, the armature shall be restacked with new laminations in the area of the hot spots following the procedures in Section 3.5.1.g.

b. Method B ("General Electric" Method)

(1) Solidly connect a lead of a high current 60 Hz alternating current power supply to each end of the armature shaft.

(2) Adjust the power supply output voltage to achieve a current flow of 200 amperes.

(3) Follow step (5) as for Method A above.

(4) Follow step (6) as for Method A above.

4.3 RESPONSIBILITY FOR INSPECTION AND TEST

Unless otherwise specified herein, the Contractor is responsible for the performance of all inspections and testing required herein and that are required to insure a quality product. The Authority reserves the right to perform, and/or have the Contractor perform under Authority supervision and witness, any of the tests and inspections specified herein, or any other tests and inspections not specifically specified herein, where such tests and inspections are deemed necessary by the Authority to insure that the repaired items conform to the prescribed requirements.
4.4  AUTHORITY ACCESS TO WORK

The Authority shall have the right to witness and/or inspect any and all work, processes, methods, parts, materials, equipment, workmanship and tests that are furnished or used by the Contractor for this Contract and may reject, without cost or liability to the Authority, any of such that, in the opinion of the Authority, is defective or unsuitable for the use and purpose intended. The Contractor, at his own expense, shall reconstruct, replace or correct, as the case may be, any such defective or unsuitable items and work.

The presence of an Authority representative shall in no way alleviate the responsibility of the Contractor to perform such inspections, of both his product and processes and those of his subcontractors and vendors. In addition, such Authority inspection shall not relieve the Contractor of his responsibility to perform the overhaul and repair work in a quality manner in accordance with the requirements of the Specification and shall not prejudice any claim, right or privilege that the Authority may have under the guarantees.

Representatives of the Authority shall be permitted full and free access to the Contractor's facilities, as well as those of his subcontractors and vendors. The Contractor shall furnish such facilities and give such assistance for inspection as the Authority's representative may require, at no cost to the Authority.

4.5  QUALIFICATIONS OF BIDDERS

Each Bidder shall meet the following qualifications at the time of submittal of his proposal and evidence of such qualification shall be included as part of that proposal.

a. The Bidder shall have demonstrated skill and successful experience in the manufacture or repair of traction motor armatures and armature coils for mass transit (subway/surface/rapid transit) applications.

b. The Bidder shall have re-manufactured or repaired at least 150 traction motor armatures for mass transit applications for a minimum of three years.

c. The traction motor armatures re-manufactured or rebuilt by the bidder shall have been in successful operation since their rebuilding.

d. The Bidder shall operate a plant adequately equipped and stocked and of sufficient capacity to properly and efficiently perform the work specified herein.
within the time specified and shall have in his possession all special equipment required for this contract.

e. The Bidder shall state in his proposal the location where the work will be performed, including the location of any subcontracted work.

f. The Bidder shall have ample financial resources to effectively and reasonably meet all Specification obligations and requirements for the work specified herein.

g. The Bidder will submit Quality Assurance Certificates as specified in section 4.1.1

5.0 PREPARATION FOR DELIVERY:

5.1 GENERAL REQUIREMENTS

Following repair and final inspection and test, each armature shall be prepared for shipment in accordance with the following requirements:

a. Armatures shall be sealed in a moisture barrier bag with sufficient desiccant to allow for 2 years of storage without any significant corrosion. The bag material should be a HD-100 or equivalent and conform to MIL-PRF-131J.

b. Shipping crates will be supplied by the Authority.

c. Commutators shall be covered with a suitable protective material such as heavy multi-layered paper or felt.

d. Armature shaft bearing surfaces, coupling seats and threaded ends shall be protected against damage by plastic covers.

e. All job documentation, checklists and reports shall be placed in a rugged plastic protective cover or envelope affixed to the moisture barrier bag. Originals shall be separately forwarded to the Authority's Manager of Equipment Engineering and Quality Assurance.
5.2 DELIVERY LOCATIONS

All repaired armatures shall be shipped, freight prepaid, to the following location:

Massachusetts Bay Transportation Authority
Subway Main Repair
80 Broadway
Everett, Massachusetts 02149

Armatures to be repaired shall be picked up by the Contractor at the above location.

6.0 NOTES

6.1 INTENDED USE

The armatures for the traction motors listed in Section 3.2 of this Specification are to be used on subway/surface rail vehicles in passenger-carrying revenue service or in work service on the Massachusetts Bay Transportation Authority.

6.2 PROPOSAL

Bidders shall submit a proposal to the Authority for the work specified herein. The following items shall be submitted if requested by the Authority:

a. Copy of current Quality Assurance Certification (reference Section 4.1.2).

b. A detailed list of the plant and special equipment that the Bidder proposes to use for this Contract, indicating which portions he already possesses.

c. Detailed information, including authority, contract number, quantity, type and contact person, on traction motor armature repair work that the Bidder has completed for other transit properties. The Authority may require, during proposal evaluation, written references or testimonials from officers of all transit authorities that have been, or still are, customers of the Bidder, attesting to the skill and experience of the Bidder, the quality of the work performed and the in-service success of traction motor armatures and repaired by the bidder.
d. The bidder shall have demonstrated skill and experience in the correct and successful manufacture of the types of armature coils required and shall submit written evidence of same. The bidder shall submit written evidence of at least three years of successful in-service rail transit experience of coils manufactured by him, or by his suppliers, as appropriate.

This should include but not limited to a list of contracts or copies of purchase orders for repair of similar equipment.

6.3 DEFINITIONS

Wherever in the Specification the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows:

Approval - Reviewed and accepted, in writing by the Authority.

Approved or Approved Type - Type, material, procedure, method as approved by the Authority.

Authority or M.B.T.A. - The Massachusetts Bay Transportation Authority, created by Chapter 563, Section 18 of the Acts of 1964 of the Commonwealth of Massachusetts, the Party of the First Part to the Contract.

Bidder - Any individual, firm, partnership or joint venture submitted a proposal on the forms provided by the Authority, for the work contemplated, acting directly or through a duly authorized representative.

Contract - The written agreement executed between the Authority, Party of the First Part, and the Contractor, Party of the Second Part, setting forth the obligations of the Parties there under, the performance of the Procurement as indicated in the Bid Documents and all authorized changes to this Contract issued subsequent to the execution of the Contract.

Contractor - The person or persons, firm, partnership, corporation, or combination thereof which has entered into contract with the Authority to supply the required services.

Equal - Whenever the words "equal" or "approved equal" are used in connection with make or quality of material or equipment in this Specification, the Authority's
decision as to whether any material or equipment proposed is equal to that specified shall be binding on the Contractor.

Original Equipment Manufacturer - The original designer and builder, or producer, of the equipment.

Notice - A written announcement.

Proposal - The bid or offer of the Bidder for the work when made out in the prescribed manner and submitted on the prescribed proposal form, properly signed and certified, and which includes the schedule of bid items.

Service Proven or Proven - The historical success of materials, supplies and methods used in the repair of traction motor armatures operating in revenue service under similar conditions on rail transit systems over a four year period.

Specification - Shall mean EEQA - 806 and any revisions thereof.

Subcontractor - An individual, firm, partnership, corporation or joint venture to whom the Contractor, with prior written approval of the Authority, sublets any part of the Contract.

Supplier, Vendor - Persons, firms, or corporations who furnish materials for the Contractor, but who do not work such material to a special design according to the Contract.
### 7.0 REVISION RECORD:

<table>
<thead>
<tr>
<th>Rev</th>
<th>Description</th>
<th>Date</th>
<th>Approv</th>
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<tr>
<td>A</td>
<td>Section 3.4.6.3.a.(12) Removed - Armature coils shall be Vacuum Pressure Impregnated in a Class H solventless polyester insulating varnish and fully cured, in accordance with an Authority approved procedure. Added - Armature coils should not be Vacuum Pressure Impregnated at this time. The VPI process shall be performed when the armature is completely wound and welded.</td>
<td>9-7-10</td>
<td>1-27-10 JH</td>
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<td>Section 4.1.2 Added – Paragraph 2,3 and 4</td>
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<td>Section 4.1.5 Added Section</td>
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<td>Section 4.2.5 Added – Paragraph 2</td>
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<td>Section 6.2(d) Added – Paragraph 2</td>
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<td></td>
<td>Appendix A – Removed 1460-B data Added 1460-B1 and 1463-E1 data</td>
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<td>B</td>
<td>Section 3.1.2 – Added Paragraph 4, Sentences 2,3,4, and 5 Section 3.1.4 - Changed $900 to $946, $355 to $373, $545 to $573</td>
<td>3-11-13</td>
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<td>C</td>
<td>Section 1.2.1 – Added replace core laminations Section 1.2.1 – Renumbered entries Section 1.2.2 – Removed coil supports and laminations Section 3.1.2 Paragraph 2 – removed core laminations Section 3.4.4.e Remove - If applicable, clean out ventilating ducts in the armature core by rodding and swabbing, being careful not to damage the core laminations. Changed 3.4.4.f to 3.4.4.e Changed 3.4.4.g to 3.4.4.f Changed 3.4.4.h to 3.4.4.g Section 3.4.5.2b Removed - b.Inspect the armature core for burn holes, welded and shorted laminations or rubbed, distorted and skewed laminations. Check for core looseness on shaft. Changed 3.4.5.2.d to 3.4.5.2.b Changed 3.4.5.2e to 3.4.5.2.c Changed 3.4.5.2f to 3.4.5.2.d</td>
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### Equipment Engineering and Quality Assurance

**Technical Specification**

**Specification:** EE&QA-806

**SUBJECT:** REQUIREMENT FOR THE OVERHAUL OF TRACTION MOTOR ARMATURES

**Date:** February 01, 2010  
**Revised:** February 21, 2017  
**Revision:** D

<p>| Section 3.4.6.2b Removed – b. Inspect and test the armature core in accordance with the requirements of Section 3.4.6.3.d through 3.4.6.3.f. Replace any defective laminations in accordance with the requirements of Section 3.4.6.3.g. |
| Changed 3.4.6.2c to 3.4.6.2.b |
| Changed 3.4.6.2d to 3.4.6.2.c |
| Changed 3.4.6.2e to 3.4.6.2.d |
| Changed 3.4.6.2f to 3.4.6.2.e |
| Changed 3.4.6.2g to 3.4.6.2.f |
| Changed 3.4.6.2h to 3.4.6.2.g |
| Changed 3.4.6.2i to 3.4.6.2.h |
| Section 3.4.6.3.b(4) Removed - <strong>CAUTION:</strong> USE EXTREME CARE TO PREVENT DAMAGE OR DISTORTION TO CORE LAMINATIONS. THE CONTRACTOR SHALL BE HELD RESPONSIBLE FOR ANY CORE DAMAGE DONE DURING STRIPPING. |
| Section 3.4.6.3.c(5) Sentence 1 Removed - , including core laminations, coil supports, ventilation holes and other areas |
| Section 3.4.6.3.c(6) Removed - <strong>CAUTION:</strong> DO NOT DRAG OVER FILING BURRS IN SUCH A WAY AS TO SHORT CIRCUIT THE LAMINATIONS. |
| Section 3.4.6.3 Removed – d. Carefully inspect the core, coil supports and slots for defects and to assure a burr free assembly. Dress armature core slots and commutator riser slots by removing burrs and sharp edges. Inspect for burn holes, welded and shorted laminations or rubbed, distorted and skewed laminations. Insure that the core is not loose on the shaft. Be sure that all laminations line up properly. Replace any defective parts. |
| Section 3.4.6.3 Removed – e. Laminations that have been bumped slightly so as to open up small gaps shall be repaired by tapping the area firmly with a fiber hammer to close up the gaps. Distorted and bent end laminations shall be pressed inward and dressed. Laminations that have been burned, welded, shorted, rubbed or |</p>
<table>
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<th>Specification:</th>
<th>EE&amp;QA-806</th>
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<td>Revision:</td>
<td>D</td>
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<th>otherwise seriously damaged shall be replaced following the procedures of Section 3.4.6.3.g.</th>
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<tr>
<td>Section 3.4.6.3 Removed – f. Perform a core loss test observing the methods and procedures of Section 4.2.5.</td>
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<td>Changed bullet listing 3.4.6.3.g up to 3.4.6.3.ad to 3.4.6.3.d up to 3.4.6.3.aa respectively</td>
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<tr>
<td>Section 3.4.6.3 Paragraph 2 – Removed core laminations and coil Supports</td>
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<td>Section 3.4.6.3.g Removed - Replace defective armature core laminations to the extent necessary depending on the extent of damage, observing the following procedure. The cost for laminations replaced shall be based on those actually replaced prorated to the cost per inch quoted by the contractor in his proposal.</td>
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<tr>
<td>Section 3.4.6.3.g Added - Replace all armature core laminations. No part of the core laminations will be reused.</td>
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<tr>
<td>Changed 3.4.6.3.g (2) - Disassemble the core, inspecting core laminations for damage and shorts and inspecting the shaft, coil supports and pressure plate for damage. Replace any defective parts.</td>
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<tr>
<td>To - Disassemble the core, inspecting the shaft and pressure plate for damage. Replace any defective parts.</td>
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<td>D</td>
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8.0 MOTOR DATA - APPENDIX A

The following data sheets contain currently available Original Equipment Manufacturer's information on Authority traction motor armatures. The Contractor shall verify this information for correctness and shall supply missing information, and other necessary information, to the Authority to update and revise the data sheets.
## M.B.T.A. TRACTION MOTOR ARMATURE DATA

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<tr>
<td>Coil Lead Throw (Bar-to-Bar)</td>
<td>20 - 21</td>
<td>1 - 63</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COIL DATA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Turns per Coil</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>No Conductors per Arm Coil</td>
<td>4</td>
<td>6 (3 Pairs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductor Size-Arm (Inches)</td>
<td>0.040 x 0.235</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductor Size-Eql (Inches)</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unwrapped Slot Section (In)</td>
<td>0.170 x 0.480</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finished Slot Section (In)</td>
<td>0.225 x 0.551</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9.0 SHAFT REPLACEMENT COST - APPENDIX B

Awarding of contract shall be determined by the submitted cost for Basic Work only.

Cost of Extra Work for each motor shaft replacement will be capped at 20% of total cost of Basic Work per armature.

Cost of all additional Extra Work not to exceed reasonable and proper industry cost and shall be pre approved by the authority.
<table>
<thead>
<tr>
<th>10.0 REQUIRED DOCUMENTS FOR REWORKED ARMATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPENDIX C</td>
</tr>
<tr>
<td>10.1 Incoming Inspection Report</td>
</tr>
<tr>
<td>10.2 Final Test Report</td>
</tr>
<tr>
<td>10.3 Armature Rewind Quality Control Checklist</td>
</tr>
<tr>
<td>10.4 VPI Process QC Sheet</td>
</tr>
<tr>
<td>10.5 Machining, Balancing, and Undercutting Quality Control Checklist</td>
</tr>
<tr>
<td>10.6 Balance Report</td>
</tr>
<tr>
<td>10.7 Small Parts Quality Control Checklist</td>
</tr>
</tbody>
</table>
10.1 Incoming Inspection Report

<table>
<thead>
<tr>
<th>Model #</th>
<th>Tracking #</th>
<th>Customer</th>
<th>Job #</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DESCRIPTION OF OPERATION**

**INSPECTION**

Damaged Parts:

<table>
<thead>
<tr>
<th></th>
<th>Pass/Fail</th>
</tr>
</thead>
</table>

Missing Parts:

<table>
<thead>
<tr>
<th></th>
<th>Pass/Fail</th>
</tr>
</thead>
</table>

**FAN**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracks</td>
<td></td>
</tr>
<tr>
<td>Excessive abrasion</td>
<td></td>
</tr>
<tr>
<td>Warpage</td>
<td></td>
</tr>
<tr>
<td>Other damage:</td>
<td></td>
</tr>
</tbody>
</table>

**SHAFT**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing surface nicks, scoring deep wear pattern</td>
<td></td>
</tr>
<tr>
<td>Surface finish must be 16 micron inches RMS or better</td>
<td></td>
</tr>
<tr>
<td>Comm end bearing surface</td>
<td></td>
</tr>
<tr>
<td>Non-comm end bearing surface</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Run out – bearing journal support</th>
<th>Surface</th>
<th>F.I.R. (Maximum)</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coupling Seat</td>
<td>0.001 Inch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bearing</td>
<td>0.001 Inch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spline Pitch Diameter</td>
<td>0.002 Inch (if appl)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Run out – shaft end support</th>
<th>Bearing journal surface</th>
<th>F.I.R. (Maximum)</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comm end</td>
<td>0.0005 inch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-comm end</td>
<td>0.0005 inch</td>
<td></td>
</tr>
</tbody>
</table>
10.2 Final Test Report

<table>
<thead>
<tr>
<th>Model #</th>
<th>Serial #</th>
<th>Customer</th>
<th>Job #</th>
</tr>
</thead>
</table>

Check armature is ready for shipping

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Result</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual inspection, good?</td>
<td>______</td>
<td>(check)</td>
</tr>
<tr>
<td>All bolt holes clear of varnish?</td>
<td>______</td>
<td>(check)</td>
</tr>
<tr>
<td>Armature to ground MΩ</td>
<td>______</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td>Hi Pot μA @ 2500 volts</td>
<td>______</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td>Ductor test (bar to bar)</td>
<td>______</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td>Banding below core iron PE</td>
<td>______</td>
<td>(check)</td>
</tr>
<tr>
<td>Banding below core iron CE</td>
<td>______</td>
<td>(check)</td>
</tr>
<tr>
<td>Job # stamped on shaft</td>
<td>______</td>
<td>(check)</td>
</tr>
<tr>
<td>Serial # stamped on shaft</td>
<td>______</td>
<td>(check)</td>
</tr>
<tr>
<td>All repair documentation is in packet</td>
<td>______</td>
<td>(check)</td>
</tr>
</tbody>
</table>

QC Inspection by: 

Date:

Comments
### 10.3 Armature Rewind Quality Control Checklist

<table>
<thead>
<tr>
<th>Description of Operation</th>
<th>Initial</th>
</tr>
</thead>
</table>

#### PREPARATION
- Inspect armature, check laminations are straight and clean. No sharp edges. **Pass/Fail**
- Map out/ mark core and comm. for lead and equalizer placement. **QC**
- Insulate core
- Charge out coils and materials

#### REWINDING
- Install first equalizer in correct comm. bar as per specs. **QC**
- Finish installing equalizers
- Install 1st coil. Check coil bottom and leads are in correct slot and comm. bar **QC**
- Install remaining coils. Check coil top and leads are in correct slot and comm. bar **QC**
- Install wedges
- Check winding height is not above core **Pass/Fail**
- Measure coil overhang " **Pass/Fail**
- Hi Pot test _______ μA @ 1200 volts **Pass/Fail**
- Bar to bar test **Pass/Fail**
- Trim excess leads from riser face

#### COMMENTS

#### TIG WELDING
- Tig weld armature and clean carbon from risers
- Hi Pot test _______ μA @ 1200 volts **Pass/Fail**
- Bar to bar test **Pass/Fail**

#### BANDING
- Install armature banding _______ lbs pressure
- Hi Pot test _______ μA @ 1200 volts **Pass/Fail**
- Bar to bar test **Pass/Fail**

PREPARE FOR VPI
## 10.4 VPI Process QC Sheet

<table>
<thead>
<tr>
<th>Model # _____</th>
<th>Field _____</th>
<th>Arm _____</th>
<th>Rotor _____</th>
<th>Stator _____</th>
<th>Job _____</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
<td>Tracking #</td>
<td>Date ____ / ____ / ____</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PREPARATION

**OPERATION**

- Check that all machined surfaces are masked correctly
- Check specs to ensure correct processing times and specs.

### PRE-HEAT

- Place piece in oven for pre heat cycle
  - **TIME** ____ : ____ AM / PM
- Remove piece from oven after pre heat cycle
  - **TIME** ____ : ____ AM / PM
- Total hours of pre-heat cycle: ____ hours

### VPI PROCESS

- **FULL CYCLE** ____ How many? 1 __ 2 ____

#### FIRST VPI CYCLE

- Check part temperature before putting in to process tank
  - ____ * F / C
- Start First VPI cycle
  - **TIME** ____ : ____ AM / PM
  - **Date** ____ / ____ / ____
- Record Dry Vac
  - Torr ____
  - Duration ____ minutes
- Record Wet vac
  - Torr ____
  - Duration ____ minutes
- Record Pressure
  - PSI ____
  - Duration ____ minutes
- Time at end of VPI cycle
  - **TIME** ____ : ____ AM / PM

#### FIRST BAKING

- Time piece put in oven
  - **TIME** ____ : ____ AM / PM
- Time piece removed from oven
  - **TIME** ____ : ____ AM / PM
  - **Date**: ____ / ____ / ____

#### SECOND VPI CYCLE (if necessary)

- Check part temperature before putting in to process tank
  - ____ * F / C
- Start second VPI cycle
  - **TIME** ____ : ____ AM / PM
  - **Date** ____ / ____ / ____
- Record Dry Vac
  - Torr ____
  - Duration ____ minutes
- Record Wet vac
  - Torr ____
  - Duration ____ minutes
- Record Pressure
  - PSI ____
  - Duration ____ minutes
- Time at end of VPI cycle
  - **TIME** ____ : ____ AM / PM
<table>
<thead>
<tr>
<th>SECOND BAKING</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Time piece put in oven</td>
<td>TIME <strong>:</strong> AM / PM</td>
<td></td>
</tr>
<tr>
<td>Time piece removed from oven</td>
<td>TIME <strong>:</strong> AM / PM   Date: <strong>/</strong>/__</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HOT DIP</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Time piece put in oven</td>
<td>TIME <strong>:</strong> AM / PM</td>
<td></td>
</tr>
<tr>
<td>Time piece removed from oven</td>
<td>TIME <strong>:</strong> AM / PM   Date: <strong>/</strong>/__</td>
<td></td>
</tr>
</tbody>
</table>
### 10.5 Machining, Balancing, and Undercutting Quality Control Checklist

<table>
<thead>
<tr>
<th>Model #</th>
<th>Tracking #</th>
<th>Customer</th>
<th>Job #</th>
</tr>
</thead>
</table>

**SHAFT INSPECTION BEFORE COMM INSTALLATION (use spec tables where necessary)**

- Check Shaft TIR CE. ______ “ PE. ______ “ Pass/Fail Laminations dia. __________ “
- Bearing journal PE ______________ “ Pass/Fail Laminations length __________ “
- Bearing journal CE ______________ “ Pass/Fail OK TO USE / REPLACE SHAFT (circle one)
- Measure commutator seat __________ “ Pass/Fail
- Check Taper Pass/Fail Check Spline Pass/Fail Initial ______________
- Check P.E. shaft diameter __________ “ Pass/Fail Date __________

**COMM / CORE INSTALLED**

**COMM. / CORE INSTALLATION**

- Install shaft New shaft ___ Existing shaft ___ Initial ________
- Install core New ___ Existing ___ Initial ________

**QC Inspection of core to establish suitability for rewinding process**

- Install comm New ___ Refurbished ___ Initial ________
- Check comm. edge to shaft shoulder measurement Initial ________
- Turn riser face down by __________ “ (Write this on comm. bars.) If OK write “OK”
- Final shaft TIR Initial ________

**SEND TO REWIND DEPT FOR WINDING**

**TURN TO SPECS BEFORE TIG WELDING**

- Final Comm diameter __________ “ Pass/Fail
- Final Riser width __________ “ Pass/Fail (initial) __________
- Final Dust groove width __________ “ Pass/Fail Date __________
- Final Dust groove depth __________ “ Pass/Fail

**SEND FOR TIG WELDING / BANDING / VPI**

**FINAL MACHINING**

- Turn comm. Final diameter __________ “
- Final TIR __________ “ Date __________ (initial) __________
- Balance armature Report attached? Yes/No Date __________ (initial) __________
- Undercut commutator __________ (initial) Bar – bar test __________ (initial) Date __________
## 10.6 Balance Report

<table>
<thead>
<tr>
<th>Model #</th>
<th>Tracking #</th>
<th>Customer</th>
<th>Job #</th>
</tr>
</thead>
</table>

INCLUDE COPY OF BALANCE MACHINE TEST REPORT
10.7 Small Parts Quality Control Checklist

Model # _____________  Job # _____________  Tracking # _____________  Date ___/___/___

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>INITIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>INITIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

REPAIRED PARTS

REPLACED PARTS
TECHNICAL SPECIFICATION
RE-606

WIRING AND CABLE SPECIFICATION

ISSUED: October 20, 1983
REVISIONS: A: February 26, 1988
B: January 26, 1988
C: December 18, 1988

SUBWAY OPERATIONS DIRECTORATE
EQUIPMENT ENGINEERING & QUALITY ASSURANCE
1.0 **SCOPE**

1.1 This specification covers electrical wire and cable to be used in rapid transit service, where applicable; exceptions or waivers to be approved by the MBTA.

2.0 **APPLICABLE DOCUMENTS**

2.1 Selection criteria and specifications for electrical insulation are contained in report UMTA-MA-06-0025-79-1 "Electrical Insulation Fire Characteristics Volume I: Flammability Tests" dated March 1979 or latest issue. Vertical Flammability Test for all wire sizes.

As a guideline for further consideration of the selection of electrical wire insulation, report UMTA-MA-06-0025-79-2 "Electrical Insulation Fire Characteristics Volume II: Toxicity" dated March 1983 or latest issue, shall be used.

3.0 **REQUIREMENTS**

3.1 **Insulation**

3.1.1 The insulation shall be cross-linked, thermosetting flame-retardant, polyolefin, rated 2000 volts AC or DC for normal operation at $110^\circ$C.

3.1.2 The insulation thickness, cable diameter, conductor size and stranding are shown in Table I. Serial Numbers in Table II.

3.1.3 **Physical Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, min</td>
<td>1500 PSI</td>
</tr>
<tr>
<td>Elongation, min</td>
<td>150%</td>
</tr>
</tbody>
</table>

3.1.3.2 **Aging Requirements**

After air oven seven (7) days @ $158^\circ$C ± $2^\circ$C for 168 hours.

Tensile strength, min percentage of unaged value 90%

Elongation, min percentage of unaged value 50%

3.1.3.3 **Heat Distortion**

$150^\circ$C ± $2^\circ$C, max. percentage of unaged value

4/0 AWG and smaller 20%
3.1.3.4 **Crush Resistance** - minimum 2,000 Lbs.

When placed between two steel plates, the sample shall resist crushing force before grounding as measured by a voltage detector.

3.1.3.5 **Moisture Absorption** Values

Gravimetric method @ 70°C ± 2°C for 168 hours

Maximum mg. per square inch. 8

Electrical Method (IPCEA-866-524)
Increase in capacitance, maximum percent

<table>
<thead>
<tr>
<th>Time</th>
<th>Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 14 days</td>
<td>3.0%</td>
</tr>
<tr>
<td>7 - 14 days</td>
<td>1.5%</td>
</tr>
<tr>
<td>Stability factor after 14 days</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

Alternate to stability factor-stability factor difference, 1 - 14 days maximum 0.5%
SIC (1 day) maximum 6.0%

3.1.3.6 **Ozone** (Test Method IPCEA S-19-81 para. 6.8)

After 24 hours exposure to an ozone concentration of 0.03% by volume at 90°C ± 2°C, there shall be no insulation cracks.

3.1.3.7 **Flammability**

Flame retardancy per para. 6.19.6 IPCEA S-19-8

Flame shall extinguish within 3 seconds when ignited source is removed.

3.1.4 **Electrical Test**

3.1.4.1 **Insulation Resistance** Constant @ 15.6°C 10,000

3.1.4.2 **Voltage Tests**

The insulated conductors shall withstand the test voltages both AC and/or DC in IPCEA - S-66-524 for 5 minutes after 6 hours immersion in water or shall withstand impulse dielectric test using an impulse test voltage of 17.5 KV.
3.1.4.3 Electrical Overload, Single Conductor

The finished insulated cable shall not short out in less than 3 minutes or crack when subjected to a IX Bend. The current for the 14 AWG wire shall be 100 amperes, and the current for the 12 AWG wire test shall be 135 amperes. The current shall be constantly adjusted to stay at the required amperage regardless of voltage drop. A nine inch sample length of finished cable shall be spirally wrapped with 18 AWG annealed bare copper wire using a lay of 0.75 inches. The wrap shall be tight fitting over the wire insulation without causing appreciable surface indentation.

0.25 inches of insulation shall be stripped from each end of the sample and the conductor shall be terminated with ring lugs. The specimen shall then be securely attached to the power supply test equipment and shall be positioned horizontally. DC amperage as applicable (see above) shall be applied to the specimen. A 1000 volt r.m.s. potential shall be applied between the conductor and the 18 AWG copper wire that is wrapped over the insulation. Time to failure as indicated by a cable dielectric breakdown shall be recorded.

3.1.4.4 Electrical Overload, 7 Wire Bundle

When the center conductor of a 7 wire bundle is overloaded according to the test method described in Req. 94-1 for a seven consecutive minute period, there shall be no signs of visible smoke generated and no visible derangement of the wire bundle. After cooling to room temperature subsequent to the 7 minute overload test, the outer six wires shall be readily untwisted from the bundle. There shall be no tacking of adjacent insulation surfaces and none of the insulated wires, including the center overloaded conductor, shall evidence insulation splits, ruptures or charring. For 14 AWG, the test current shall be 100 amperes DC and for 12 AWG, the test current shall be 135 amperes DC. The current shall be constantly adjusted at these values despite voltage drop of the wire being tested.

Seven nine inch sample lengths shall be tightly twisted with a left hand lay and a lay length of one inch or less. The ends of this wire bundle shall be firmly bound with 1/2 inch wide glass cloth tape. Strip 1/4 inch of insulation from each end of the center conductor only and apply the applicable DC current to the center wire. The bundle test specimen shall be observed for the current application period for the evolution of heavy smoke, insulation melting or other deleterious effects. After the 7 minute current application period, the wire bundle shall be twisted apart and the inside and the outside of the wire bundle shall be visually examined for signs of insulation damage.

3.1.4.5 Corrosivity (ASTM 2671 Copper Mirror)

The test specimen shall be approximately 0.4 gram of the insulation and cut into small pieces.
3.1.4.5 Corrosivity (ASTM 2671 Copper Mirror) (Continued)

After a test period of 16 hours @ 175°C ± 2°C, the removal of more than 5% of the copper constitutes a failure.

3.1.4.6 Hot Oil Resistance

After 96 hours immersion in ASTM oil #2 @ 150°C ± 2°C, the cable diameter increase shall not exceed 50%. The insulation shall show no cracks, ruptures or splits and shall pass subsequent wet dielectric test of 6 KV for 5 minutes.

3.1.4.7 Cold Bend

When tested in accordance with IPCEA-S-61-402 except at 65°C ± 3°C, no cracks will be visible and sample will withstand 6 KV wet dielectric test.

3.1.4.8 Abrasion Resistance per G.E. Scrape Abrasion Test

Average Cycles 500 Cycles

3.2 Conductor

Conductor shall consist of soft annealed tinned copper per ASTM-B-33. Conductor diameters shall not exceed values given in Table 1 of this specification. Unilay construction may be used at the option of the manufacturers. Stranding shall be in accordance with Table 1.

3.3 Separator

A paper or other suitable separator may be used if required.

3.4 Dimensions

The finished cable shall be uniform in diameter throughout its length and the overall dimensions shall not exceed the values given in Table 1 of this Specification.

3.5 Finish

Each cable shall be clearly and continuously printed with AWG size, MBTA serial number and MBTA specification number. The height of the characters to be the diameter of the wire or cable.

The manufacturer’s identification, including name, size and part number, may be included, but these shall be offset from the MBTA-required printing by at least 90 degrees on the circumference of the cable.

3.6 Inspection

Certified laboratory reports and a 3 foot sample for each gauge shall accompany each delivery of wire and cable. The manufacturers have the right to challenge individual inspections of the MBTA or its agents.
### TABLE I - OPTION 1

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3,831</td>
<td>14</td>
<td>19/27</td>
<td>0.074</td>
<td>45</td>
<td>0.172</td>
</tr>
<tr>
<td>6,088</td>
<td>12</td>
<td>19,25</td>
<td>0.094</td>
<td>45</td>
<td>0.192</td>
</tr>
<tr>
<td>10,910</td>
<td>10</td>
<td>27,24</td>
<td>0.128</td>
<td>45</td>
<td>0.228</td>
</tr>
<tr>
<td>14,950</td>
<td>8</td>
<td>37/24</td>
<td>0.147</td>
<td>55</td>
<td>0.267</td>
</tr>
<tr>
<td>24,640</td>
<td>6</td>
<td>61/24</td>
<td>0.207</td>
<td>55</td>
<td>0.367</td>
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<tr>
<td>42,420</td>
<td>4</td>
<td>105/24</td>
<td>0.264</td>
<td>55</td>
<td>0.384</td>
</tr>
<tr>
<td>90,900</td>
<td>1</td>
<td>225/24</td>
<td>0.390</td>
<td>65</td>
<td>0.535</td>
</tr>
<tr>
<td>111,100</td>
<td>1/0</td>
<td>275/24</td>
<td>0.440</td>
<td>65</td>
<td>0.585</td>
</tr>
<tr>
<td>131,300</td>
<td>2/0</td>
<td>325/24</td>
<td>0.477</td>
<td>65</td>
<td>0.627</td>
</tr>
<tr>
<td>181,800</td>
<td>3/0</td>
<td>450/24</td>
<td>0.565</td>
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<td>0.715</td>
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</tbody>
</table>

On wire less than No. 14, size data to be no greater than N.E.C. values.

### TABLE I - OPTION 2

<table>
<thead>
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On wire less than No. 14, size data to be no greater than N.E.C. values.
<table>
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<th>SIZE</th>
<th>MBTA Serial Number</th>
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<tr>
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</table>
REVISIONS AND ADDENDA

October 20, 1983

Retyped:

Scope changed from "for the Overhaul of the #5 Cambridge-Dorchester RTL Cars" to "in Red Line Rapid Cars".

"Wire and Cable" changed to Electrical Wire and Cable".

Sections and paragraphs re-numbered.

A. February 26, 1988

Added:

Wire sizes through No. 22 to Tables.

Table II, MBTA Serial Number of Wires.

Changed:

1.1 From "Red Line Rapid Transit Cars"

   to

   "in rapid transit service, where applicable; exceptions or
   waivers to be approved by the MBTA".

3.1.2 Changed from "Table 1"

   to

   Table 1, Serial numbers in Table II".

B. January 26, 1989

Revised Section 2.0, which originally read: "Department of Transportation
Guidelines for Flammability and Smoke Emission Specification, TSC-76-LFS-6
shall be applied; exceptions must be approved by the MBTA,
Equipment Engineering.

C. December 18, 1998

Section 3.5: Deleted words "only, with no other characters printed"
from first sentence. Added second paragraph.