SAFETY PRECAUTIONS
MAINTENANCE AND REPAIR

• When lifting parts or assemblies, make sure all slings, chains, or cables are correctly fastened, and that the load being lifted is balanced. Make sure the crane, cables, and chains have the capacity to support the weight of the load.

• Do not lift heavy parts by hand, use a lifting mechanism.

• Wear safety glasses.

• DISCONNECT THE BATTERY CONNECTOR before doing any maintenance or repair on electric lift trucks. Disconnect the battery ground cable on internal combustion lift trucks.

• Always use correct blocks to prevent the unit from rolling or falling. See HOW TO PUT THE LIFT TRUCK ON BLOCKS in the Operating Manual or the Periodic Maintenance section.

• Keep the unit clean and the working area clean and orderly.

• Use the correct tools for the job.

• Keep the tools clean and in good condition.

• Always use HYSTER APPROVED parts when making repairs. Replacement parts must meet or exceed the specifications of the original equipment manufacturer.

• Make sure all nuts, bolts, snap rings, and other fastening devices are removed before using force to remove parts.

• Always fasten a DO NOT OPERATE tag to the controls of the unit when making repairs, or if the unit needs repairs.

• Be sure to follow the WARNING and CAUTION notes in the instructions.

• Gasoline, Liquid Petroleum Gas (LPG), Compressed Natural Gas (CNG), and Diesel fuel are flammable. Be sure to follow the necessary safety precautions when handling these fuels and when working on these fuel systems.

• Batteries generate flammable gas when they are being charged. Keep fire and sparks away from the area. Make sure the area is well ventilated.

NOTE: The following symbols and words indicate safety information in this manual:

⚠️ WARNING
Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠️ CAUTION
Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury and property damage.

On the lift truck, the WARNING symbol and word are on orange background. The CAUTION symbol and word are on yellow background.
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This section is for the following models:

All Electric Lift Trucks
"THE QUALITY KEEPERS"

HYSTER APPROVED PARTS
General

This section describes disassembly and assembly, brush installation, inspection, and checks for malfunctions of DC motors. Inspect the commutator and brushes every 350 hours of operation. The commutator is the rotating electric connection between the armature and the electric power supplied by the battery. Brushes made of carbon compounds slide on the rotating commutator and are the path for electricity from the battery to the commutator and the armature. The maintenance of the commutator and the brushes is important to the good operation of a DC motor.

Traction motors and hydraulic pump motors are similar in design. The hydraulic pump motors are smaller than the traction motors, but the disassembly and maintenance of these motors are similar.

The cooling fan in the traction motors is fastened to the armature and can be removed from the armature. The cooling fan can be removed during disassembly of the traction motor.

The cooling fan in the hydraulic pump motors can be a press fit on the armature shaft and is not easily removed during disassembly of the motor. The armature and cooling fan must be removed from the drive end of the motor during disassembly.

The assembly and disassembly of the motor used for the power steering pump is described in the Steering System section. This motor is a permanent magnet motor.

Brush and Commutator Inspection

HYDRAULIC PUMP MOTOR AND TRACTION MOTOR

**NOTE:** When inspecting brush conditions and motor commutator conditions for head damage or abnormal wear, the battery maintenance and condition should be eliminated as a cause first. See Industrial Battery 2240 SRM 1.

**NOTE:** The brushes and commutator can be inspected, the brushes can be replaced, and Stoning the Commutator can be done with the motor installed in the truck.

**NOTE:** Inspect the brushes and commutator every 350 hours for best operation and to prevent motor damage. The hydraulic pump motor normally has more start cycles than other motors, so it can have more wear and possible damage.

**NOTE:** The following procedure is for inspecting the brushes and commutator with the motor installed in the lift truck. The same inspections can be done with the motor removed. If the motor is removed, start at Step 3.

1. To rotate the commutator of the traction motor without moving the truck, the drive wheels must be raised. See Figure 1. Raise drive wheels so commutator of the traction motor can be rotated without moving lift truck. See How To Raise Drive Wheels in the Operating Manual or the Periodic Maintenance SRM section for your lift truck.

   **NOTE:** For some models of lift trucks, the battery does not need to be removed to access the electric motors. Other models will require the removal of the battery before gaining access to the electric motors. To remove the battery, either raise the hood panels or unfasten the floor plate, depending on which motor needs to be accessed.

2. Remove battery. See How to Remove Battery in the Operating Manual or the Periodic Maintenance SRM section for your lift truck. Remove access plate to motors. If the battery in your lift truck does not need removal for access to the motors, go to Step 3.
WARNING
Compressed air can move particles so that they cause injury to the user or to other personnel. Make sure that the path of the compressed air is away from all personnel. Wear protective goggles or a face shield to prevent injury to the eyes.

**NOTE:** Vacuum cleaning, when possible, is the recommendation of manufacturers of electric motors. The use of compressed air can send dirt particles into the bearings and other areas of the motor that can cause possible damage.

3. Remove brush covers at rear of motor. See Figure 2. Wear eye protection. Use a vacuum cleaner or compressed air to remove dirt and brush dust from commutator area.

4. Remove and inspect brushes for damage or uneven wear. Replace all brushes if any brush is worn or damaged. The brushes must be at least half their original length. Move brush springs away from top of each brush and pull brushes from their holders to inspect surface that rides on commutator. See Figure 3. That surface must have the same shape as the commutator and must not have cracks or defects. Some brushes have wear sensor wires attached, even if they are not connected to an indicator. Replace these brushes if brushes are worn enough to see sensor at commutator end of brush.

5. Inspect commutator surface. See Table 1 and Table 2. Carefully rotate armature. DO NOT damage commutator if you use a tool to rotate armature.

The commutator wears slowly in normal service. The mica must be cut below the surface of the commutator bars after a long service period or after a commutator has been turned in a lathe.

A commutator that has been in service will have a smooth and polished surface with a darker brown color where it rotates under the brushes. A variation of color on the commutator surface between light brown and darker brown is normal. The surface condition is the lubrication between the commutator and the brushes. The brushes will wear rapidly if this surface condition does not develop during the first 6 to 10 hours of operation after a commutator with a new surface is installed. If the commutator has deep grooves, rough edges of the bars, or a few bars that are black or raised above the others, the motor must be removed for service.

6. Inspect white or gray insulation (mica) between commutator bars. The mica must not touch the brushes or the brushes will wear very rapidly.

7. To replace a brush set, remove screw that holds brush wires to bus. Pull brush end of springs from brushes, and pull brushes from holders. Lift brush springs away from holders, and install new brushes so brush commutator surface fully touches commutator. Make sure the springs are pushing on each brush. Install and tighten screws for brush wires and bus connectors.
8. Carefully install brush covers so sparks are kept inside motor housing. Install battery as described in Operating Manual or the Periodic Maintenance SRM section for your lift truck.

Figure 3. Brush Removal and Inspection
Table 1. Normal Commutator Surfaces

A light brown surface of the commutator where it rotates on the brushes is a normal condition. The surface of the commutator must be smooth.

Variations between light brown and dark brown colors are also normal. The surface of the commutator must be smooth.

A condition called slot bar marking is also normal if the commutator surface is smooth. The variable color occurs in a pattern according to the number of conductors per slot.

A very dark surface is also a normal and an acceptable condition if the commutator surface is smooth.

STEERING PUMP MOTOR

NOTE: Some electrical trucks use a steering pump motor. Refer to your truck model’s service manual for instructions on removal and installation of steering pump motors.

1. Disconnect battery connector. Remove floor plate from lift truck for access to steering pump motor. Open hood for access to motor. Remove screws that hold two brush cover plates to motor housing.

2. Inspect brushes and commutator as described in previous paragraphs for traction and hydraulic pump motors. The brush replacement procedure is also the same, although there are only two brushes for the steering pump motor. See Table 3.
3. Install brush covers and screws. Install floor plate or close hood and connect battery connector.

NORMAL COMMUTATOR SURFACE

A commutator that has been in service will have a smooth and polished surface with a darker brown color where it rotates under the brushes. See Table 1. A variation of color on the commutator surface between light brown and darker brown is normal.

This surface condition is the lubrication between the commutator and the brushes. The brushes will wear rapidly if this surface condition does not develop during the first 6 to 10 hours of operation after a commutator with a new surface is installed.

COMMITATOR PROBLEMS

Commutator and motor problems and are shown in Table 2.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Cause</th>
<th>Illustration</th>
</tr>
</thead>
</table>
| Heavy streaks and fine grooves indicate the beginning of damage to the commutator. | • Operation of the motor in dirty and abrasive conditions.  
• Continuous operation of a motor with a light load.  
• Brush pressure is too low.  
• Worn brushes. | |
| Grooves and lines that have followed the heavy streaks and fine grooves shown above. The armature must be removed from the motor so the commutator can be repaired. A commutator with this condition will cause the brushes to wear rapidly. | • Operation of the motor in dirty and abrasive conditions.  
• Continuous operation of a motor with a light load.  
• Brush pressure is too low.  
• Worn brushes. | |

Table 2. Commutator Problems
### Table 2. Commutator Problems (Continued)

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Cause</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grooves that are the width of the brushes.</td>
<td>• Operation of the motor in dirty and abrasive conditions.</td>
<td><img src="HM100011" alt="Illustration" /></td>
</tr>
<tr>
<td></td>
<td>• Wrong type of brushes for this motor and operation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Brush pressure is too high.</td>
<td></td>
</tr>
<tr>
<td>A condition called copper drag occurs when copper from the commutator</td>
<td>• Operation of the motor in dirty and abrasive conditions.</td>
<td><img src="HM100012" alt="Illustration" /></td>
</tr>
<tr>
<td>bar is pulled into the slot between the commutator bars. This condition</td>
<td>• Brush holder is not adjusted electrically correct for the motor.</td>
<td></td>
</tr>
<tr>
<td>will cause a short circuit between the commutator bars if it is not</td>
<td>• Wrong type of brushes for this motor and operation.</td>
<td></td>
</tr>
<tr>
<td>corrected. The brushes will wear rapidly.</td>
<td>• Brush pressure is wrong (too high or too low).</td>
<td></td>
</tr>
<tr>
<td>Electrical burns on commutator bars on opposite sides of the</td>
<td>• Open armature winding.</td>
<td><img src="HM100013" alt="Illustration" /></td>
</tr>
<tr>
<td>commutator.</td>
<td>• Motor has been stalled.</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2. Commutator Problems (Continued)

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Cause</th>
<th>Illustration</th>
</tr>
</thead>
</table>
| Copper wears rapidly at the edge of the commutator bars. | • Operation of the motor in dirty and abrasive conditions.  
• Wrong type of brushes for this motor and operation. | ![Illustration](HM100014) |
| 1. Flashover causes burning of the ends of the commutator bar.  
2. Open circuit in winding causes deep burning of adjacent commutator bars.  
3. Overheating causes damage to varnish insulation. | • Motor has been too hot. Wrong lift truck for the application.  
• Motor has been stalled.  
• Open armature winding.  
• Open field coil. | ![Illustration](HM100015) |
| Brush and commutator damage occurs when the high commutator hits and forces the brush up. Arcing and burns occur as the brush moves back down to the normal surface. Check for loose or high commutator bars. | • Motor has been stalled. (High commutator bars at each brush position can occur if the motor is stalled.)  
• Motor has been too hot. | ![Illustration](HM100016) |
| 1. High commutator bars at each brush position can occur if the motor is stalled.  
2. Rapid brush wear from high commutator bars. | |
Brush Replacement

1. Motor brushes must be replaced before they are worn enough to damage the surface of the commutator. Move the brush spring and remove a brush from its brush holder. Install new brushes as a set if length of any brush is worn to a minimum length. See Table 3. If the brush lead is fastened to the brush with a rivet, install a new set of brushes if it is worn to within 3 mm (0.118 in.) of the rivet. If a brush does not move easily in its holder, a new set of brushes must be installed.

The lead wire for some brushes is installed directly into the carbon compound of the brush. New brushes must be installed before the lead wire cuts a groove in the commutator. Install a new brush set when a brush is worn to a short length.

Brushes are made to different specifications for motors used in different applications. Use only new brushes approved by Hyster Company for that motor.

**NOTE:** For some models of lift trucks, the battery does not need to be removed to access the electric motors. Other models will require the removal of the battery before gaining access to the electric motors.

2. Remove battery as necessary for your lift truck. See How To Remove Battery in the Operating Manual or the SRM section Periodic Maintenance for your lift truck.

3. Remove access plate to motors. Remove brush covers to motor. See Figure 2. Wear eye protection. Use a vacuum cleaner or compressed air to remove dirt and brush dust from commutator area.

4. Make a note of the arrangement and connections of the brush assembly. See Figure 4. The new brushes must be installed in the same positions from which the worn brushes were removed.

5. Loosen screw that fastens brush wire to its terminal. Remove brush springs and brushes.

6. Inspect brush holders for burns and damage. Make sure brush holders are fastened tightly to brush mounting plate at end of motor. Make sure new brushes will move freely and smoothly in brush holders. Check that brush mounting plate is holding brush holder so it does not move.

7. Connect new brush wire to its terminal mount.

**NOTE:** When new brushes must be installed, a recommendation is to also install new brush springs. Damage from heat can cause the brush springs to have the wrong spring pressure.

### Table 3. Brush Wear Replacement Guide

<table>
<thead>
<tr>
<th>Brush Height</th>
<th>17 mm (0.67 in.)</th>
<th>22 mm (0.87 in.)</th>
<th>28 mm (1.10 in.)</th>
<th>30 mm (1.18 in.)</th>
<th>31 mm (1.22 in.)</th>
<th>32 mm (1.26 in.)</th>
<th>40 mm (1.57 in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear</td>
<td>8 mm (0.31 in.)</td>
<td>12 mm (0.47 in.)</td>
<td>14 mm (0.55 in.)</td>
<td>15 mm (0.59 in.)</td>
<td>16 mm (0.63 in.)</td>
<td>16 mm (0.63 in.)</td>
<td>16 mm (0.63 in.)</td>
</tr>
<tr>
<td>Worn Brush Height</td>
<td>9 mm (0.35 in.)</td>
<td>10 mm (0.39 in.)</td>
<td>14 mm (0.55 in.)</td>
<td>15 mm (0.59 in.)</td>
<td>15 mm (0.59 in.)</td>
<td>16 mm (0.63 in.)</td>
<td>20 mm (0.79 in.)</td>
</tr>
</tbody>
</table>
8. Check brush springs for damage from heat and corrosion. If brush springs are damaged, install new brush springs. Check brush springs for approximately equal pressure.

Brush springs normally have a spring pressure of approximately:
1.0 to 2.0 Newtons per each cm$^2$
(1.5 to 3.0 lbf per each in$^2$) when measured with a spring scale.

A brush for a traction motor has an area of approximately:
$5.33 \times 1.27 \text{ cm} = 6.8 \text{ cm}^2$
($2.1 \times 0.5 \text{ in.} = 1.05 \text{ in}^2$).

Brush springs for the traction motor normally have a spring force of approximately:
9.1 to 11.3 Newtons
(36 to 44 ozf) when measured with a spring scale as shown in Figure 5.

A brush for a hydraulic pump motor has an area of approximately:
$4.42 \times 0.95 \text{ cm} = 4.21 \text{ cm}^2$
($1.74 \times 0.375 \text{ in.} = 0.653 \text{ in}^2$).

Brush springs for the hydraulic pump motor normally have a spring force of approximately:
5.2 to 7.4 Newtons
(20 to 28 ozf) when measured with a spring scale as shown in Figure 5.
**WARNING**

Wear eye protection. Raise the drive wheels. Operate the motor at low speed. Protect your fingers. You are doing work close to moving parts of the motor. Do not use a brush seater stone less than 60 mm (2.4 in.) in length.

**NOTE:** The brush springs used in motors made by Hyster have a constant force design. The force of the brush spring against the brush stays almost constant as the brush wears and becomes shorter in its brush holder.

**NOTE:** New brushes made by the manufacturer are normally made to fit the surface of the commutator when they are installed. This contact surface must be checked when new brushes are installed. The contact surface **MUST** be approximately 85 percent of the brush surface where it touches the commutator.

---

**Stoning the Commutator**

1. If the commutator has grooves or other damage, the armature must be removed so the commutator can be repaired. Motors are normally repaired by service persons that have the special equipment required. Connect battery so the motor can be operated. See Figure 6. The battery must be removed for access to the motor. Use a jumper cable to connect battery to lift truck.

2. Close seat switch and key switch so motor will operate.

**NOTE:** A brush seater stone can also be fastened to a wood stick with glue as shown in Figure 6. This arrangement makes it easier to apply a brush seater stone in small spaces.

3. Operate motor so commutator rotates slowly. Apply brush seater stone to moving commutator with light pressure. Move brush seater stone backward and forward across surface of commutator until marks on commutator are removed.

4. Turn key switch to **OFF** position and disconnect battery. Check all brush contact surfaces. The brushes fit correctly when 85 percent of the brush contact surface touches the commutator. This stoning procedure normally requires approximately 15 to 45 minutes.

5. When the brushes have the correct contact surface with the commutator, use a vacuum cleaner to remove abrasive dust from commutator area and motor.

6. When the installation and checks are complete, install brush cover. Make sure wires to brushes do not touch any part of motor case and cause a short circuit.

A small contact surface can cause burns and a rough surface on the commutator. If the contact surface is less than approximately 86 percent, the new brushes must be made to fit the commutator better.

9. If new brushes must be made to fit the surface of the commutator, see Stoning the Commutator. Use a Brush Seater and Commutator Stone (No. 23-007M from the Ideal Company or an equivalent brush seater stone). Stoning the commutator is most easily done when the motor rotates slowly. When the motor rotates at higher speeds, the centrifugal force removes the abrasive particles from the commutator more quickly.

**NOTE:** To rotate the commutator of the traction motor without moving the truck, the drive wheels must be raised. See **How to Raise Drive Wheels** in the **Operating Manual** or the SRM section **Periodic Maintenance** for your lift truck.
Figure 6. Stoning the Commutator

Legend for Figure 6
1. RAISE DRIVE WHEELS
2. JUMPER
3. BATTERY
4. BRUSH SEATER STONE
Motors Repair

DISASSEMBLE

See the Master Drive Unit section or the Frame section for your lift truck for instructions on the removal and installation of the traction motor.

See the Hydraulic System section for instructions to remove and install the hydraulic pump and motor.

See the Brush and Commutator Inspection and Brush Replacement in this section for more information on these components of the motor.

Traction Motor and Hydraulic Pump Motor

NOTE: It is recommended that the bearings and the seal be replaced every 3,000 hours or 36 months, whichever comes first.

1. Clean outside surfaces of motor before disassembly. See Figure 8, Figure 9, and Figure 10. Put motor on its commutator (brush) end on a bench. On hydraulic motor assemblies, make index marks on pump and motor. Make index marks on end frames of motor and field frame so correct assembly is possible.

2. On hydraulic motor assemblies, remove two cap screws that fasten pump to pump motor. See Figure 11 or Figure 12. Remove pump. Put an index mark on armature shaft at the position of the coupler hub for correct assembly. Remove coupler hub from armature shaft by loosening setscrew and sliding hub off shaft and key. Do not lose key.

3. Remove brush cover. Remove brushes and spring assemblies.

4. Remove hex head screws from commutator end of motor. Carefully slide end frame from motor and armature shaft. Do not damage parts. A puller is frequently necessary to separate end frame from field frame.

⚠️ CAUTION

The drive end frame and the armature are heavy components. Work carefully so the field coils, pole pieces, and armature are not damaged during disassembly and assembly.

5. Remove screws that fasten drive end frame to field frame. Remove end frame and armature.

6. Remove drive end frame from armature.

If the brush holder (1) must be loosened or removed from the end frame for repairs, the brush holder must be installed again in the same position. See Figure 7. Make alignment marks between the brush holder and the end frame before the brush mounting plate (4) is released. The brush holder must be installed again in the same position.

If a new brush holder must be installed, there will not be an alignment mark on the new brush holder. Make an alignment mark on end frame with a reference point on brush holder that must be removed. Install new brush holder so reference point and alignment mark are aligned. The new brush holder must be installed in the same position as the old holder so the timing will be correct.

7. Remove screws that fasten brush holder assembly to commutator end frame.

8. Disassemble components of motor as necessary to make repairs.

Use a plastic or rubber hammer as necessary to loosen end frame.

9. Remove screws that fasten brush holder assembly to commutator end frame.

Disassemble components of motor as necessary to make repairs.

![Figure 7. Brush Holder and Mounting Plate](image)
Figure 8. Typical Traction Motor (Example 1)
Steering Pump Motor

NOTE: Some lift trucks could be equipped with a Brushless DC Power Steering motor, which is non-repairable.

NOTE: Some electrical trucks use a steering pump motor. Refer to the service manual for your truck model for instructions on the removal and installation of steering pump motors.

1. See Power Steering Motor and Pump for the removal and installation procedures for the steering pump motor. Make index marks on the steering pump and the drive end frame of the motor. Remove two capscrews that hold steering pump to motor. Remove pump and allow oil to drain from drive end frame.

2. Remove brush covers. See Figure 2. Remove two screws that hold brushes and terminal wires to brush holders. Pull brush springs out of the way and pull two brushes from holders.

---

Diagram labeling:

1. SNAP RING
2. BEARING
3. SEAL
4. DRIVE END FRAME
5. FAN COVER
6. SNAP RING
7. FAN
8. KEY
9. ARMATURE
10. BEARING
11. BRUSH COVER
12. COMMUTATOR END FRAME
13. TERMINAL
14. BRUSH MOUNTING PLATE
15. BUS CONNECTOR
16. WIRE
17. BRUSH SPRING
18. BRUSH
19. BRUSH HOLDER
20. FIELD FRAME

Figure 9. Typical Traction Motor (Example 2)
3. Make alignment marks on commutator end frame and field frame. Remove four long screws that hold commutator end frame to drive end frame. Pry commutator end frame from field frame. The bearing will stay with the armature. Make sure the special spring stays in the end frame.

4. Make alignment marks on drive end frame and on field frame. Use a soft hammer to tap drive end frame from field frame. The bearing will stay with the armature.

5. Pull armature assembly from field frame. The force of the permanent magnets in the frame makes it difficult to remove the armature. Use a pry bar to help move armature assembly.

6. Make alignment marks on brush holder plate and on commutator end frame. Remove two
screws that hold brush plate to commutator end frame. Remove brush holder assembly.

ASSEMBLE

Traction Motor and Hydraulic Pump Motor

1. Make sure all components are clean. If bearings were worn, install new bearings in end frames. See Figure 8 or Figure 9.

2. If cooling fan was removed, install it on armature. Make sure field coils and pole pieces are installed correctly in field frame.

3. Install brush holder assembly in commutator end frame. Make sure alignment marks are aligned.

4. Install drive end frame on armature.

5. Carefully install armature and drive end frame in field frame. Make sure index marks are aligned. Install and tighten screws.

6. Carefully install commutator end frame on armature and fasten it to field frame. Install and tighten hex head screws.

7. Install brushes and spring assemblies. See Brush Replacement and Brush Alignment, Traction and Hydraulic Motors in this section.

8. On hydraulic motor assemblies, install key and coupler hub to index mark on armature shaft. Tighten setscrew. Install other key and align pump with coupler and alignment marks. Install two capscrews that fasten pump to pump motor. See Figure 11, Figure 12, or Figure 13.

---

Figure 11. Typical Hydraulic Pump Motor (Example 1)
**Steering Pump Motor**

**NOTE:** Some lift trucks could be equipped with a Brushless DC Power Steering motor, which is non-repairable.

**NOTE:** Some electrical trucks use a steering pump motor. Refer to your truck’s service manual for instructions on the removal and installation of steering pump motors.

1. Replace seal in drive end frame. Replace bearings on armature by pushing only on inner races.

2. Install armature into field frame so commutator is aligned with brush inspection openings in field frame.

3. Lubricate seal lip with hydraulic oil. Align index marks and carefully install drive end frame on armature and field frame assembly.

4. Align index marks and install brush holder assembly in commutator end frame. Install and tighten two screws.

5. Make sure special spring is in position in commutator end frame. Align index marks and install commutator end frame. Carefully install four long screws through field frame into drive end frame. Tighten screws.

---

**Figure 12. Typical Hydraulic Pump Motor (Example 2)**
1. DRIVE END COVER
2. ARMATURE
3. TOLERANCE RING
4. FIELD COIL
5. POLE PIECE (4)
6. HOUSING
7. HEX HEAD BOLT (8)
8. BRUSH COVER
9. BRUSH PLATE
10. BRUSH HOLDER (4)
11. BRUSH SPRING (4)
12. BRUSH (4)
13. SCREW (4)
14. WASHER
15. BRUSH TERMINAL
16. END PLATE (COMMUTATOR CPL)
17. END PLATE
18. FAN
19. SHROUD (FAN)

Figure 13. Typical Hydraulic Pump Motor (Example 3)
6. Install brush springs and brushes. Make sure angle of brush is in correct position on commutator. Put end of brush spring on each brush. Connect brush wires and wires for terminals to correct brush holder. Install brush covers.

7. Install new O-ring on mounting surface of pump and align index marks. Align pump drive tang with armature and install pump on motor. Install and tighten capscrews.

**Brush Alignment, Traction and Hydraulic Motors**

**NOTE:** The brush holder in these motors can be rotated for timing of the brush alignment with the commutator. This process normally requires special equipment and training. A special repair service for electric motors is required to align the brushes for the correct timing with the commutator. If the brushes are not timed correctly with the commutator, the motor will have a low power output. The procedures for timing an electric motor are not described in this section. Do not rotate the brush holder from its original position.

If the brush holder must be loosened or removed from the end frame for repairs, the brush holder must be installed again in the same position. See Figure 7. Make alignment marks between brush holder and end frame before brush mounting plate is released. The brush holder must be installed again in the same position.

If a new brush holder must be installed, there will not be an alignment mark on the new brush holder. Make an alignment mark on end frame with a reference point on brush holder that must be removed. Install new brush holder so the reference point and the alignment mark are aligned. The new brush holder must be installed in the same position as the old holder so the timing will be correct.

**Tests for Damaged Field and Armature**

The tests described in the following paragraphs are to help a service person check a motor for damage and to determine if it must be sent to a repair service for rebuilt motors. The resistance checks will not normally indicate a short circuit in a motor winding. A resistance greater than 1 to 2 ohms can indicate a damaged winding. The motor must be removed from the lift truck and disassembled as shown in the illustrations before the tests can be done.

**TEST FOR AN OPEN CIRCUIT IN ONE ARMATURE WINDING**

The armature windings in large electric motors normally have less than 1 ohm of resistance. The two commutator bars for a winding are found 180 degrees apart on the commutator. If an ohmmeter (R × 1 scale) is used to check the resistance between the two commutator bars of the winding, a resistance of more than 1 ohm indicates a problem in that winding. A resistance of infinity (∞) indicates an open (damaged) winding. See Figure 14.

If the armature has an open circuit, there will normally be two burned commutator bars on opposite sides of the commutator. These burned areas will cause the brushes to wear rapidly. When the motor operates, large electric sparks and arcs occur as the damaged commutator bars rotate under each brush. See Table 2.

![Figure 14. Test for an Armature Open Circuit](image-url)
Tests for Damaged Field and Armature

TEST FOR SHORT CIRCUIT IN ONE ARMATURE WINDING

A short circuit in a motor winding is difficult to test because of the normal low resistance (less than 1 ohm) of a good armature. Special equipment is necessary to check for a short circuit in a motor winding. A motor with a short circuit in an armature winding will have a different sound when it begins to operate, but a service person must have experience to hear and understand the difference in sound. A winding with a short circuit will also run hotter than a good winding and can have indications of heat damage. A winding that shows heat damage when the other windings are normal can have a short circuit. See Figure 15.

Another indication of a short circuit will be a higher than normal current draw by the motor. A higher than normal current draw can also indicate other problems or needed adjustments and does not always indicate a short circuit in a motor winding.

Figure 15. Test for an Armature Winding Short Circuit

TEST FOR SHORT CIRCUIT TO ARMATURE SHAFT

NOTE: Clean the dirt and brush dust from the commutator area before making a test for a short circuit.

An ohmmeter (R x 10,000 scale) can be used to test for a short circuit between an armature winding and the armature shaft. Put one probe on the armature shaft and the other probe on a commutator bar. See Figure 16. A resistance of less than 1 megohm indicates a problem between a winding and the armature shaft.

Figure 16. Test for Short Circuit to Armature Shaft

TEST FOR OPEN CIRCUIT IN FIELD COIL

The field windings in large electric motors normally have less than 1 ohm of resistance. If an ohmmeter (R x 1 scale) is used to check the resistance between the two terminals of the winding, a resistance greater than 1 ohm indicates a problem in that winding or corrosion in the terminal connection. See Figure 17.

Figure 17. Test for Open Field Circuit
TEST FOR SHORT CIRCUIT IN FIELD COIL

A short circuit in a motor field winding is difficult to test because of the normal low resistance (less than 1 ohm) of a good field. Special equipment is necessary to check for a short circuit in a motor winding. A motor with a short circuit in a field winding will have a different sound when it begins to operate, but a service person must have experience to hear and understand the difference in sound. A winding with a short circuit will also run hotter than a good winding and can have indications of heat damage.

Another indication of a short circuit will be a higher than normal current draw by the motor. A higher than normal current draw can also indicate other problems or needed adjustments and does not always indicate a short circuit in a motor winding.

TEST FOR SHORT CIRCUIT BETWEEN FIELD AND MOTOR CASE

Make sure that carbon dust has been cleaned from the motor before making this test. An ohmmeter (R × 10,000 scale) can be used to test for a short circuit between the field and the motor case. Put one probe on the motor case and the other probe on a field terminal. Check the resistance between the field terminal and the motor case. A resistance of less than 1 megohm indicates a problem between the field terminal and the motor case.

BRUSH HOLDER TEST

Make sure the carbon dust has been removed from the brush holders. Use an ohmmeter (R × 10,000 scale) to measure the resistance between the brush holder and the motor case. The correct resistance is an indication of infinity (∞).

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>POSSIBLE CAUSE</th>
<th>PROCEDURE OR ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy streaks and fine grooves (see Table 2).</td>
<td>Operation in a dirty or abrasive environment.</td>
<td>Clean commutator more frequently.</td>
</tr>
<tr>
<td></td>
<td>Continuous operation of motor with a light load.</td>
<td>Increase load on motor from time to time.</td>
</tr>
<tr>
<td></td>
<td>Brush pressure is too low.</td>
<td>Increase brush pressure.</td>
</tr>
<tr>
<td></td>
<td>Worn brushes.</td>
<td>Replace brushes.</td>
</tr>
<tr>
<td>Grooves and lines following heavy streaks. The armature must be replaced or the brushes will wear rapidly (see Table 2).</td>
<td>Operation in a dirty or abrasive environment.</td>
<td>Clean commutator more frequently.</td>
</tr>
<tr>
<td></td>
<td>Continuous operation of motor with a light load.</td>
<td>Increase load on motor from time to time.</td>
</tr>
<tr>
<td></td>
<td>Brush pressure is too low.</td>
<td>Increase brush pressure.</td>
</tr>
<tr>
<td></td>
<td>Worn brushes.</td>
<td>Replace brushes.</td>
</tr>
<tr>
<td>PROBLEM</td>
<td>POSSIBLE CAUSE</td>
<td>PROCEDURE OR ACTION</td>
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<tr>
<td>------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Grooves the width of the brushes (see Table 2).</td>
<td>Operation in a dirty or abrasive environment.</td>
<td>Clean commutator more frequently.</td>
</tr>
<tr>
<td></td>
<td>Wrong type of brushes for this motor and operation.</td>
<td>Replace brushes with correct type.</td>
</tr>
<tr>
<td></td>
<td>Brush pressure is too high.</td>
<td>Adjust brush pressure.</td>
</tr>
<tr>
<td>Copper drag occurs when copper from the commutator is pulled into the slot between the commutator bars. This problem will cause a short circuit between the commutator bars (see Table 2).</td>
<td>Operation in a dirty or abrasive environment.</td>
<td>Clean commutator more frequently.</td>
</tr>
<tr>
<td></td>
<td>Brush holder is not correctly adjusted electrically for the motor.</td>
<td>Adjust brush holder.</td>
</tr>
<tr>
<td></td>
<td>Wrong type of brushes for this motor and operation.</td>
<td>Replace brushes with correct type.</td>
</tr>
<tr>
<td></td>
<td>Brush pressure is incorrect (too high or too low).</td>
<td>Adjust brush pressure.</td>
</tr>
<tr>
<td>Electrical burns on commutator bars on opposite sides of the commutator (see Table 2).</td>
<td>Open armature winding.</td>
<td>Replace armature.</td>
</tr>
<tr>
<td></td>
<td>Motor has been stalled.</td>
<td>Use correct operating techniques.</td>
</tr>
<tr>
<td>Copper wears rapidly at the edge of the commutator bars (see Table 2).</td>
<td>Operation in a dirty or abrasive environment.</td>
<td>Clean commutator more frequently.</td>
</tr>
<tr>
<td></td>
<td>Wrong type of brushes for this motor and operation.</td>
<td>Replace brushes with correct type.</td>
</tr>
<tr>
<td>PROBLEM</td>
<td>POSSIBLE CAUSE</td>
<td>PROCEDURE OR ACTION</td>
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</tbody>
</table>
| Burning/Overheating          | 1. Flashover causes burning of the commutator bar.  
                              | 2. Open circuit in winding causes deep burning of adjacent commutator bars.  
                              | 3. Overheating causes damage to varnish insulation (see Table 2).  | Motor has been too hot.  
                              | Wrong lift truck for the application.  
                              | Motor has been stalled.  
                              | Open armature winding.  
                              | Open field coil.  | Use correct lift truck for the application.  
                              | Use correct operating techniques.  
                              | Replace armature or resurface commutator in a lathe.  
                              | Replace field coil.  |
| Commutator bars are either too high or too loose, both of which can cause damage to brushes (see Table 2). | Motor has been stalled.  | Use correct operating techniques.  |
| Motor has been too hot.      | Use correct lift truck for the operation.  |