



# Switched Reluctance (SR) Drive Motor

## Section 06-02

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# Scope of This Publication

To briefly describe the SR motor, its component parts, motor settings and adjustments.

## Safety

This publication contains special instructions that pertain to safety, operation, maintenance, and repair of the motor. Listed below are the signal words and symbols that precede these instructions and their meanings:


### DANGER

- The danger label indicates a hazardous situation which, if not avoided, will result in death or serious injury.

### WARNING

- The warning label indicates a hazardous situation which, if not avoided, could result in death or serious injury.

### CAUTION

- The caution label, used with the safety alert symbol indicates a hazardous situation which, if not avoided, could result in minor or moderate injury (includes the safety alert symbol .

### CAUTION

- The caution label (without safety alert symbol) is used to address practices not related to personal injury – only equipment damage.

### NOTICE

The NOTICE graphic is to indicate areas of importance to the reader that are not related to personal injury or machine damage.

## Safety, Warnings and Cautions

### WARNING

#### ELECTRICAL SHOCK

- Electrical shock hazard exists if touching the braking grids, motor leads, or any electrical connections when the generator is primed or until five minutes after the engine has been shut down following operation of the machine, or if the ignition switch is switched ON. Do not touch any of these components if they are energized. Contact with these components could result in serious injury or death.
- Electrical shock hazard exists if performing inspection or service procedures that involves contact with any component of the electrical system, opening the electrical converter cabinet or

removing axle access covers. Before touching any electrical components, the electrical system **MUST** be locked out. Follow local procedures for that process. Failure to avoid touching energized components can cause electrical hazards resulting in serious injury or death.

- **Electrical shock hazard exists when entering the electrical converter cabinet. Dangerously high voltage may be present in the Electrical Converter Cabinet at high throttle, after the engine goes to low throttle, or for five minutes after the engine is shut off or any time the ignition key is switched ON. Do not enter the cabinet before performing the Bus Discharge Verification Procedure. Failure to perform the Bus Discharge Verification Procedure can cause shock hazards resulting in serious injury or death.**
- **Electrical shock hazards exist when the red LED lights on the control boards are glowing. Converter bus voltage (up to 730 VDC) is present in the electrical cabinet and at the braking grids when the red LED lights are glowing on the Control Boards. The Control Boards are located on the face of each Converter Assembly inside the converter cabinet. Perform the Bus Discharge Verification Procedure before entering the electrical converter cabinet. Failure to perform the bus discharge verification procedure before entering the electrical converter cabinet can cause electrical shock hazards resulting in serious injury or death.**
- **Electrical shock hazard exists if using common rubber hose or rubber wrap to insulate electrical connectors. Do not use these materials as they may be conductive. Only use materials that are specified for electrical insulation. Failure to use proper insulating materials can cause shock hazards resulting in serious injury or death.**
- **Electrical shock hazards exists if entering or placing any body part inside the electrical converter cabinet. The potential voltage on a bus that has not discharged could be over 700VDC. Perform the Bus Discharge Verification Procedure before entering the electrical converter cabinet, axle housings or braking grid enclosure. Check with site specific isolation procedures before working on the machine. Failure to perform the bus discharge verification procedure before entering the electrical converter cabinet can cause electrical shock hazards resulting in serious injury or death.**
- **Risk of fatal electrical shock or injury by contact in the electrical cabinet is possible if the engine is running, the LINC software indicates voltage on the bus, or the red bus LED's in the electrical cabinet are illuminated. All Generation II SR equipment has the ability to produce voltage at low throttle. Even with the engine off, there may be a residual of 12-15VDC on the bus. Do not enter the electrical cabinet or touch any components in the electrical cabinet without performing the Bus Discharge Verification Procedure. Failure to do so may result in fatal electrical shock or other injury.**

### **CRUSH HAZARD**

- **Crush hazards exist in machine pivot area and area between the tires. Do not enter these areas unless it is verified that the operator has control over the steering and that personnel locking the frame lock have good communication with the operator. Entering the pivot area and area between the tires while the machine is moving or pivoting (articulating) could cause crush hazards resulting in serious injury or death.**

## **CAUTION**

### **MOTOR DAMAGE**

- **Use caution when installing the motor into the axle of the loader. The copper terminals must not be hit against the axle during installation. If the bar is hit it can push into the motor and damage the internal insulation. The damaged insulation may allow the metallic brake dust to accumulate and cause either phase to phase short circuit or a phase to ground short circuit.**

### **ELECTRICAL SHORT CIRCUIT**

- **Be sure that the bolts used to bolt the leads are not too long and cause a short circuit. The connections should be coated with an electrical insulation paint or varnish to prevent short circuits in the event of contamination build up in the bottom of the axle.**

# Introduction



Figure 1. SR motors (typical)

## B40A SR Motor (L-1350)

The B40A is a dual bearing SR motor. It consists of a 12 pole stator and an 8 pole rotor. The motor is a bi directional 4 quadrant motor. This means it is capable of operating in power mode or generator mode for retarding. It does not use any brushes. The endbell and bearing components on the motor are the same or similar to those used on the B40 motors, for parts commonality. The motor is rated up to 3500 rpm and runs at varying speeds depending on the command and limits of the machine.

## B60 SR Motor (L-1850/2350)

The B60 is a dual bearing SR motor. It consists of an 18 pole stator and a 12 pole rotor. The motor is a bi directional 4 quadrant motor. This means it is capable of operating in power mode or generator mode for retarding. It does not use any brushes. The motor is rated up to 3000 rpm and runs at varying speeds depending on the command and limits of the machine.

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# Component Descriptions

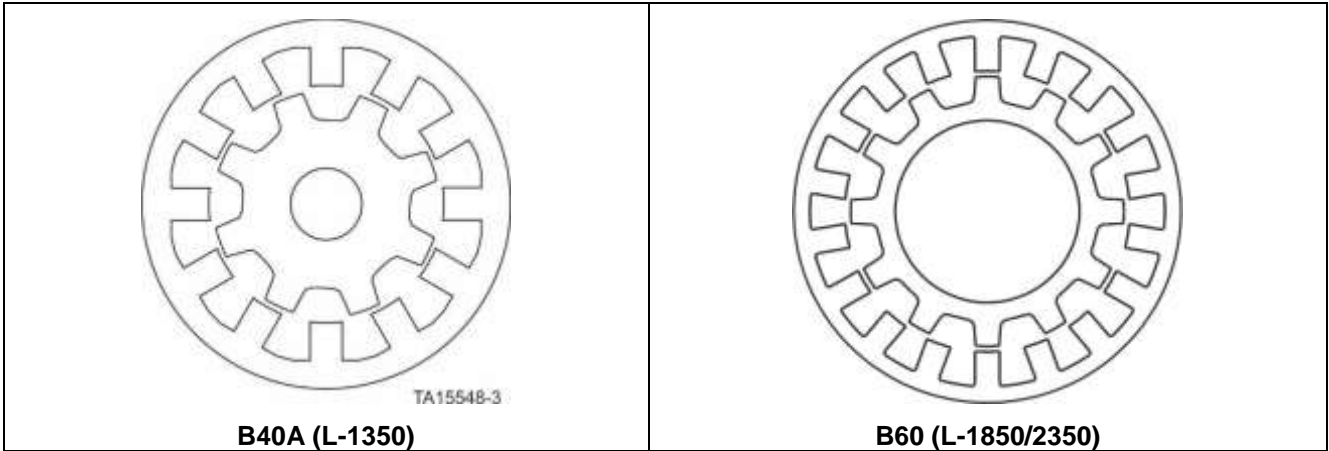


Figure 2. Motor laminations

## Rotor

The rotor does not have any copper – it consists of laminations with poles mounted on a shaft, pressed, and held together with plates at each end.



Figure 3. Rotor (typical)

## Stator

Each pole of the stator has a single multi-turn coil of copper wire. These coils are installed in a “green” state (no epoxy or varnish in the coil) and then the stator is processed in a (VPI) Vacuum Pressure Impregnated system to fully impregnate the coil and adhere the coil to the stator pole.

### NOTICE

The B40A motor stator is different from the B40 motor stator and is not interchangeable. The coils have different number of turns and there have been some small changes to the endbell to allow mounting of the Rotor Position Transducer (RPT) assembly.

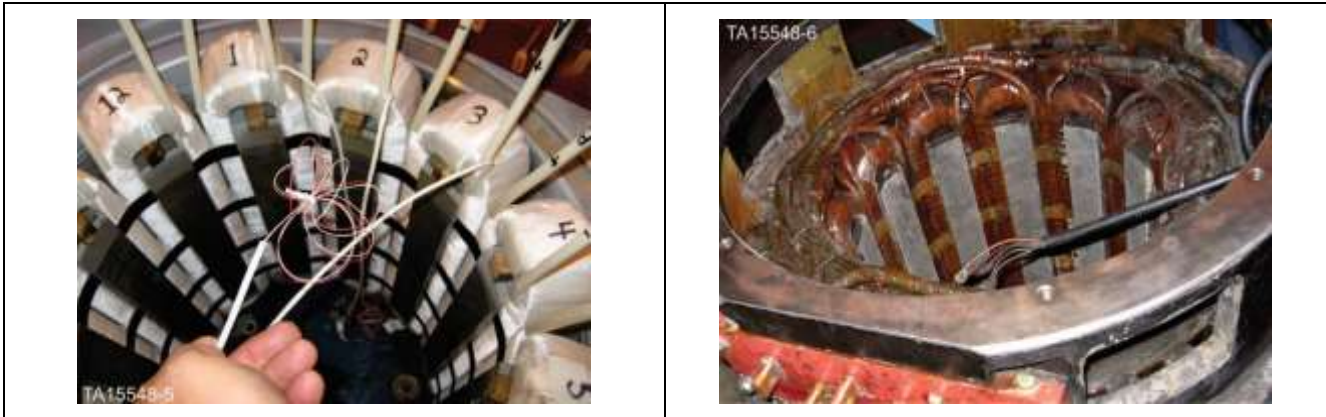


Figure 4. Stator coils (typical)

# Stator Coils

The coils are joined in parallel in 3 groups or phases. All of the coils in a group are energized at the same time.

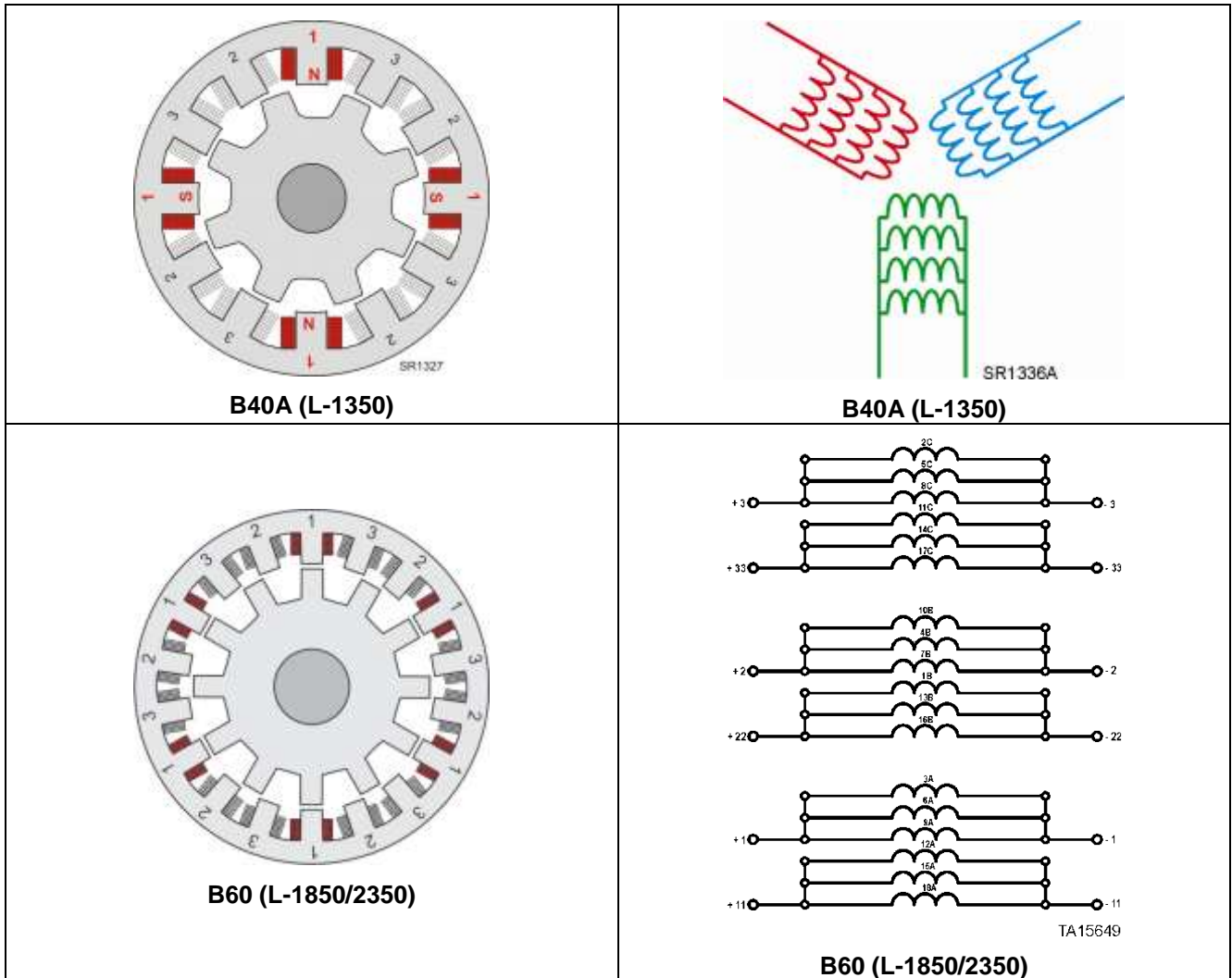


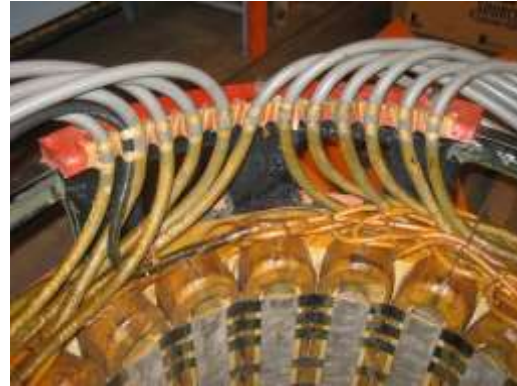
Figure 5. Motor coil groups

# Internal Connections

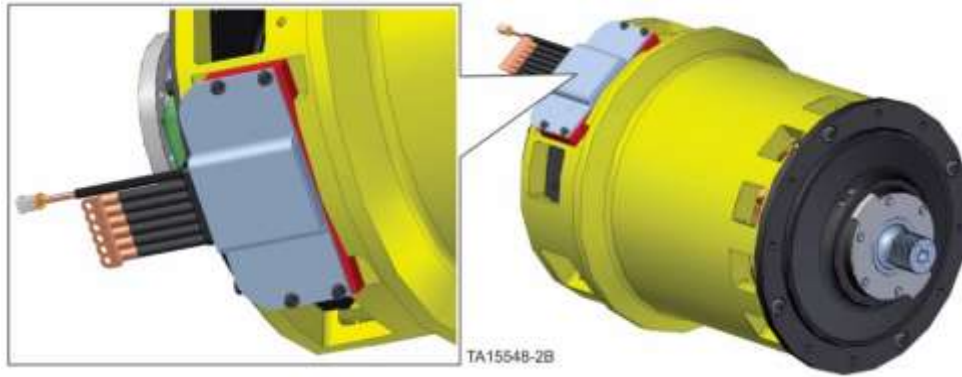
There are 3 sets of primary power connections to the motor. Early production motors had leads attached externally to the motor, and could be removed (unbolted) from the motor. The leads on current production motors are attached to the coils inside the motor and cannot be removed by unbolting.



B40A (L-1350) early production leads

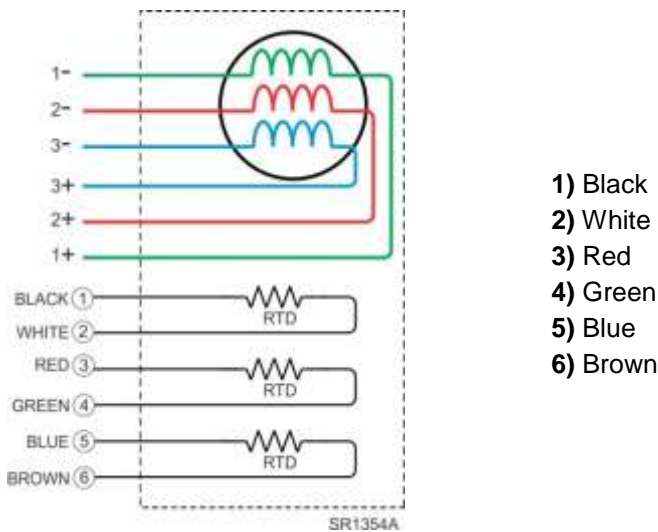


B60 (L-1850/2350)



B40A (L-1350) current production leads

Figure 6. Motor leads (typical)



- 1) Black
- 2) White
- 3) Red
- 4) Green
- 5) Blue
- 6) Brown

Figure 7. Internal motor lead connections (typical)

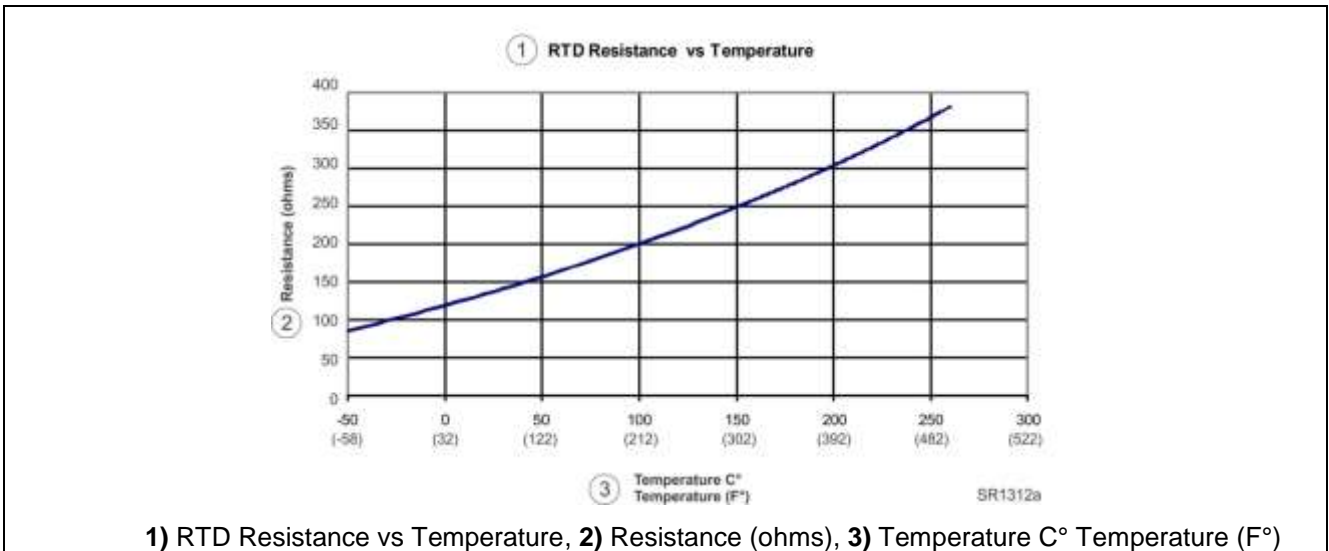
# Resistance Temperature Detectors (RTD)

The temperature of the motor is monitored by RTD devices. These are installed along with the coils during fabrication of the stator. The stator is then VPI'd. These devices cannot be changed without changing the coil.



**Figure 8. Motor RTD (typical)**

The RTD has a nominal resistance of 120 ohms at 0°C (32°F). Resistance increases as temperature increases as shown below. The motor has 3 RTD sensors – one per group of coils. The LINCII software only looks at the highest temperature so the motor can run with less than 3 RTDS. A defective RTD would be shorted out, so it will be ignored by the LINCII software.



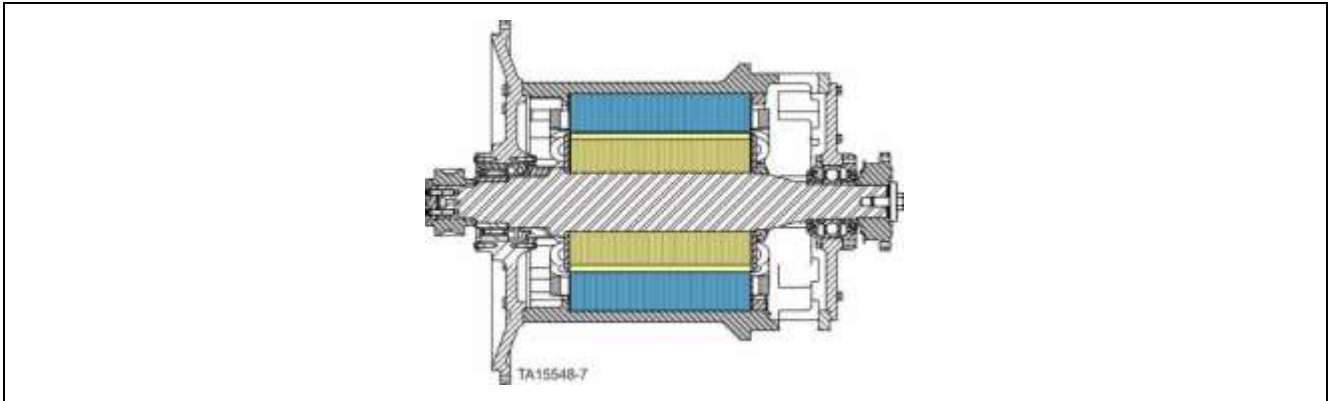
**1) RTD Resistance vs Temperature, 2) Resistance (ohms), 3) Temperature C° Temperature (F°)**

**Figure 9. RTD temperature chart**

There is an RPT connector and RTD connector on the motor. They are connected by a cable located near the power connections in the axle. These devices are all connected directly to the associated master converter panels in the electrical cabinet.

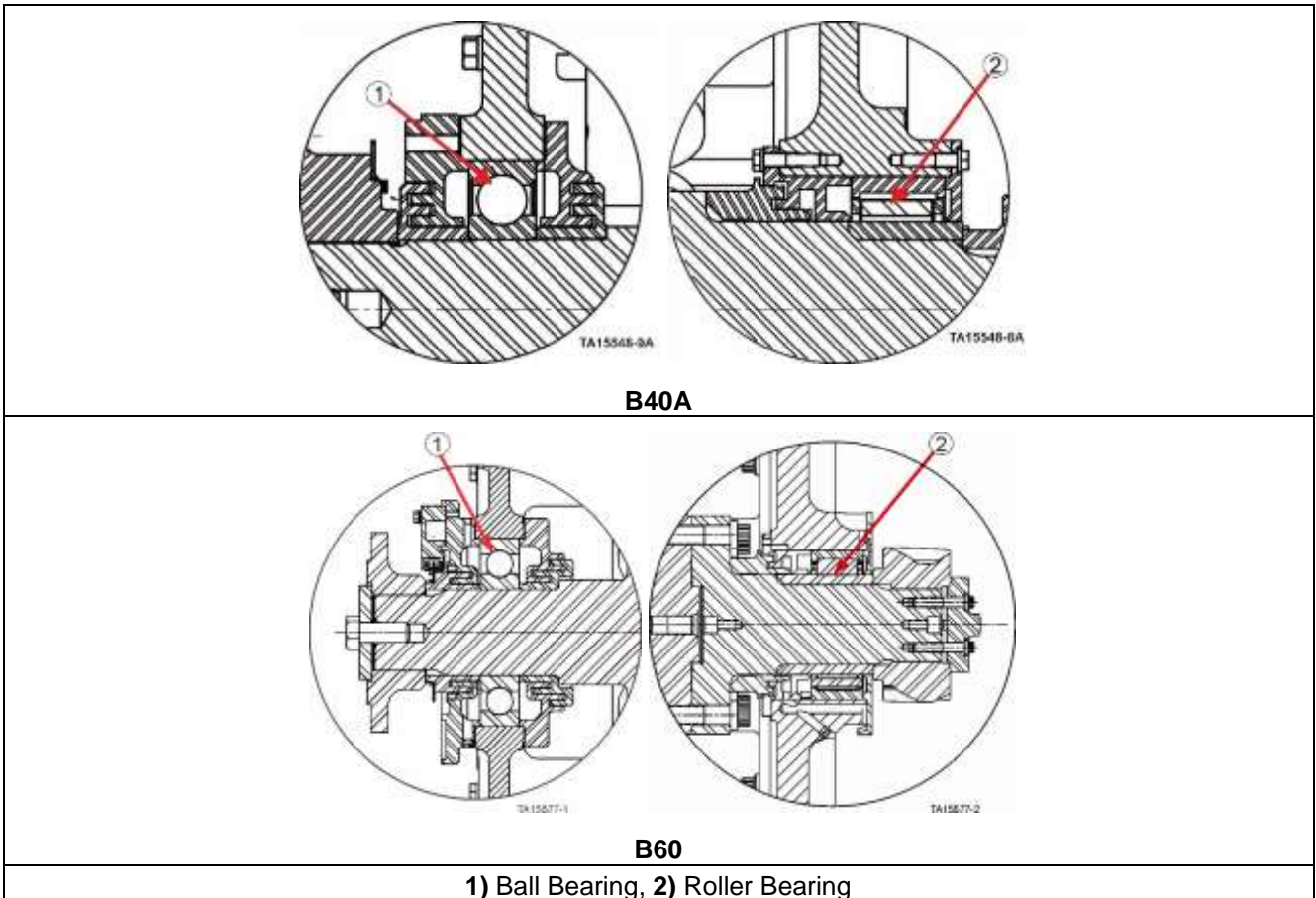
# Bearings

The motor has two bearings. Both bearings use non contact labyrinth type seal systems. The bearings and labyrinth seals do not require any additional greasing during their operating lifetime. The grease will be replaced during motor rebuild.

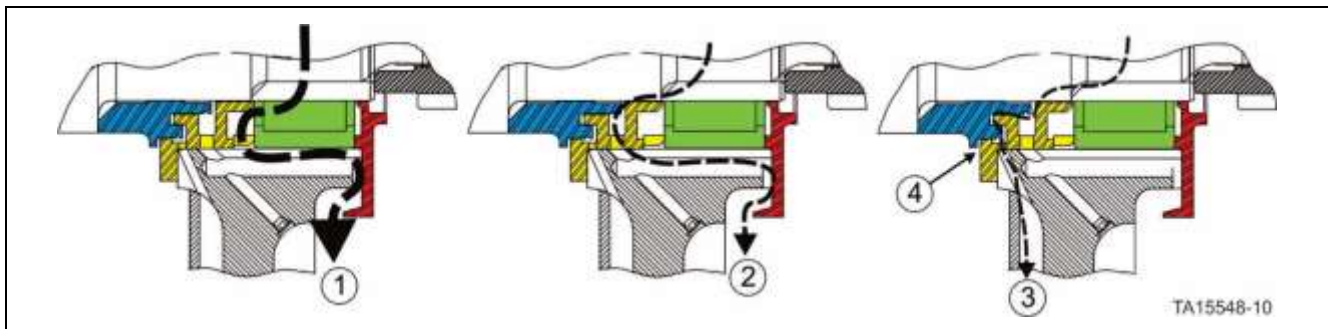


**Figure 10. Motor cross section (typical)**

The rotor end connected to the planetary drive (Drive End - DE), uses a roller bearing that is lubricated by the oil in the planetary drive. It has a three stage labyrinth on one side to prevent oil from going into the motor. Please note that this type of seal will leak oil when stationary if the oil level is over full or if the machine is parked on a severe side slope. The rotor end connected to the brake disk (Non Drive End - NDE), uses a roller bearing that has a grease filled labyrinth on both sides of the bearing.



**Figure 11. Roller and ball bearing configurations**  
 1) Ball Bearing, 2) Roller Bearing



- 1) Primary oil flow back into planetary drive.
- 2) Secondary oil flow that gets past slinger goes back into planetary drive.
- 3) Third oil flow is typically nothing. Any oil that gets to this location will flow through angle on endbell into axle.
- 4) This area will typically be wet with oil and may attract dust.

**Figure 12. Roller bearing labyrinth oil flow (typical)**

## Rotor Position Transducer (RPT)

The position and speed of the motor is determined by use of RPT (Rotor Position Transducer) device mounted on the end of the motor next to the brake disk. The RPT reads the position of the shutter tabs as they pass through the sensor. Only three of the six RPT's are used at any one time, the other three are spares.



Figure 13. Motor RPT assembly (typical)

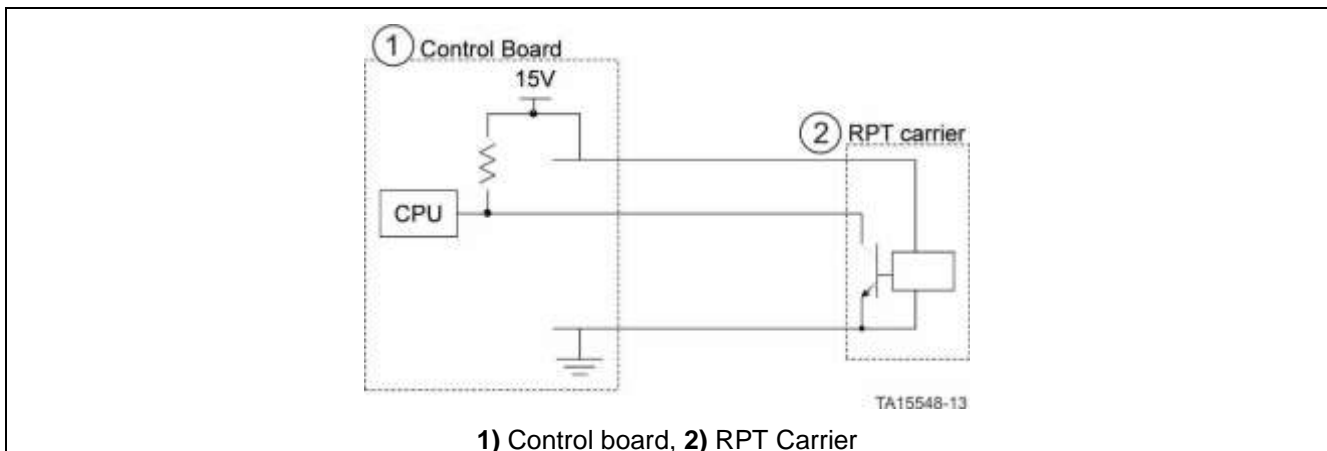


Figure 14. RPT schematic (typical)

## Bearing Maintenance

Typical bearing life will be 15,000-20,000 hours. However this can vary widely depending on the application and duty cycle of the mine.

## NOTICE

Check bearing clearance periodically to determine when wear is occurring. Use trend analysis to determine bearing condition.

# Removal and Installation

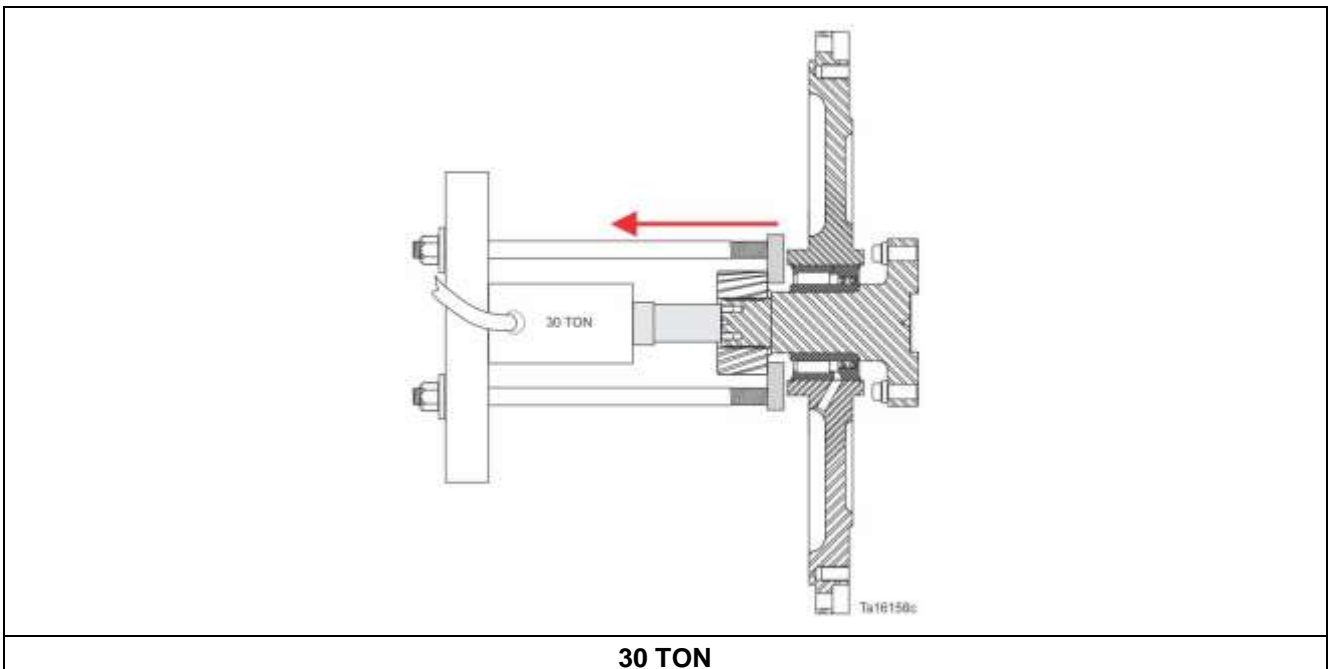
## Removal of Shell Pinion (Wheel Loader Traction Motor)

- a. Install a bearing puller with lip behind the pinion.



Figure 15. Bearing puller installation

- b. Install a 30 TON porta-power.
  - Use 1" diameter puller bars.



30 TON  
Figure 16. Pinion puller installation

- c. Attempt to pull the shell pinion.
  - If the shell pinion does not move at 30 tons – remove the ram.
- d. Evenly apply heat to the shell pinion with a large rosebud type heating tip - preferably two (2) so that the shell pinion can be heated as quickly as possible before the heat soaks into the pinion shaft. Typically only 200°F is required to remove the shell pinion.

## CAUTION

**DO NOT** use a cutting tip. **DO NOT** allow any localized heating on the shell pinion - keep the heating tips moving.

## CAUTION

**DO NOT** exceed 275° F (135°C) at any point on the pinion. Use temperature paint or crayons of a lower value to monitor the temperature.

## CAUTION

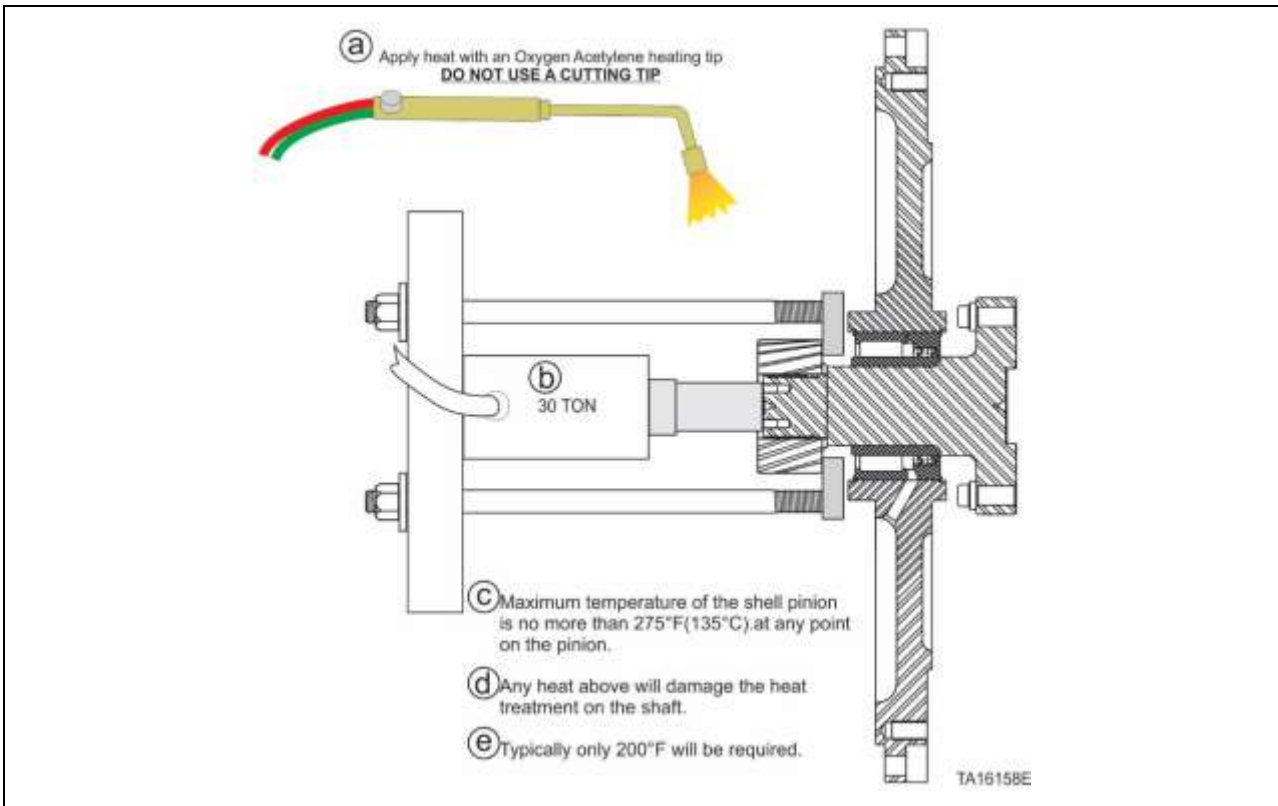
Heating the pinion will likely temper (soften) the parts of the pinion and it is likely that the shell pinion will crack when put under load.

## CAUTION

This procedure sacrifices the shell pinion to assure no damage to the shaft. The pinion should not be reused. The heat is limited so that the shaft is not damaged



**Figure 17. Heating the shell pinion**



**a)** Apply heat with an Oxygen Acetylene heating tip **DO NOT USE A CUTTING TIP**, **b)** 30 TON, **c)** Maximum temperature of the shell pinion is no more than 275°F (135°C) at any point on the pinion, **d)** Any heat above will damage the heat treatment on the shaft, **e)** Typically only 200°F will be required.

**Figure 18. Puller setup**

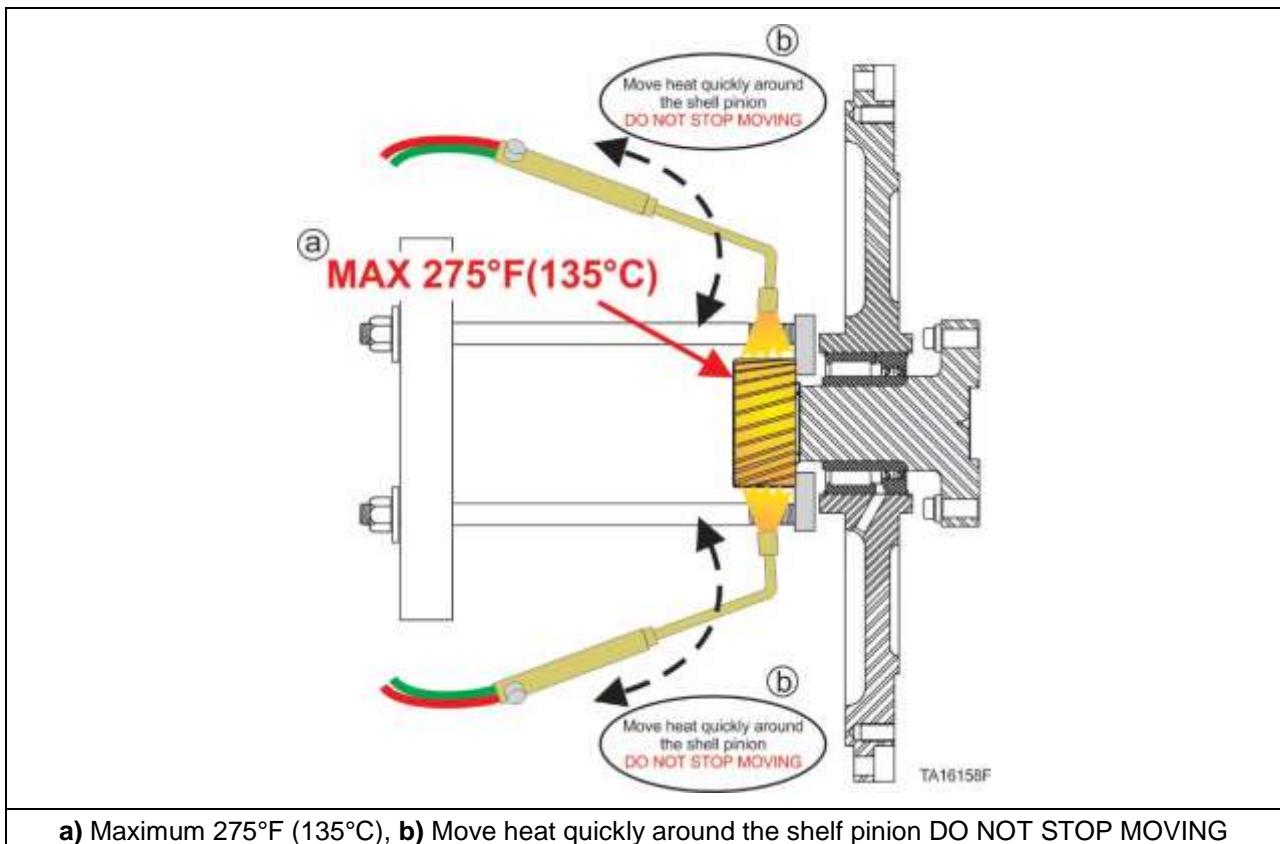
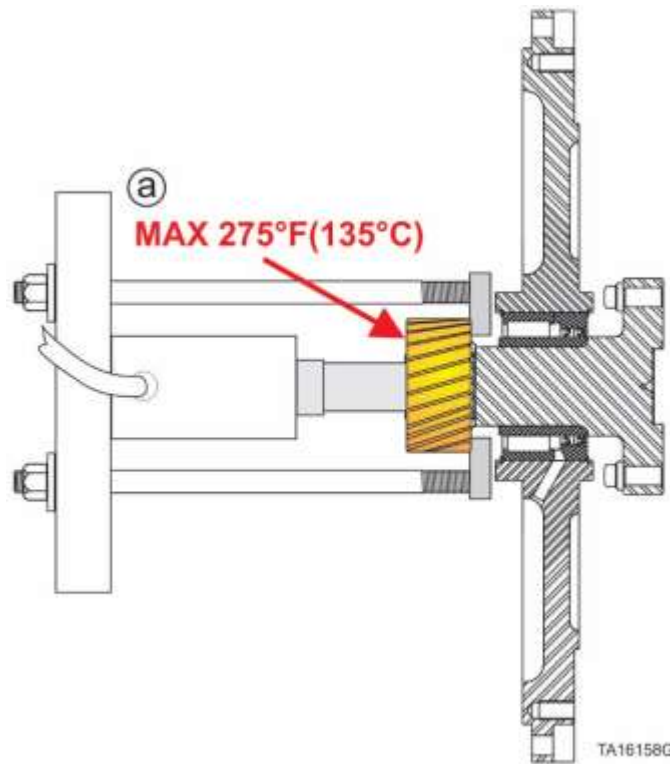


Figure 19. Heating the pinion

- e. Quickly install the ram and pull the shell pinion off.

## CAUTION

Increased or prolonged heating of the shell pinion can cause heat to soak into the pinion shaft and cause damage to the splines when the pinion is removed.



a) Maximum 275°F (135°C)

Figure 20. Heated pinion

## NOTICE

If the shell pinion still does not move, then the shell pinion will need to be cut off in order to save the pinion shaft.

## CAUTION

Do not increase the tonnage of the porta-power as spline damage to the pinion shaft and the shell pinion can occur.

## Installation of New Shell Pinion (Wheel Loader Traction Motor)

- a. Prior to installation, check the ends of the splines on pinion shaft and the splines internal to the shell pinion. File all burrs and edges so that they can engage properly.
  - The spline teeth on the pinion shaft and the shell pinion should be thoroughly cleaned and checked for burrs before installation.

## NOTICE

Even small particles of dirt or burrs can produce galling and greatly increase the force required for installation (or prevent installation entirely).

# NOTICE

For installation, have all the appropriate press equipment for pressing the shell pinion onto the shaft.

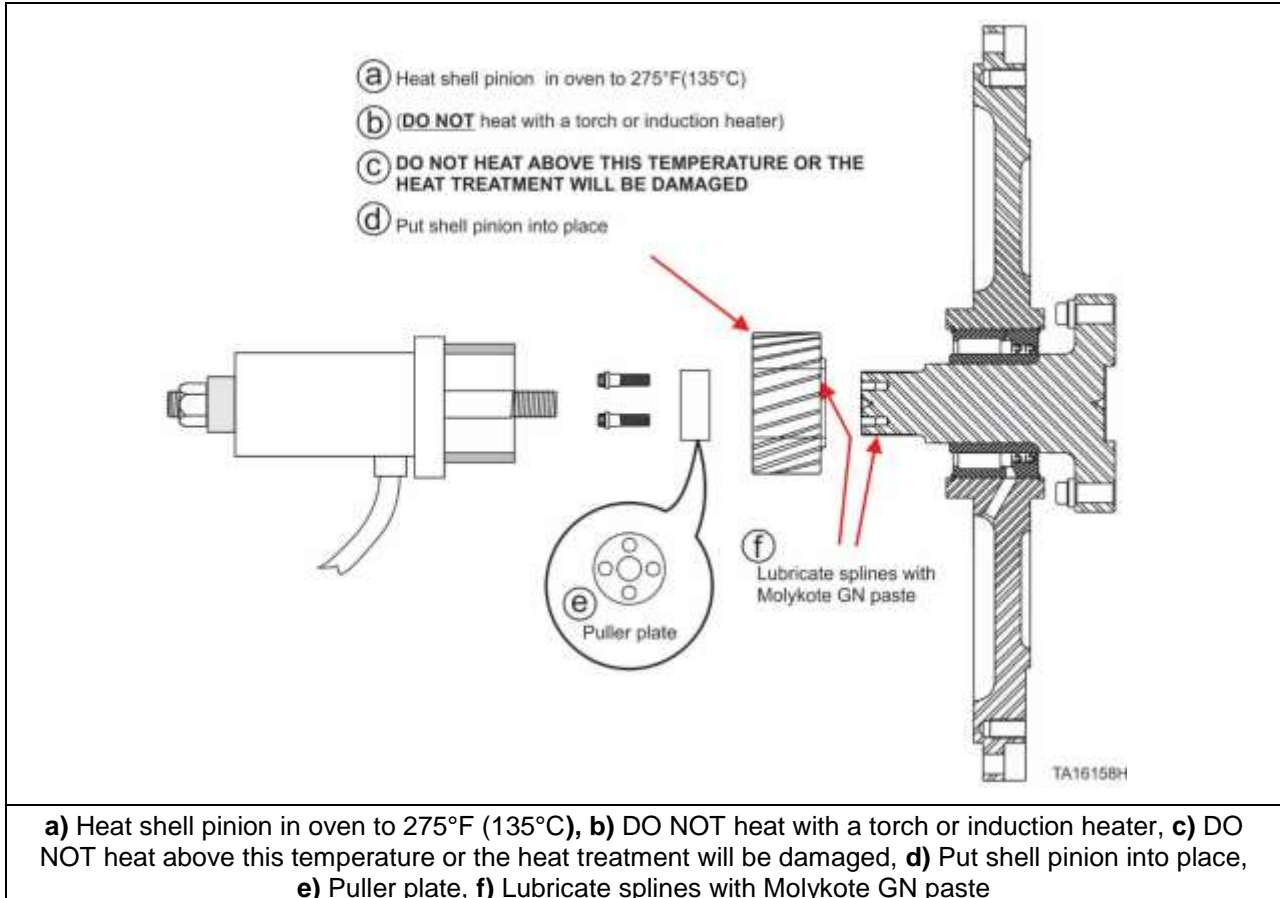


Figure 21. Pinion installation assembly

- b. A thin coat (almost invisible) of MolyKote GN paste should be applied to the splines on the pinion shaft and in the shell pinion to aid in installation and to prevent galling.
- Heat the pinion in an oven to 275° F (135°C).

## CAUTION

The pinion should NEVER be heated above 275°F (135°C) as temperatures above this will temper (soften) the carburized case of the teeth.

## CAUTION

DO NOT heat the shell pinion with a torch.

## CAUTION

DO NOT heat the shell pinion with an induction heater. The induction heater will heat the pinion unevenly and can damage the shell pinion.

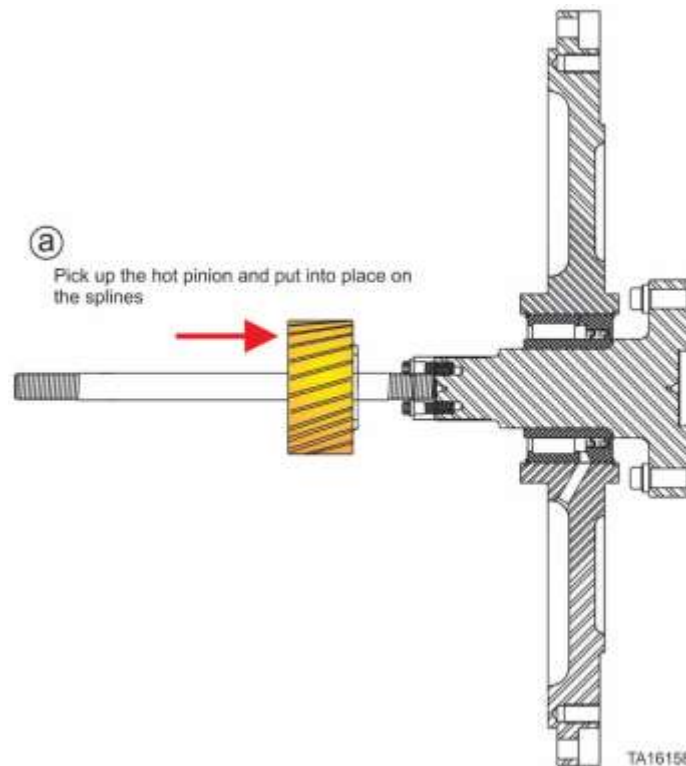
## ⚠ CAUTION

Use proper gloves for handling the hot shell pinion.

- c. Place the shell pinion onto the shaft.

## NOTICE

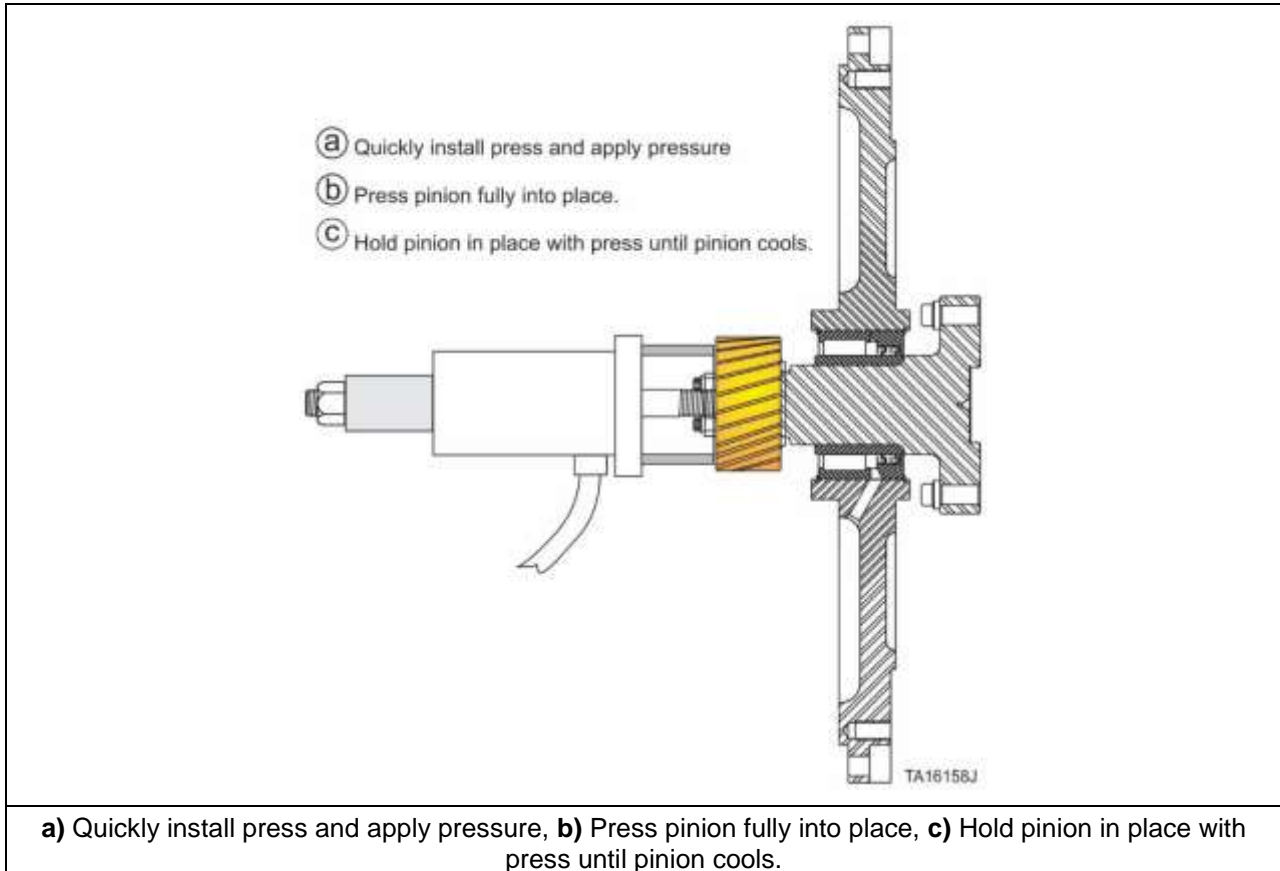
This will typically install fully onto the splines by hand without pressing.



a) Pick up the hot pinion and put into place on the spines

**Figure 22. Moving hot pinion**

- d. Once the pinion is in place, quickly install the press and press the shell pinion with a hydraulic press (port-a-power). With the shell pinion at this temperature, only about 5 to 10 tons of press is required to hold it in place while cooling.

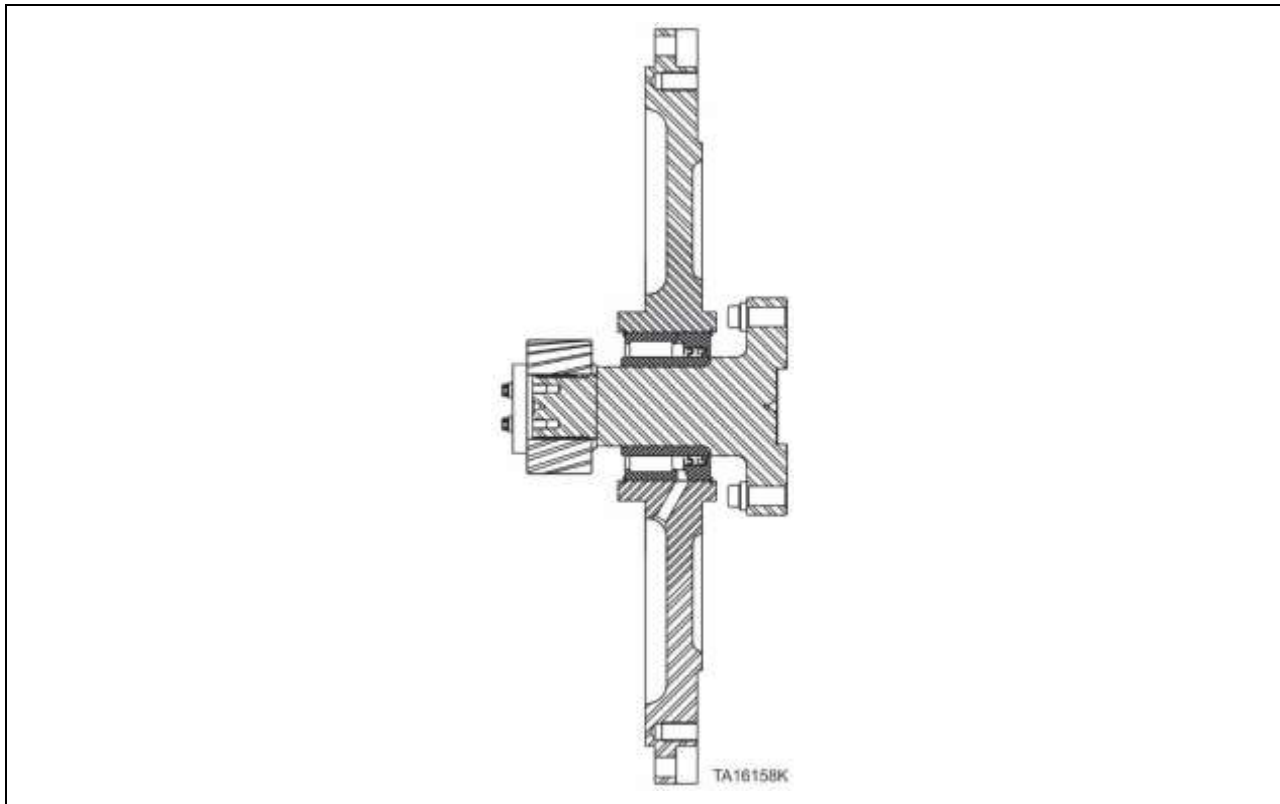


**Figure 23. Press the pinion onto shaft**

## CAUTION

### Hold in place with press until it cools

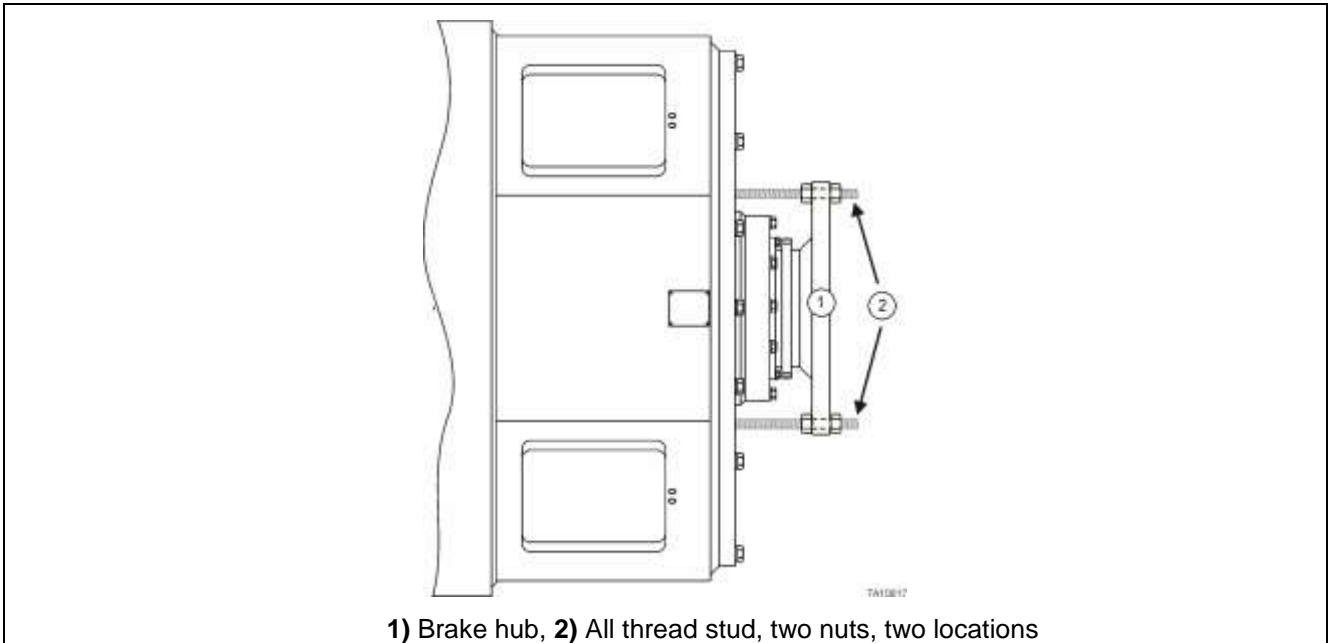
- e. Remove press
- f. Install the retainer plate and capscrews
- g. Torque capscrews per the torque chart.



**Figure 24. Cross-section of pinion installed**

## Shipping Motor to Rebuild Facility

- a. Remove disc brake rotor and caliper assembly per the instructions in DISC PAD REPLACEMENT. Do not remove the brake hub. The brake hub must be sent to the rebuild center with the motor as it is an important part of assembly and testing procedures.
- b. Remove motor seal ring.
- c. Hoist the motor onto a shipping pallet and remove hoisting device.
- d. Lock armature shaft to prevent bearing brinelling damage during shipment (caused by excessive vibration). Lock the armature with studs and nuts or bolts (of the appropriate size and length for your application) between the brake hubs and endbell. The fasteners should only be tightened enough to remove the end play from the bearing.
- e. Secure motor onto pallet with metal banding and then construct a plywood box around the motor.



**Figure 25. Typical locking procedure for traction motor**

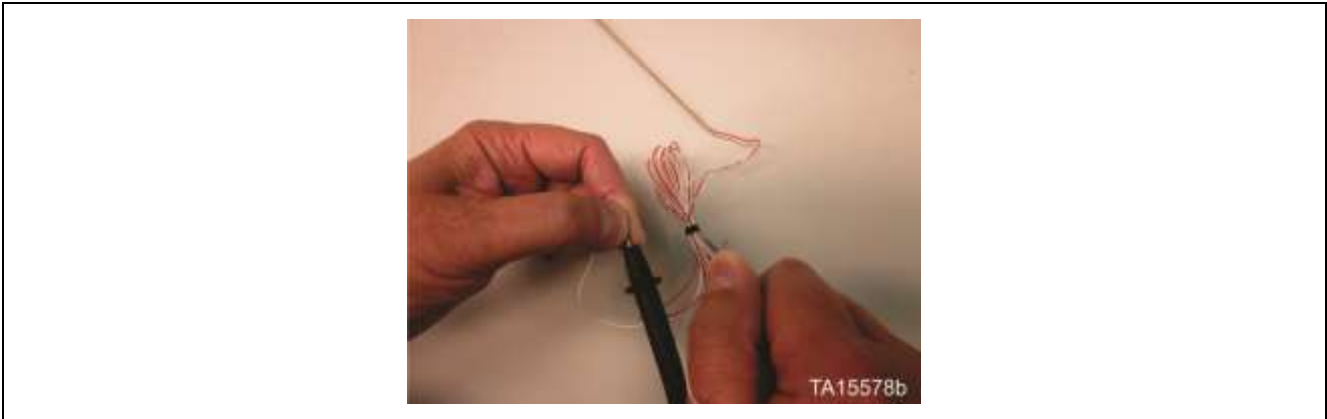
# Troubleshooting

## Testing RTD Cable Pairs

Configure multimeter to read 200 ohms.



Test cable pairs on RTD cable.



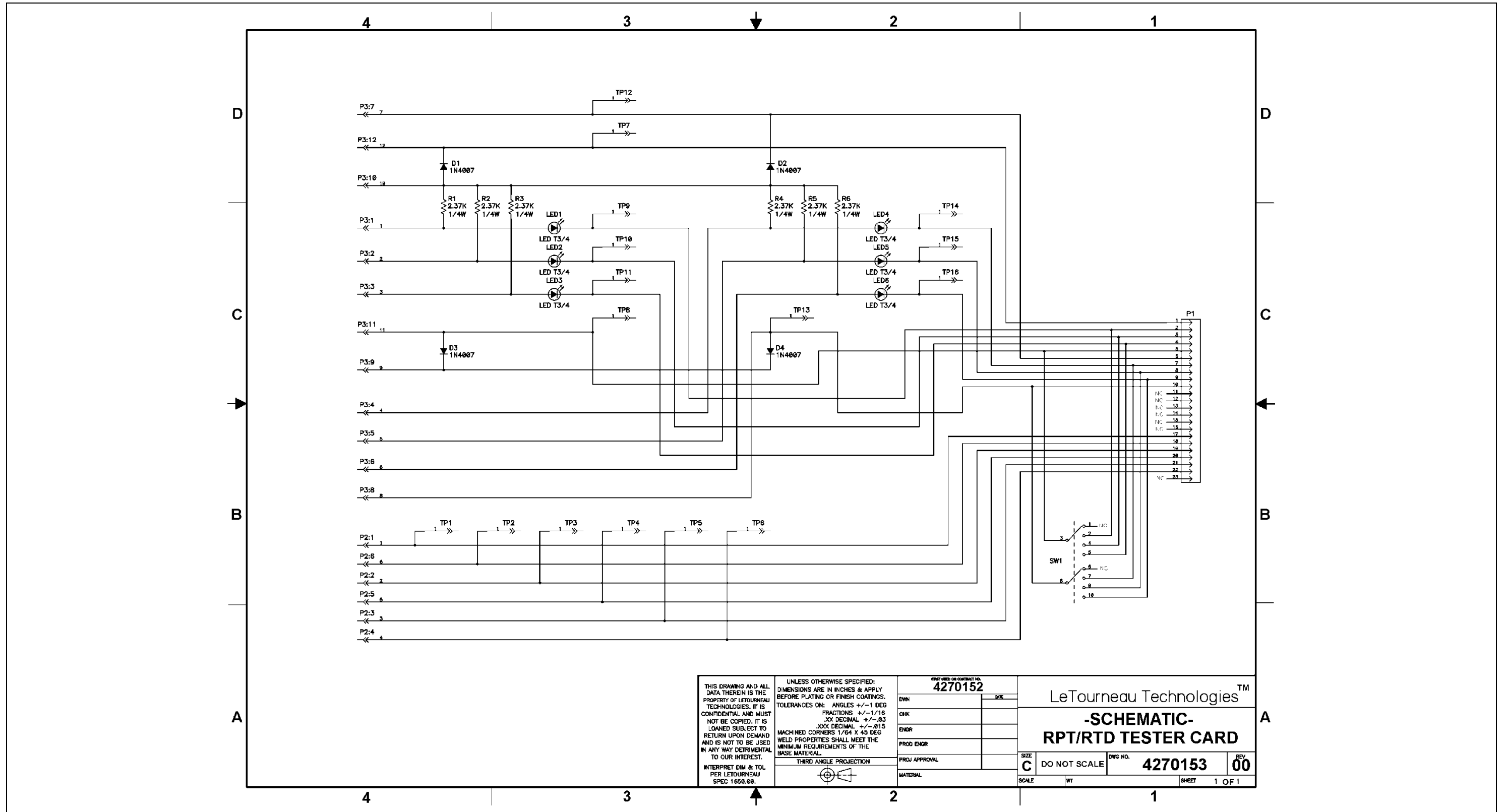
RTD	Six Conductor Cable Pair	Meter Test Leads	Measurement @ Room Temperature
1B	White	Red	134 – 142 Ω
1B	Black	Black	134 – 142 Ω
2C	Orange (Brown)	Red	134 – 142 Ω
2C	Blue	Black	134 – 142 Ω
3A	Green	Red	134 – 142 Ω
3A	Red	Black	134 – 142 Ω

Meter should read between 134 to 142 ohms (optimal reading is 134-142 ohms at room temperature).

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# Schematics

## RPT/RTD Test Card Schematic



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