BALDOR • RELIANCE

RPM Low Voltage DC Bus Motor, Frame 140

Designed for operation with an SCR Control

4/09 Installation & Operating Manual MN606

Important:
Be sure to check www.baldor.com to download the latest version of this manual in Adobe Acrobat PDF format.

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Section 1

General Information

Overview

This manual contains general procedures that apply to Baldor Motor products. Be sure to read and understand the Safety Notice statements in this manual. For your protection, do not install, operate or attempt to perform maintenance procedures until you understand the Warning and Caution statements.
A Warning statement indicates a possible unsafe condition that can cause harm to personnel.
A Caution statement indicates a condition that can cause damage to equipment.

Important:

This instruction manual is not intended to include a comprehensive listing of all details for all procedures required for installation, operation and maintenance. This manual describes general guidelines that apply to most of the motor products shipped by Baldor. If you have a question about a procedure or are uncertain about any detail, Do Not Proceed. Please contact your Baldor District Office for more information or clarification.

Before you install, operate or perform maintenance, become familiar with the following:

- NEMA Publication MG-2, Safety Standard for Construction and guide for Selection, Installation and Use of Electric Motors and Generators.
- ANSI C51.1
- The National Electrical Code
- Local codes and Practices

Safety Notice:

This equipment contains high voltage! Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt installation, operation and maintenance of electrical equipment.
Be sure that you are completely familiar with NEMA publication MG-2, safety standards for construction and guide for selection, installation and use of electric motors and generators, the National Electrical Code, IEC and local codes and practices. Unsafe installation or use can cause conditions that lead to serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.

WARNING: Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.

WARNING: Disconnect all electrical power from the motor windings and accessory devices before disassembling of the motor. Electrical shock can cause serious or fatal injury.

WARNING: Be sure the system is properly grounded before applying power. Do not apply AC power before you ensure that all grounding instructions have been followed. Electrical shock can cause serious or fatal injury.

WARNING: Avoid extended exposure to machinery with high noise levels. Be sure to wear ear protective devices to reduce harmful effects to your hearing.

WARNING: Surface temperatures of motor enclosures may reach temperatures which can cause discomfort or injury to personnel accidentally coming into contact with hot surfaces. When installing, protection should be provided by the user to protect against accidental contact with hot surfaces. Failure to observe this precaution could result in bodily injury.

WARNING: Guards must be installed for rotating parts to prevent accidental contact by personnel. Accidental contact with body parts or clothing can cause serious or fatal injury.

WARNING: This equipment may be connected to other machinery that has rotating parts or parts that are driven by this equipment. Improper use can cause serious or fatal injury. Only qualified personnel should attempt to install operate or maintain this equipment.

WARNING: Do not by-pass or disable protective devices or safety guards. Safety features are designed to prevent damage to personnel or equipment. These devices can only provide protection if they remain operative.

WARNING: Avoid the use of automatic reset devices if the automatic restarting of equipment can be hazardous to personnel or equipment.

WARNING: Incorrect motor rotation direction can cause serious or fatal injury or equipment damage. Be sure to verify motor rotation direction before coupling the load to the motor shaft.

WARNING: Be sure the load is properly coupled to the motor shaft before applying power. The shaft key must be fully captive by the load device. Improper coupling can cause harm to personnel or equipment if the load decouples from the shaft during operation.

WARNING: Use proper care and procedures that are safe during handling, lifting, installing, operating and maintaining operations. Improper methods may cause muscle strain or other harm.

WARNING: Pacemaker danger – Magnetic and electromagnetic fields in the vicinity of current carrying carrying conductors and permanent magnet motors can result result in a serious health hazard to persons with cardiac pacemakers, metal implants, and hearing aids. To avoid risk, stay way from the area surrounding a permanent magnet motor.

WARNING: Before performing any motor maintenance procedure, be sure that the equipment connected to the motor shaft cannot cause shaft rotation. If the load can cause shaft rotation, disconnect the load from the motor shaft before maintenance is performed. Unexpected mechanical rotation of the motor parts can cause injury or motor damage.

WARNING: Motors that are to be used in flammable and/or explosive atmospheres must display the UL label on the nameplate along with CSA listed logo. Specific service conditions for these motors are defined in NFPA 70 (NEC) Article 500.

WARNING: The SCR controller may apply hazardous voltages to the motor leads after power to the controller has been turned off. Verify the controller is incapable of delivering hazardous voltages and that the voltage at the motor leads is zero before proceeding. Failure to observe this precaution may result is severe bodily injury or death.

WARNING: Use only UL/CSA listed explosion proof motors in the presence of flammable or combustible vapors or dust.

WARNING: Motors that are to be used in flammable and/or explosive atmospheres must display the UL label on the nameplate along with CSA listed logo. Specific service conditions for these motors are defined in NFPA 70 (NEC) Article 500.

Safety Notice Continued

WARNING: **UL Listed motors must only be serviced by UL Approved Authorized Baldor Service Centers if these motors are to be returned to a hazardous and/or explosive atmosphere.**

WARNING: **This equipment is at line voltage when AC power is connected. Disconnect and lockout all ungrounded conductors of the ac power line before proceeding. Failure to observe these precautions could result in severe bodily injury or loss of life.**

WARNING: **Rotating parts can cause serious or fatal injury. If relubrication is performed with the motor running, to avoid injury do not contact any rotating parts.**

WARNING: **Solvents can be toxic and/or flammable. Follow manufacturer's safety procedures and directions.**

WARNING: **Space Heaters operate at line voltage. Disconnect power to space heaters before performing maintenance work on motor. Failure to observe this precaution could result in severe bodily injury or loss of life.**

WARNING: **Thermostat contacts automatically reset when the motor has slightly cooled down. To prevent injury or damage, the control circuit should be designed so that automatic starting of the motor is not possible when the thermostat resets.**

Caution: **To prevent premature equipment failure or damage, only qualified maintenance personnel should perform maintenance.**

Caution: **Do not over–lubricate motor as this may cause premature bearing failure.**

Caution: **Do not lift the motor and its driven load by the motor lifting hardware. The motor lifting hardware is adequate for lifting only the motor. Disconnect the load (gears, pumps, compressors, or other driven equipment) from the motor shaft before lifting the motor.**

Caution: **If eye bolts are used for lifting a motor, be sure they are securely tightened. The lifting direction should not exceed a 20 ° angle from the shank of the eye bolt or lifting lug. Excessive lifting angles can cause damage.**

Caution: **Do not use the coupling to compensate for poor alignment. This can result in vibration, noise, coupling wear, overloaded bearings and early failure.**

Caution: **To prevent equipment damage, be sure that the electrical service is not capable of delivering more than the maximum motor rated amps listed on the rating plate.**

Caution: **If a Motor Insulation test (High Potential Insulation test) must be performed, disconnect the motor from any Speed Control or drive to avoid damage to connected equipment.**

Caution: **Do not use Silicone grease or Sealing Compounds (RTV) on or in the vicinity of the motor or its air supply. Silicone vapor inside the motor will result in extremely rapid brush wear.**

Caution: **Vertical mount hand hole covers are required to provide protection to vertically mounted drip–proof motors. Stock motors and other motors designed for horizontal mounting can be adapted for vertical mounting by ordering vertical mount hand hole covers from Baldor.**

Caution: **Use of these radial load capacities requires the accurate calculation of the radial load for the application. Radial loads for gears, sprockets, and flywheel are usually accurately determined. Radial loads for V–belt drives are subject to error due to the exclusion of pre–tension load (belt tightening). The calculations of the radial load for a V–belt drive must include the pre–tension for transmitting the horsepower, pre–tension for centrifugal force on the belts, Pre–tension for high start torques, Rapid acceleration or deceleration, Pre–tension for drives with short arc–of–contact between the V–belt and sheave and low coefficient of friction between belt and sheave caused by moisture, oil or dust.**

Caution: **Series wound motors must never be allowed to run with no load (broken belt etc.) An unloaded motor may reach destructive high speeds.**

Caution: **Motors designed for forced ventilation must have cooling air when fields are excited at rated voltage. Installations having the air supply interrupted when the motor is not operating must have field disconnected or field voltage reduced to 50% rated by means of field economizing resistor and relay or motor insulation life will be significantly reduced.**

If you have any questions or are uncertain about any statement or procedure, or if you require additional information please contact your Baldor District Office.

Receiving

Each Baldor Electric Motor is thoroughly tested at the factory and carefully packaged for shipment. When you receive your motor, there are several things you should do immediately. Do not unpack until ready for use.

1. Observe the condition of the shipping container and report any damage immediately to the commercial carrier that delivered your motor.
2. Verify that the part number of the motor you received is the same as the part number listed on your purchase order.

Caution: **Do not lift the motor and its driven load by the motor lifting hardware. The motor lifting hardware is adequate for lifting only the motor. Disconnect the load (gears, pumps, compressors, or other driven equipment) from the motor shaft before lifting the motor.**

Handling

The motor should be lifted using the lifting lugs or eye bolts provided.

1. Use the lugs or eye bolts provided to lift the motor. Never attempt to lift the motor and additional equipment connected to the motor by this method. The lugs or eye bolts provided are designed to lift only the motor. Never lift the motor by the motor shaft or the hood of a WPII motor. If eye bolts are used for lifting a motor, be sure they are securely tightened. The lifting direction should not exceed a 20° angle from the shank of the eye bolt. Excessive lifting angles can cause motor damage.
2. To avoid condensation inside the motor, do not unpack until the motor has reached room temperature. (Room temperature is the temperature of the room in which it will be installed). The packing provides insulation from temperature changes during transportation.

3. When lifting a WPII (Weather Proof Type 2) motor, do not lift the motor by inserting lifting lugs into holes on top of the cooling hood. These lugs are to be used for hood removal only. A spreader bar should be used to lift the motor by the cast lifting lugs located on the motor frame.
4. If the motor must be mounted to a plate with the driven equipment such as pump, compressor etc., it may not be possible to lift the motor alone. For this case, the assembly should be lifted by a sling around the mounting base. The entire assembly can be lifted as an assembly for installation.
   Do not lift the assembly using the motor lugs or eye bolts provided. Lugs or eye bolts are designed to lift motor only. If the load is unbalanced (as with couplings or additional attachments) additional slings or other means must be used to prevent tipping. In any event, the load must be secure before lifting.

Storage

Storage requirements for motors and generators that will not be placed in service for at least six months from date of shipment. To avoid condensation inside the motor, do not unpack until the motor has reached room temperature. (Room temperature is the temperature of the room in which it will be installed). The packing provides insulation from temperature changes during transportation.
Improper motor storage will result in seriously reduced reliability and failure. An electric motor that does not experience regular usage while being exposed to normally humid atmospheric conditions is likely to develop rust or rust particles on surrounding surfaces to contaminate the bearings. The electrical insulation may absorb an excessive amount of moisture leading to the motor winding failure.
A wooden crate “shell” should be constructed to secure the motor during storage. This is similar to an export box but the sides & top must be secured to the wooden base with lag bolts (not nailed as export boxes are) to allow opening and reclosing many times without damage to the “shell”.
Minimum resistance of motor winding insulation is 5 Meg ohms or the calculated minimum, which ever is greater.
Minimum resistance is calculated as follows: Rm = kV + 1

where: (Rm is minimum resistance to ground in Meg–Ohms and
kV is rated nameplate voltage defined as Kilo–Volts.)

Example: For a 480VAC rated motor Rm =1.48 meg–ohms (use 5 MΩ).
For a 4160VAC rated motor Rm = 5.16 meg–ohms.

Preparation for Storage

1. Some motors have a shipping brace attached to the shaft to prevent damage during transportation. The shipping brace, if provided, must be removed and stored for future use. The brace must be reinstalled to hold the shaft firmly in place against the bearing before the motor is moved.
2. Store in a clean, dry, protected warehouse where control is maintained as follows:
   a. Shock or vibration must not exceed 2 mils maximum at 60 hertz, to prevent the bearings from brinelling. If shock or vibration exceeds this limit vibration isolation pads must be used.
   b. Storage temperatures of 10°C (50°F) to 49°C (120°F) must be maintained.
   c. Relative humidity must not exceed 60%.
   d. Motor space heaters (when present) are to be connected and energized whenever there is a possibility that the storage ambient conditions will reach the dew point. Space heaters are optional.

Note: Remove motor from containers when heaters are energized, reprotect if necessary.

3. Measure and record the resistance of the winding insulation (dielectric withstand) every 30 days of storage.
   a. If motor insulation resistance decreases below the minimum resistance, contact your Baldor District office.
   b. Place new desiccant inside the vapor bag and re–seal by taping it closed.
   c. If a zipper–closing type bag is used instead of the heat–sealed type bag, zip the bag closed instead of taping it. Be sure to place new desiccant inside bag after each monthly inspection.
   d. Place the shell over the motor and secure with lag bolts.
4. Where motors are mounted to machinery, the mounting must be such that the drains and breathers are fully operable and are at the lowest point of the motor. Vertical motors must be stored in the vertical position. Storage environment must be maintained as stated in step 2.
5. Motors with Ball and roller bearing (anti–friction) motor shafts are to be rotated manually every 3 months. Ball bearings are deep grooved, double shielded with sufficient lubricant packed into the bearings by the manufacturer for “life lubrication.” The initial lubricant is supplemented by a supply packed into larger reservoirs in the end shield at time of assembly. No grease fittings are provided, the initial lubrication is adequate for up to 5 years of operation under normal conditions.
6. All breather drains are to be fully operable while in storage (drain plugs removed). The motors must be stored so that the drain is at the lowest point. All breathers and automatic “T” drains must be operable to allow breathing and draining at points other than through the bearings around the shaft.
   Vertical motors should be stored in a safe stable vertical position.
7. Coat all external machined surfaces with a rust preventing material.
   An acceptable product for this purpose is Exxon Rust Ban # 392.
8. Carbon brushes should be lifted and held in place in the holders, above the commutator, by the brush holder fingers. The commutator should be wrapped with a suitable material such as cardboard paper as a mechanical protection against damage.

Non–Regreaseable Motors
Non–regreasable motors with “Do Not Lubricate” on the nameplate should have the motor shaft rotated 15 times to redistribute the grease within the bearing every 3 months or more often.

Removal From Storage

1. Remove all packing material.
2. Measure and record the electrical resistance of the winding insulation resistance meter at the time of removal from storage. The insulation resistance must not be less than 50% from the initial reading recorded when the motor was placed into storage. A decrease in resistance indicates moisture in the windings and necessitates electrical or mechanical drying before the motor can be placed into service. If resistance is low, contact your Baldor District office.
3. Regrease the bearings as instructed in Section 3 of this manual.
4. Reinstall the original shipping brace if motor is to be moved. This will hold the shaft firmly against the bearing and prevent damage during movement.

EMC Compliance Statement for European Union

The motors described in this instruction manual are designed to comply 2004/108/EC . These motors are commercial in design and not intended for residential use. When used with converters, please consult converter manufacturers literature regarding recommendations on cable types, cable shielding, cable shielding termination, connection recommendations and any filters which may be recommended for EMC compliance. For additional information, consult Baldor MN1383.

Section 2

General Information

Overview

Installation should conform to the National Electrical Code as well as local codes and practices. When other devices are coupled to the shaft, be sure to install protective devices to prevent future accidents. Some protective devices include, coupling, belt guard, chain guard, shaft covers etc. These protect against accidental contact with moving parts. Machinery that is accessible to personnel should provide more protection in the form of guard rails, screening, warning signs etc.

Considerations

Caution: **Do not lift the motor and its driven load by the motor lifting hardware. The motor lifting hardware is adequate for lifting only the motor. Disconnect the load (gears, pumps, compressors, or other driven equipment) from the motor shaft before lifting the motor.**

Caution: **If eye bolts are used for lifting a motor, be sure they are securely tightened. The lifting direction should not exceed a 20° angle from the shank of the eye bolt or lifting lug. Excessive lifting angles can cause damage.**

After storage or after unpacking and inspection to see that all parts are in good condition, do the following:

1. Rotate the motor or generator shaft by hand to be sure there are no obstructions to free rotation.
2. A motor or generator that has been in storage for >3 months should be tested for moisture (dielectric withstand insulation test) and relubricated (if regreaseable type) prior to being put into service.
3. A motor with roller bearings is shipped with a shaft block. After removing the shaft block, be sure to replace any bolts used to hold the shaft block in place during shipment that are required in service.

Caution: **Do not use Silicone Sealing Compounds (RTV) on or in the vicinity of the motor or its air supply. Silicone vapor inside the motor will result in extremely rapid brush wear.**

Location Location should be dry, clean and well ventilated. Be sure that oil seepage into the motor is prevented. Commutator end of the motor should be accessible for maintenance and brush changing.

Air Supply Cooling air through a self–ventilated or forced–ventilated motor must be clean and have relative humidity between 30 and 100% with no free water in the air. Use of damp, cool outside air with high humidity and free water may cause the motor to flash over. Extremely dry air may cause excessive brush and commutator wear. Cooling air temperature must not exceed the maximum ambient temperature indicated on the motor nameplate (Standard 40°C). Cooling air temperature must be less than than 0°C to provide base speed and regulation. Use of air <0°C may cause excessive brush and commutator wear due to the low relative humidity. Cooling air absolute humidity must be at least 2 grains per cu. ft.

Ambient The motor or generator should be installed in a location compatible with the enclosure and specific ambient. Allow adequate air flow clearance between the motor and any obstruction. Locate the machine where the ambient temperature is not over 40°C (104°F) unless otherwise marked on the nameplate and where clean air has free access to ventilating intake and outlet openings. Except for machines with a suitable protective enclosure, the location should be clean and dry.

Note: Motors located in damp, moist environment must have space heater, or fields energized at 50% voltage to protect against condensation when motor is not operating.

Separately ventilated motors must have sufficient volume of air to adequately cool the motor unless the motor nameplate specifies a different value.

Maximum Safe Speed

The maximum safe speed shown on the nameplate is the maximum mechanically safe speed. This speed must not be exceeded under any condition. Motor control must not exceed the maximum speed for all load conditions including no–load. Drive systems whose design characteristics inherently prevent the DC motor or generator from exceeding the maximum safe operating speed must also prevent the motor or generator from exceeding the maximum safe speed if a single component failure should occur.

Installation

RPMIII motors are designed to be mounted by the “Mounting Feet” (hardware not furnished).
Motor or generator must be mounted on a rigid, solid base or foundation. (Poor base construction may cause resonances in the motor/base assembly which can result in bearing failure and other damage.)
Foundation caps and sole plates are designed to act as spacers for the equipment they support.
If these devices are used, be sure that they are evenly supported by the foundation or mounting surface.
When installation is complete and accurate alignment of the motor or generator and load is accomplished, the base should be grouted to the foundation to maintain this alignment.
DC motors have ball bearings and may be operated in any position. For any position other than base down, new drain holes should be provided so condensation can drain from motor.

Alignment

Inspect motor shaft and couplings for dirt, paint etc. and clean to remove all debris. Pulley or coupling should be carefully fitted. Do not hammer pulley or coupling onto the motor shaft.
Accurate alignment of the motor with the driven equipment is extremely important. Proper alignment is a key step for long life of bearings, shafts and belts, and minimum downtime. Misalignment can cause excessive vibration and damaging forces on shaft and bearings. For direct coupled drives, flexible couplings facilitate alignment.
For belt drives, the driving and driven tension must be adjusted as required for proper operation.
The belt sheave should be placed as close as possible to the motor bracket.
For direct drive, flexible couplings must be used between the motor shaft and the load shaft.
Motor shaft and load shaft must be aligned to values recommended for the specific coupling before coupling is connected. Mechanical vibration and roughness during operation may indicate poor alignment.
Use dial indicators to check alignment. The space between coupling hubs should be maintained as recommended by the coupling manufacturer.

Doweling & Bolting

After proper alignment is verified, dowel pins should be inserted through the motor feet into the foundation. This will maintain the correct motor position should motor removal be required.
(Baldor motors are designed for doweling.)

1. Drill dowel holes in diagonally opposite motor feet in the locations provided.
2. Drill corresponding holes in the foundation.
3. Ream all holes.
4. Install proper fitting dowels.
5. Mounting bolts must be carefully tightened to prevent changes in alignment.
   Use a flat washer and lock washer under each nut or bolt head to hold the motor feet secure.
   Flanged nuts or bolts may be used as an alternative to washers.

Guarding

WARNING: Guards must be installed for rotating parts such as couplings, pulleys, external fans, belts, chains and unused shaft extensions, should be permanently guarded to prevent accidental contact by personnel. Accidental contact with body parts or clothing can cause serious or fatal injury.

Guards must be installed for rotating parts such as couplings, pulleys, external fans, and unused shaft extensions. This is particularly important where the parts have surface irregularities such as keys, key ways or set screws.
Surface temperature of motor enclosure may reach temperatures which can cause discomfort or injury to personnel accidentally coming into contact with hot surfaces. When installing, protection should be provided by user to protect against accidental contact with hot surface.
Some satisfactory methods of guarding are:

1. Covering the machine and associated rotating parts with structural or decorative parts of the driven equipment.
2. Providing covers for the rotating parts. Covers should be sufficiently rigid to maintain adequate guarding during normal service.

Electrical Installation

WARNING: Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.

WARNING: The SCR Controller may apply hazardous voltages to the motor leads after power to the controller has been turned off. Verify that the controller is incapable of delivering hazardous voltages and that the voltage at the motor leads is zero before proceeding. Failure to observe this precaution may result in severe bodily injury or death.

Terminal Connectors

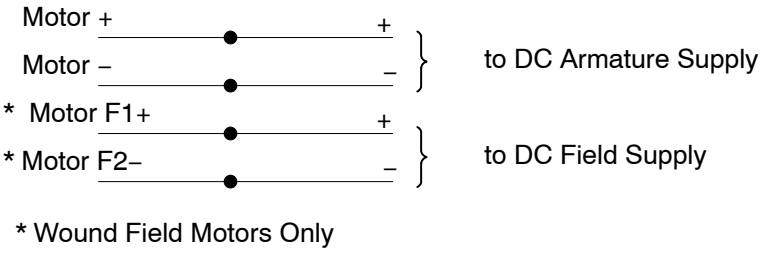
All motors must be installed in accordance with NEC and local requirements. Fuses, thermal cutouts and other protective devices should be of the proper size and rating for the load.

WARNING: Be sure the system is properly grounded before applying power. Do not apply power before you ensure that all grounding instructions have been followed. Electrical shock can cause serious or fatal injury. National Electrical Code, IEC and Local codes must be carefully followed.

Motor Connections

Connect the motor leads as shown in Figure 2-1.

Figure 2-1 Connection Diagram



Power

Check the motor nameplate and the SCR Control nameplate to be sure the voltage and type of power rating is the same for both. The power code of the motor and power source should be the same. The letter code for the control may be equal or less than the motor. For example a motor with a “D” power code may be used on a supply with a “D” or “C” or less code. Table 2–1 defines these codes.

Table 2-1 Power Codes

Code	Description
A	DC Generator, battery or twelve pulse/cycle 6 phase, full control
C	Six pulse/cycle, 3 phase, full control, 230VAC or 460VAC, 60Hz, input to rectifier.
D	Three pulse/cycle, 3 phase, semi–bridge, half control, 230VAC or 460VAC, 60Hz, input to rectifier.
E	Three pulse/cycle, 3 phase, half wave (single way), 460VAC, 60Hz, input to rectifier.
K	Two pulse/cycle, single phase, full wave (bridge circuit with 2 controlled rectifiers and 2 uncontrolled rectifiers with free–wheeling rectifier), 230VAC, 60Hz, input to rectifier.

When the armature power supply cannot be designated by a single letter code (A–K) the power source can be determined by the code stamped on the nameplate:

M/N F–V–H–L

Where:

M Total pulses per cycle
N Total controlled pulses per cycle
F Free Wheeling (if used), F=used, blank=not used
V Nominal Line–to–Line voltage at input to rectifier
H Line frequency (in Hz)
L Value of inductance (in milli henries) to be added externally to the motor armature circuit

Example 1: “6/3 F-380-60-12”
Requires a power supply with 6 total pulses per cycle, 3 controlled pulses per cycle (S-3), with free wheeling, 380 volts, 60 Hz AC input to bridge, and a 12 millinery choke to be added externally to the motor armature circuit.

Thermostat Connection

Motors may have one or more thermostats (leads marked P1, P2, etc.) to indicate motor overheating. Thermostat contacts must be connected in the motor control or indicating circuit. Failure to connect the thermostat leads will void the motor warranty. The leads should be connected in series with the “Stop” button described in the control Installation and Operation manual.

Grounding

In the USA consult the National Electrical Code, IEC, Article 430 for information on grounding of motors and generators, and Article 250 for general information on grounding. In making the ground connection, the installer should make certain that there is a solid and permanent metallic connection between the ground point, the motor or generator terminal housing, and the motor or generator frame.
Motors with resilient cushion rings usually must be provided with a bonding conductor across the resilient member. Some motors are supplied with the bonding conductor on the concealed side of the cushion ring to protect the bond from damage. Motors with bonded cushion rings should usually be grounded at the time of installation in accordance with the above recommendations for making ground connections. When motors with bonded cushion rings are used in multimotor installations employing group fusing or group protection, the bonding of the cushion ring should be checked to determine that it is adequate for the rating of the branch circuit over current protective device being used.
There are applications where grounding the exterior parts of a motor or generator may result in greater hazard by increasing the possibility of a person in the area simultaneously contacting ground and some other nearby live electrical parts of other ungrounded electrical equipment. In portable equipment it is difficult to be sure that a positive ground connection is maintained as the equipment is moved, and providing a grounding conductor may lead to a false sense of security.
Select a motor starter and over current protection suitable for this motor and its application. Consult motor starter application data as well as the National Electrical Code, IEC and/or other applicable local codes.
Due to the higher switching frequencies of inverter controls, the ground connection/path must be low impedance, not only low resistance.

WARNING: Incorrect motor rotation direction can cause serious or fatal injury or equipment damage. Be sure to verify motor rotation direction before coupling the load to the motor shaft.

WARNING: Guards must be installed for rotating parts such as couplings, pulleys, external fans, and unused shaft extensions, should be permanently guarded to prevent accidental contact by personnel. Accidental contact with body parts or clothing can cause serious or fatal injury.

WARNING: Be sure the system is properly grounded before applying power. Do not apply power before you ensure that all grounding instructions have been followed. Electrical shock can cause serious or fatal injury. National Electrical Code, IEC and Local codes must be carefully followed.

First Time Start Up

If motor has been in storage or idle for some time, check winding insulation integrity.

1. Be sure that all power to motor and accessories is off.
2. Disconnect motor shaft from the load.
3. Manually rotate the motor shaft to ensure that it rotates freely.
4. The brushes should move easily in their holders and should make proper contact on the commutator.
5. The interior of the motor should be clean and dry.
4. Couple the load to the motor shaft.
6. Install all panels and covers that were removed during installation.

First Time Start Up Continued

7. Verify the mechanical installation is secure. All bolts and nuts are tightened etc., covers and protective devices are securely in their places.
8. Remove all unused shaft keys and loose rotating parts to prevent them from flying off.
5. The driven machine should be unloaded if possible.
9. Ensure that all separately excited fields are excited at their rated voltage and that relative polarities of all fields are correct. Refer to checking relative polarity of DC motor fields.
10. When motor or generator is supplied as part of drive system, refer to the drive system instruction manual for operating instructions. Tachometer feedback must be properly connected for closed loop operation. Reversed polarity or broken connections can cause dangerous overspeed conditions.
11. Inspect all electrical connections for proper termination, clearance, mechanical strength and electrical continuity.
12. Be sure all shipping materials and braces (if used) are removed from motor shaft.
13. Unless otherwise ordered, brush rigging is assembled for standard direction of rotation, counterclockwise for motors and clockwise for generators facing the commutator end.
    RPMIII motors and generators operate in either direction of rotation.

Caution: **Motors designed for cooling by a separate source of forced ventilation must not be operated without the air supply. Be sure blower is running in proper direction to avoid motor overheating.**

14. Start the motor and ensure rotation is correct and operation is smooth without excessive vibration or noise. If rotation direction is incorrect, change the direction in the SCR Control programming.

Note: When starting, small sparks may appear on the commutator due to particles of dirt. Other than this, there should be few if any, sparking at the brushes.

WARNING: **Surface temperatures of motor enclosures may reach temperatures which can cause discomfort or injury to personnel accidentally coming into contact with hot surfaces. Protection should be provided by the user to protect against accidental contact with hot surfaces. Failure to observe this precaution could result in bodily injury.**

15. After 1 hour of operation, disconnect power and connect the load to the motor shaft. Verify all coupling guards and protective devices are installed. Ensure motor is properly ventilated.
16. If motor is totally enclosed fan–cooled or non–ventilated it is recommended that condensation drain plugs, if present, be removed. These are located in the lower portion of the end–shields.
    Totally enclosed fan–cooled XT motors are normally equipped with automatic drains which may be left in place as received.

While operating the motor, observe the performance. It should run smoothly with little noise. The bearings should not overheat and should reach normal operating temperature. Any undue noise, overheating, or erratic performance should be investigated and necessary corrective action taken immediately to prevent serious dam age. Refer to Maintenance and Troubleshooting section of this manual.

Operation

WARNING: **Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.**

WARNING: **Surface temperatures of motor enclosures may reach temperatures which can cause discomfort or injury to personnel accidentally coming into contact with hot surfaces. When installing, protection should be provided by the user to protect against accidental contact with hot surfaces. Failure to observe this precaution could result in bodily injury.**

WARNING: **Incorrect motor rotation direction can cause serious or fatal injury or equipment damage. Be sure to verify motor rotation direction before coupling the load to the motor shaft.**

WARNING: **Guards must be installed for rotating parts such as couplings, pulleys, external fans, and unused shaft extensions, should be permanently guarded to prevent accidental contact by personnel. Accidental contact with body parts or clothing can cause serious or fatal injury.**

Caution: **Do not operate motors with a roller bearing unless a radial load is applied so that damage to the roller bearing does not occur.**

Motor Performance

During operation observe the motors' performance. It should run smoothly with little noise. The bearings should not overheat and should reach a normal operating temperature. Any undue noise, overheating, or erratic performance should be investigated and corrective action taken immediately to prevent serious damage.
All RPM motors are lubricated before shipment and will operate for a long period before regreasing is required. The period will vary depending on environmental and service conditions.
Refer to Maintenance section of this manual.

Balance

Motors are dynamically balanced to NEMA limits unless ordered differently. Balance is done with a full length 1/2 height shaft key. A full shaft key is shipped with motor.
Sheave or coupling should be balanced with a 1/2 height shaft key.

SCR Control Settings

Be sure to properly set the Control parameters according to the Motor Nameplate ratings.
Many parameter values can be set but as a minimum the following are very important:

Acceleration/Deceleration time	Set according to the load requirements to prevent excess heat buildup.
Field Control Parameters	Field Power Supply settings, limits and gain settings.
Control Output Limits	Minimum and Maximum Speed values and Current Limit values.
Control Output Protection values	Overload, Torque and other values to protect the motor.
Feedback parameters	Set according to the feedback device being used.

Note: Permanent Magnet “PM” motors are not always designed for across the line starting. Across the line starting may cause loss of flux resulting in an increase in speed and possibly instability. Wound field motors can be started across the line with full applied voltage. However, for frequent starting or reversing, voltage should be reduced for normal brush and commutator life.
The PM motor should not be plug reversed or dynamically braked or regeneratively braked unless provisions are made to limit the maximum instantaneous current to a value not greater than the maximum allowable peak amperes shown on the nameplate.

Section 3

Maintenance & Troubleshooting

WARNING: **UL Listed motors must only be serviced by UL Approved Authorized Baldor Service Centers if these motors are to be returned to a hazardous and/or explosive atmosphere.**

WARNING: **Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.**

WARNING: **The SCR Controller may apply hazardous voltages to the motor leads after power to the controller has been turned off. Verify that the controller is incapable of delivering hazardous voltages and that the voltage at the motor leads is zero before proceeding. Failure to observe this precaution may result in severe bodily injury or death.**

WARNING: **Surface temperatures of motor enclosures may reach temperatures which can cause discomfort or injury to personnel accidentally coming into contact with hot surfaces. When installing, protection should be provided by the user to protect against accidental contact with hot surfaces. Failure to observe this precaution could result in bodily injury.**

WARNING: **Guards must be installed for rotating parts such as couplings, pulleys, external fans, and unused shaft extensions, should be permanently guarded to prevent accidental contact by personnel. Accidental contact with body parts or clothing can cause serious or fatal injury.**

General Inspection

Inspect the motor at regular intervals, approximately every 500 hours of operation or every 3 months, whichever occurs first. Keep the motor clean and the ventilation openings clear.

The following steps should be performed at each inspection:

1. Check that the motor is clean. Check that the interior and exterior of the motor is free of dirt, oil, grease, water, etc. Oily vapor, paper pulp, textile lint, etc. can accumulate and block motor ventilation. If the motor is not properly ventilated, overheating can occur and cause early motor failure.
2. Perform a dielectric with stand test periodically to ensure that the integrity of the winding insulation has been maintained. Record the readings. Immediately investigate any significant decrease in insulation resistance.
3. Check all electrical connectors to be sure that they are tight.
4. If used, ventilating air filters must be kept clean or replaced to ensure full volume of cooling air.

Caution: **Do not use Silicone grease or Sealing Compounds (RTV) on or in the vicinity of the motor or its air supply. Silicone vapor inside the motor will result in extremely rapid brush wear.**

Relubrication & Bearings

No grease fittings are provided, as the initial lubrication is adequate for up to 5 years of operation under normal conditions. Ball bearings are deep grooved, double shielded with sufficient lubricant packed into the bearings by the manufacturer for “life lubrication.” The initial lubricant is supplemented by a supply packed into larger reservoirs in the end shield at time of assembly. If lubrication is required, contact your local Baldor District Office.

WARNING: **Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.**

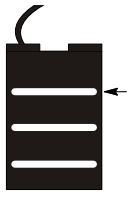
WARNING: **The SCR Controller may apply hazardous voltages to the motor leads after power to the controller has been turned off. Verify that the controller is incapable of delivering hazardous voltages and that the voltage at the motor leads is zero before proceeding. Failure to observe this precaution may result in severe bodily injury or death.**

WARNING: **Surface temperatures of motor enclosures may reach temperatures which can cause discomfort or injury to personnel accidentally coming into contact with hot surfaces. Protection should be provided by the user to protect against accidental contact with hot surfaces. Failure to observe this precaution could result in bodily injury.**

Brushes

Brush pressure is correctly established at the factory and maintained at the correct value throughout the life of the brush by means of a constant pressure design. Brushes and brush–holders should be clean so brushes move freely in the holders and make proper contact with the commutator. Replace worn brushes, see Figure 3-1. Replace brushes with new brushes of the same grade before wear permits the rivet or tamped pigtail to score the commutator. It is best to change out the complete set.

Figure 3-1 Brush Wear Indicator



Brushes have 3 wear lines.
At inspection if “Final Wear Line” is the only line show replace all brushes. Brushes should be replaced betw second and final wear line. Inspect every 3–months.

Brush Change procedure

1. Be sure all power is disconnected and no voltage is present at the motor leads.
2. Remove hand hole covers from each side of the opposite drive end bracket.
3. Fit the face of new brushes to the contour of the commutator with sandpaper only, no emery abrasive. Keep brush lead (pigtail) connections tight.
4. Install the hand hole covers to each side of the commutator bracket.
5. Restore power.

Check brushes to make certain that they move freely in the holders and make proper contact with the commutator. Replace worn brushes, see Figure 3-1, Brushes should be inspected every 3–months.
Give complete motor identification when ordering parts. New brushes should be fitted to the commutator curvature. Remove all carbon dust (see Carbon Dust). Short brush life and poor commutation may be due to a rough commutator, a shorted armature, or poor undercutting of mica.
Dirt and chemicals in the air are common source of trouble.

Commutator

A commutator in good condition is clean and smooth with a medium polish and a light brown color.
Keep clean by occasionally wiping with a canvas pad.
Use no lubricant or emery abrasive.
If a commutator becomes rough, it needs to be resurfaced.

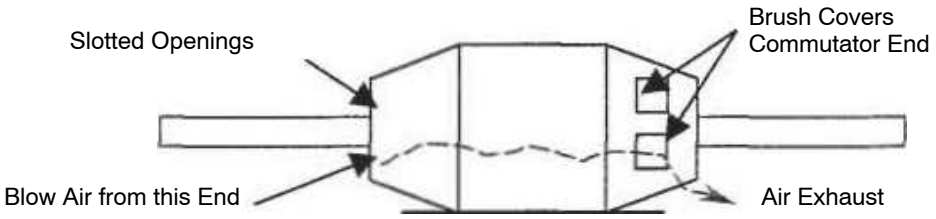
Brakes

Motor mounted brake, when supplied, must be adjusted and maintained in accordance with the instructions for the specific brake. Refer to separate instructions supplied.

Carbon Dust (see Figure 3-2)

Wear safety glasses (or full face shield) and dust mask for this procedure.
Make sure no other personnel are in the work area. Use only a clean, dry (preferably filtered) high pressure air source for the purpose of blowing out any carbon dust that has collected inside the motor frame and or around the windings in the motor. It is critical that the air supply be both clean and free of moisture. Remove the brush covers at the commutator end of the motor. Motor should be cleaned every 3–months.

Figure 3-2



1. Place a shop vacuum at the Air Exhaust location to collect dust particles.
2. Starting at the opposite commutator end of the motor, place the air supply through the slotted opening in the bracket directing the flow between the openings on each side of the windings inside the motor frame. Blow out all carbon that may have collected between the field coils and in the armature slots.
3. Continue this procedure at the drive end (blowing toward the commutator end of the motor) until all areas between the coils have been reached — the complete inside circumference — emphasizing the areas between the windings.
4. At the commutator end of the motor, vacuum all carbon dust or debris that collected in the bottom of the brackets prior to blowing the commutator end of the motor.
5. Take specific care to clean around the connection studs of this motor.

Troubleshooting

WARNING: Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.

WARNING: The SCR Controller may apply hazardous voltages to the motor leads after power to the controller has been turned off. Verify that the controller is incapable of delivering hazardous voltages and that the voltage at the motor leads is zero before proceeding. Failure to observe this precaution may result in severe bodily injury or death.

WARNING: Surface temperatures of motor enclosures may reach temperatures which can cause discomfort or injury to personnel accidentally coming into contact with hot surfaces. Protection should be provided by the user to protect against accidental contact with hot surfaces. Failure to observe this precaution could result in bodily injury.

Armature Overheating

Excessive overloads will cause a noticeable odor of overheated varnish or charred insulation. The commutator may eventually become blackened and pitted and the brushes burned. This overheating may be general and uniform. Remedy, remove the overload and rewind or replace armature if damaged beyond use.

An open-circuited armature coil will cause flashing at the commutator. Two adjacent bars will show severe burning and a resulting overheated armature. Short-circuited coils or commutator bars may cause local heating that could destroy the insulation at that spot. This may result in the burning of the armature coils, banding or commutator bars.

Grounds in the armature circuit may be found by measuring insulation resistance from the motor frame and to a commutator bar. If the armature is grounded, the resistance is less than 1 meg ohm.

Field Coil Overheating

The blowers or external cooling systems must remain in operation if the main field windings remain fully energized with the motor at standstill. Failure to do so may cause too much heat build-up which could cause reduced insulation life.

When using field economy circuits to reduce voltage to the main fields during standstill, blowers do not need to be operating. The most common failure with overheated field coils is a short in one or more of the shunt coils. Shorted coils show less than half the line voltage for two pole motors. This is with the fields connected for high voltage (in series). Shorted four pole motor coils will read less than 1/4 of the line voltage with the coils connected for high voltage (in series).

A grounded coil may cause overheating. This defect may be tested as shown by the ground test for an armature. With brushes lifted, place one test point of the megger on either field lead, the other on the motor frame. The megger will read less than 1 meg ohm, if a grounded coil is present.

An open field coil on a motor will cause the armature to have no torque. The motor may run at a very high speed at no load. The commutator may be flashing. To locate an open coil, apply line voltage to the shunt coils (brushes lifted). A voltmeter will show no reading across a good coil. It will show about the line voltage across the open coil. These tests should be done by experienced and qualified personnel. If you find any of these defects, don't run the motor. Contact your local Baldor District Office.

Excessive Load

Excessive load may be found by checking the DC armature ampere input and comparing it with the rating on the nameplate. An excessive load may prevent the motor from starting or accelerating to full load speed. It could finally result in premature failure of the motor or control. Be sure to use an averaging type ammeter if the motor's power is coming from a rectifier or SCR control.

Jogging and Repeated Starts

Repeated starts or jogs of motors may reduce the life of the brushes and winding insulation. The heat produced by excessive starting may be more than what can be dissipated by the motor under a constant full load conditions. If you must frequently start or jog a motor, you should check the application with the local Baldor District Office.

Heating

Duty cycle and maximum ambient temperature are shown on the nameplate of the motor. If there is any question about safe operation, contact the local Baldor District Office.

Motor overheating may be caused by improper ventilation, excessive ambient temperature, dirty conditions or an inoperable blower or dirty filter. Electrical causes may be due to excess current caused by an overload or over-voltage to the fields.

Thermostat

Some motors have a standard temperature-sensing thermostat mounted to their interpole winding. This normally closed thermostat opens when the temperature limit is exceeded. Another option available is a normally open thermostat that closes with temperature.

On blower cooled or separately ventilated motors, the protection capabilities of the thermostats are greatly reduced at low speeds. This is because the interpoles have the same amount of heat transfer regardless of speed. Armature heat transfer is less at low speed. There is less internal air turbulence at low speeds causing higher temperatures at the armature.

The thermal time constant for interpoles can be as much as five times longer than the armature's time constant. Because of this, the thermostat cannot be relied upon to protect the armature during extreme overloads lasting a short time.

The ripple of the rectified power supply and manufacturing tolerances of mounting the device affect the thermostat's accuracy. For thermostat contact ratings, refer to Thermostats in Section 2 of this manual.

Checking Relative Polarity Of DC Motor Fields

Motor speed is unstable if speed increases due to an increase in load current. As a result of instability, motor speed may hunt or overspeed. One possible cause of unstable performance of shunt wound DC motors is incorrect series field polarity relative to the shunt field due to improper connection.

Relative polarity of the shunt and series fields can be checked as follows:

1. Connect a low scale (3 volts) DC voltmeter across the shunt field terminals P1 and P2 with P1 connected to the positive (+) meter terminal. At least one of the shunt field leads must be disconnected from the controller.
2. Use two flashlight batteries as a source of low voltage (3 volts). Connect the negative battery post to the S-2 series field terminal. Hold one end of a jumper wire to the positive (+) battery post so the other end of the wire can be used to make and break contact with the S-1 series field terminal.
3. The procedure is to watch the deflection of the voltmeter needle when contact is made with S-1 and when contact is broken.
4. When contact is made, the needle will first deflect in either the up scale or down scale direction and then return to zero. Deflection will be in the opposite direction when contact is broken.
5. Relative polarities of the shunt and series fields are correct (ampere-turns are cumulative) if the voltmeter needle deflects up scale when contact is made and down scale when contact is broken.
6. Relative polarities of the shunt and series fields are incorrect (ampere-turns are differential) if the voltmeter needle deflects down scale when contact is made and up scale when contact is broken.
   The motor connections must be changed so that relative polarity is correct.

If only one series field terminal is available at the controller, use it and the available armature terminal for the test. For example, use S-2 and A-1 if S-1 and A-2 are connected together at the motor and not brought to the controller.

Humidity And Brush Wear

This curve represents 2 grains of water per cubic foot of dry air or 4.6 grams per cubic meter of dry air.

Zone of Safe Brush Operation

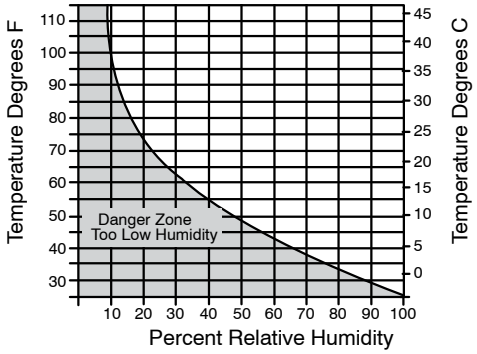


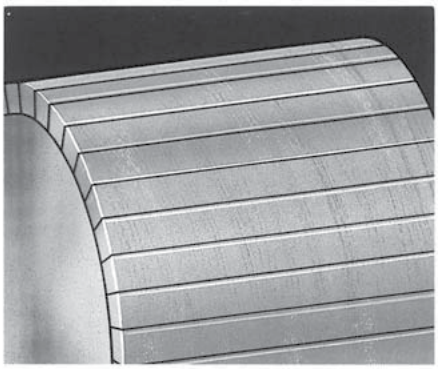
Table 3-1 Troubleshooting Chart

Symptom	Possible Causes	Possible Solutions
Motor will not start	Usually caused by line trouble, such as, single phasing at the starter.	Check source of power. Check overloads, fuses, controls, etc.
Excessive humming	High Voltage.	Check input line connections.
	Loose pole pieces.	Torque the bolts.
Motor Over Heating	Overload. Compare actual amps (measured) with nameplate rating.	Locate and remove source of excessive friction in motor or load. Reduce load or replace with motor of greater capacity.
	Improper ventilation.	Check external cooling blower to be sure air is moving properly across cooling fins. Check blower for proper direction of rotation. Check motor brush covers to ensure they are solid on the commutator end and that they are not louvered. Check filter for dirt, clean or replace. Excessive dirt build-up on motor. Clean motor.
	Armature rubbing on stator.	Check air gap clearance and bearings.
		Tighten Thru Bolts that hold the endplates to frame.
	Field over voltage.	Check input voltage.
	Full voltage on field with motor stopped.	Reduce field voltage to 60% with field economy circuit in the control.
	Grounded winding.	Perform dielectric test and repair as required.
	Improper connections.	Inspect all electrical connections for proper termination, clearance, mechanical strength and electrical continuity. Refer to connection diagram.
Bearing Over Heating	Misalignment.	Check and align motor and driven equipment.
	Excessive belt tension.	Reduce belt tension to proper point for load.
	Excessive end thrust.	Reduce the end thrust from driven machine.
	Excessive grease in bearing.	Remove grease until cavity is approximately 3/4 filled.
	Insufficient grease in bearing.	Add grease until cavity is approximately 3/4 filled.
	Dirt in bearing.	Contact your Baldor Service Center.
Vibration	Misalignment.	Check and align motor and driven equipment.
	Rubbing between rotating and stationary parts.	Isolate and eliminate cause of rubbing.
	Armature out of balance.	Have armature balance checked are repaired at your Baldor Service Center.
	Resonance.	Contact your Baldor Service Center.
Noise	Foreign material in air gap or ventilation openings.	Contact your Baldor Service Center.
Growling or whining	Bad bearing.	Replace bearing.
Excessive sparking at motor or generator commutator.	Sparking	1. Dirty or corroded commutator due to dirt, ambient contaminants, oil or oil mist, etc. 2. Brushes incorrectly seated. 3. High or feather–edged mica. 4. Faulty machine adjustment. 5. Interpoles failed or improperly adjusted. 6. Loss of brush spring tension. 7. Brushes sticking in brush holder. 8. Unit overload. 9. Defective commutator or armature. 10. Unequal spacing of holders around commutator.
High commutator bars produce a rough commutator.	Generally associated with sparking and noisy operation of the brushes on the commutator.	Loose commutator.
Low commutator bars produce rough commutator.	Generally associated with sparking and noisy operation of the brushes on the commutator.	1. Loose commutator. 2. High mica. 3. Open or high resistance connection at commutator.
Streaking or threading of commutator surface.	Rough commutator with associated sparking. Fine lines in brush track.	1. Low average current density in brushes due to light machine loading. 2. Contaminated atmosphere. 3. Oil on commutator or oil mist in air. 4. Humidity too low. 5. Lack of film forming properties in brush. 6. Brush too abrasive.
Bar etching or burning.	Rough commutator with associated sparking and eventual flashover.	1. High mica. 2. Operation of machine with brushes off neutral. 3. Commutator dirty. 4. Incorrect spring tension. 5. Machine overload or rapid load change such as plugging.
Bar marking at pole–pitching spacing.	1. Two bars marking 180° apart on 4–pole machine at start. 2. Three bars marking 120° apart on 6–pole machine at start. * 3. As pitch bar marking progresses, it will eventually show at all bars on the machine. 4. Associated sparking and eventual flashover.	1. Shorted commutator bars or coils. 2. Open armature or field circuit. 3. Unequal air gap. 4. Cyclic disturbance either electrical or mechanical.
Bar marking at slot–pitch spacing.	Sparking and marking of one or more bars at equal spacing around commutator according to bar–per–slot ratio with ventual flashover.	Unequal compensation of armature coils. The energy unbalance is reflected into the last coil in the slot to undergo commutation, and will result in a spark at the brush.
Rapid commutator or brush wear.	Bright commutator surface.	1. Abrasive material under brush. 2. Too abrasive a brush. 3. Low average brush current density due to light machine loading. 4. Contaminated atmosphere. 5. Humidity too low. 6. Incorrect brush tension.

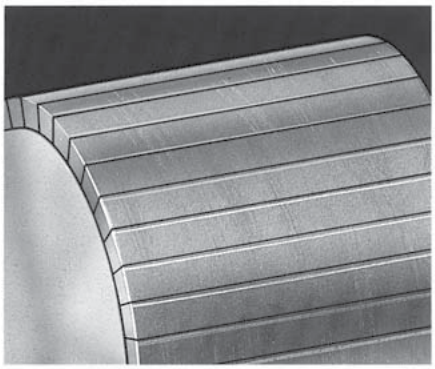
* Four bars marking 90° apart on 8–pole motor at start.

Guide To Commutator Appearance

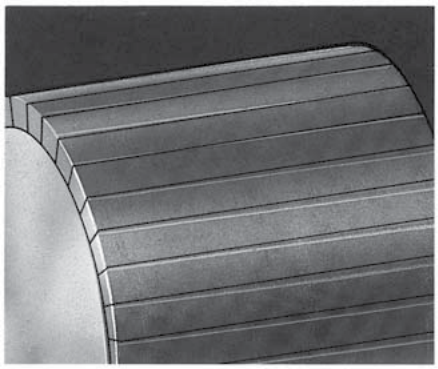
(This chart courtesy of Helwig Carbon Products, Inc., Milwaukee, WI)



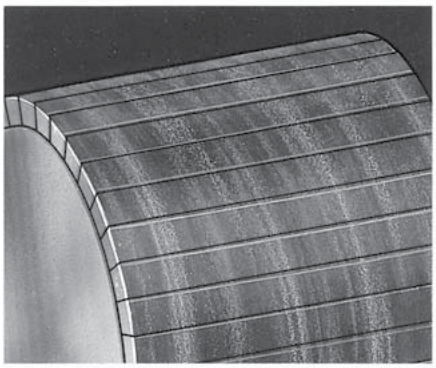
Light Film: Indicates good brush performance. Light load, low humidity, brush grades with low filming rates, or film reducing contamination can cause lighter color.



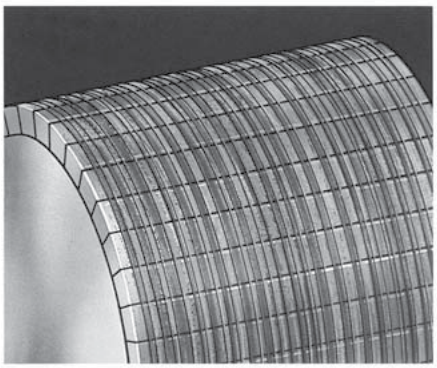
Medium Film: Is the ideal commutator condition for maximum brush and commutator life.



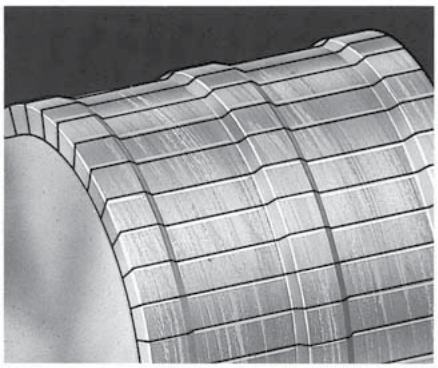
Heavy Film: Results from high load, high humidity or heavy filming rate grades. Colors not in the brown tones indicate contamination resulting in high friction and high resistance.



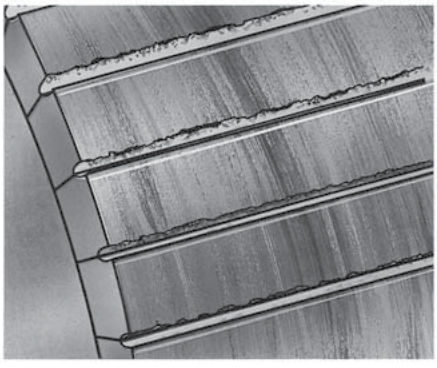
Streaking: Results from metal transfer to the brush face. Light loads and/or light spring pressure are most common causes. Contamination can also be a contributing factor.



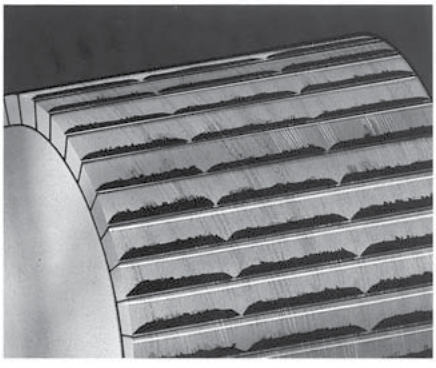
Threading: Is a further development of the streaking condition as the metal transferred becomes work hardened and machines into the commutator surface. With increased loads and increased spring pressure this condition can be avoided.



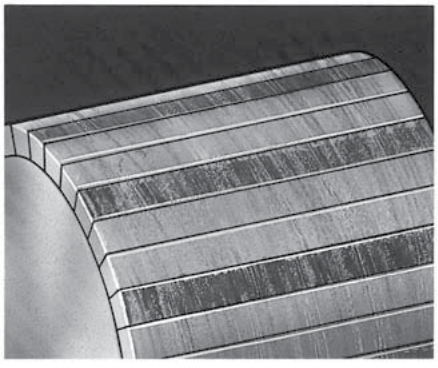
Grooving: May result from an overly abrasive brush grade. The more common cause is poor electrical contact resulting in arcing and the electrical machining of the commutator surface. Increased spring pressure reduces this electrical wear.



Copper Drag: Develops as the commutator surface becomes overheated and softened. Vibration or an abrasive grade causes the copper to be pulled across the slots. Increased spring pressure will reduce commutator temperature.



Bar Edge Burning: Results from poor commutation. Check that brush grade has adequate voltage drop, that the brushes are properly set on neutral and that the interpole strength is correct.



Slot Bar Marking: Results from a fault in the armature windings. The pattern relates to the number of conductors per slot.

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