DC Motor Troubleshooting

Based on the EASA TechNote "Troubleshooting DC Motors"

ALWAYS

- Disconnect the power before handling any parts of the electrical equipment
- Lock out and tag out all electrical circuits
- Test for voltage before touching any components
- Check for and eliminate the danger of "stored energy" caused by raised or spring–loaded equipment

The basic testing equipment you will need to troubleshoot DC motors in the field includes:

- Megohmmeter
- AC voltmeter
- DC clamp–on ammeter
- Ohmmeter
- DC voltmeter
- Tachometer

Find out if the failed motor was:

1. Operating successfully for a period of time before failing; or if it was
2. Installed recently.

MOTORS WITH A PREVIOUS HISTORY OF SUCCESSFUL OPERATION

If the motor has been operated successfully, problems such as incorrect hook–up or internal misconnection can be ruled out immediately.

Before proceeding,

1. Record relevant motor nameplate data (hp, RPM, rated voltages and currents for armature and field)
2. Inspect the motor for any obvious defects that would prevent safe testing such as:
   - Damaged windings (Smoke, copper particles)
   - Loose connections (melted wire nuts, burned insulation)
   - Broken or missing parts (pulleys, belts, covers, etc…)
   - Defective brushes or brush holders

PROBLEM: MOTOR WILL NOT START

Check to make sure adequate AC power is available at the control unit (use AC voltmeter)

If the main fuse is blown, DO NOT apply power to the motor until you have completed a determination of why the fuse blew.

Use the megohmmeter to measure the insulation resistance of all windings

1. Armature Circuit (armature winding, commutator, brush holders, interpoles, series field)
2. Shunt Field (any "ground" conditions must be repaired before power is applied to the motor)

If the main fuses are OK, press the start button and measure the armature and shunt field voltages at the controller using a DC voltmeter. All output voltages must be in accordance with the motor nameplate. If rated voltage is measured, the problem is in the motor or motor wiring. A zero or a very low reading indicates that something is wrong with the controller or control wiring.

Procedure 1: Test and inspect controller

If no output is read from the controller, determine if the problem is in the control circuit and correct it.

- Is the controller tripped?
  - If tripped determine cause and correct problem.
    - Over current (excessive load over a period of time)
    - Over voltage (overhauling type of load)
    - Over Heat (high ambient temperatures – overloading)
      - Are the thermostats in the motor is tripped (N/C contacts)?
    - No tach signal
  - Attempt a reset
- Make sure the controller is getting a start signal (N/O contacts)
- Make sure there is not a STOP signal (N/C contacts)

If the controller isn't functioning by this point, it's pretty safe to say that the controller is defective.

Procedure 2: Test and inspect motor

Inspect electrical connections to the motor.

Correct any loose or broken connections.

Check for signs of heating or "resistive connections"

Examine the brushes

Are they all making good contact on the commutator?

Are there any loose brush leads (replace any brushes that are too short or damaged)

If the motor still does not operate, disconnect the power supply from the motor and use the ohmmeter to check the armature circuit for continuity.

An open connection in the armature circuit could be caused by:

1. Worn and hung up brushes
2. Blown brush shunts
3. Open interpole circuit
4. Open series field (if so equipped)
5. Open armature (Commutator connections or winding)

PROBLEM: OVERLOAD RELAY TRIPS OR FUSES BLOW WHEN MOTOR STARTS

A starting current that is too high causes tripping the overload relay or blowing fuses when starting.

- **Grounded windings**

  Test all windings for ground failure using the megohmmeter. Any grounded windings must be repaired before power is applied to the motor

- **Mechanical problems with the motor or driven equipment**
  1. Mechanical problems such as worn bearings or a broken pinion could cause a mechanical overload.
  2. Determine if the problem is in the motor itself or in the driven equipment. Uncouple the motor and turn the armature by hand. If the armature moves freely and the motor starts without tripping the overload relay or blowing fuses when uncoupled, the problem is most likely in the driven equipment and not in the motor.

- **Shorted armature winding**
  1. You can check the armature for shorts while the motor is uncoupled. After removing all brushes from the commutator, apply rated voltage to the shunt field and rotate the armature by hand. One or more shorted coils is indicated if the armature seems to be "bound up" or cogs as you rotate it.
  2. If the motor will run for a short while before the overload trips or the fuse blows, shut down the motor and then feel the armature coils with your hand. Shorted coils will feel hotter than the others because they will have had heavy circulating currents induced into the shorted turns.

- **Defective field winding**

  A DC motor must have 100% field strength to produce its maximum torque and to keep the armature amperage within proper limits. Reduced field strength will cause high armature currents.

  1. Test the shunt field **continuity** by measuring and recording the resistance of the shunt with an ohmmeter. A reading of infinity indicates an open circuit in the winding, which requires repairs to the motor.

2. Test the shunt field winding for **shorted turns**.
   Compare your shunt field resistance measurement to the nameplate data.
   2.1. The motor nameplate may tell you field resistance. Remember, if the motor is HOT, your measured resistance will be higher than the "@ 20° C" resistance listed on the nameplate. If the resistance of the field is equal to or less than the resistance listed on the nameplate, your winding is probably shorted.
   2.2. If the nameplate doesn't tell you the correct resistance, you can calculate a good estimate using this formula:

   $$\text{Field Volts/Field Amps} = \text{Field Resistance } (\Omega)$$

   <u>Note:</u> The field amps on the nameplate will be correct for the motor running at its normal full load condition with HOT fields.

   To estimate HOT resistance when you are measuring a COLD field, use this old "rule of thumb":

   $$(\Omega_{cold} \times 10) / 8 = \Omega_{hot}$$

3. In "Compound Wound or Stabilized Shunt Wound" motors, test for shorts between the shunt and the series coils using the megohmmeter. Any shorts between the windings will require repairs to the motor.

PROBLEM: MOTOR RUNS AT HIGHER THAN RATED RPM

- Verify correct tachometer feedback

- Measure the armature and the shunt field voltages at the motor terminals to be sure they are in accordance with the nameplate data.
  1. The speed of the motor will increase if the armature voltage is higher than shown on the nameplate
  2. The speed may also be higher if the applied shunt field voltage is lower than the value shown on the nameplate.

- If applied voltages are in accordance with the motor rating, there is a defect in the winding. Test for:
  1. Grounds in all windings
  2. Shorts in shunt field
  3. Shorts between shunt and series field (if it is a compound–wound motor)
  4. Continuity in shunt and series coils (high resistance indicates an open circuit)

PROBLEM: MOTOR RUNS AT LOWER THAN RATED RPM

- Measure the armature and field voltage at the controller and compare it with the nameplate value.
  1. Reduced armature voltage will decrease motor speed
  2. Increased field voltage will decrease motor speed

- If applied armature and field voltages are in accordance with the motor nameplate, inspect for high resistance connections in the armature circuit.
  1. Loose connections and check for hot spots and discolored insulation around the connections
  2. Contactors in controller making good contact
  3. Broken or "breaking" conductors due to "flexing"
  4. Shorting contactors must be closed during operation

- If the speed of the motor varies continuously with constant voltages applied, and you have eliminated excessive resistance in the armature circuit, check for shorted armature coils.
  1. You can check the armature for shorts while the motor is uncoupled. After removing all brushes from the commutator, apply rated voltage to the shunt field and rotate the armature by hand. One or more shorted coils is indicated if the armature seems to be "bound up" or cogs as you rotate it.
  2. Shut down the motor and then feel the armature coils with your hand. Shorted coils will feel hotter than the others because they will have had heavy circulating currents induced into the shorted turns.

PROBLEM: SPARKING UNDER THE BRUSHES

Sparking under the brushes is a **commutation problem**. Mechanical problems (rather than electrical ones) are usually the cause. First of all, measure the armature current with the DC ammeter to see if the motor is overloaded. If the armature current is OK, concentrate on mechanical problems associated with the brushes.

- **Inspect the Brushes**
  1. Make sure no brushes are missing and that all of them are properly seated on the commutator
  2. Check that all brush leads are intact and that they are securely fastened to the brush holder
  3. Check brush springs for correct pressure
  4. Make sure the brushes fit properly and move freely in their brush boxes. They should not be too tight or too loose
  5. Check brush holder mountings for looseness, which could be caused by burnt brush holder insulation (carbonization) or loose fasteners
  6. Check the brush rigging jumpers to be certain that they are tight and securely connected
  7. Inspect the brush–mounting ring for damage, and make sure it is securely locked in the neutral position

- **Inspect the Commutator (mechanical focus)**
  1. Physical damage (for example, from rubbing)
  2. Is the commutator run–out excessive?
     Commutator run–out should be less than "0.001" when the commutator is new. The normal operating speed of the machine will dictate how much tolerance in run–out can be allowed. Generally, if the commutator run–out exceeds "0.005" to "0.010" the commutator should be turned.
  3. Inspect the commutator, making certain there are no *raised* segments
  4. Make sure there are no segments with flat spots
  5. Check for *high mica*
  6. Be sure there is no foreign matter between the commutator bars
  7. All of the conditions above can cause the brushes to bounce at high motor speeds. The interruption of the armature current will invariably cause sparking
  8. Severe vibrations from an unbalanced armature
  9. Run the motor uncoupled before removing it for service to see if the imbalance is in the motor or the machine
  10. Worn bearings
  11. Uneven air gaps can result if bearing clearances are out of whack. The movement of the armature can also cause the brushes to bounce

- **Inspect the Commutator (electrical focus)**
  Inspect the commutator segments for signs of discoloration

1. Burned segments indicate open circuits
   - Broken coil leads behind the risers.
   - Thrown solder and loose connections at the risers.

2. Darkened segments can indicate shorted armature coils. The armature can be tested as we mentioned earlier to determine if it is shorted. *Be Advised*, a **definite pattern** of darkened commutator segments (every third or fourth segment, for instance), is often mistakenly assumed to indicate a problem. The design of the armature can produce patterns in the film that the brushes put down. Some characteristics of armature design that can cause current fluctuations and *bar patterning* are:
   - Odd turns in armature coils
   - Commutator bar and armature core slot combinations

   The bottom line is, if the discoloration pattern is repeated around the entire diameter of the commutator, there is probably NOT a problem with the armature winding.

NEWLY INSTALLED MOTORS

The troubleshooting procedures outlined previously all apply to motors that fail after having been *in operation* for sometime. Now we will discuss troubleshooting motors that fail shortly after installation.

PROBLEM: NEWLY INSTALLED MOTOR DOES NOT START OR FAILS SHORTLY AFTER INSTALLATION

If a new motor or *newly repaired* motor malfunctions the first time it is put in service:

1. Make sure the control unit is properly matched to the motors nameplate ratings
2. Determine if the overcurrent devices are properly sized and properly adjusted
3. Check the control unit's input and output connections
4. Check the motor lead connections to be sure they are ***correct*** and tight
5. Make sure the controller is functioning properly

If these checks indicate no reason for the malfunction, gather all the facts that you can and call Electrical Equipment Company for assistance.

Some of the procedures outlined below require special equipment and great familiarity with the construction of DC motors. We highly recommend that they should be undertaken only with the aid and assistance of motor shop personnel. You will especially want the motor shop personnel there to protect your interests if you feel there are any manufacturer or repair warranty considerations.

PROBLEM: NEWLY INSTALLED MOTOR RUNS AT HIGHER THAN RATED RPM

- **Make sure the shunt field is properly connected** for the voltage provided by the controller.
  If a dual voltage shunt field motor has the fields connected for high voltage and low voltage is applied to the field, the motor will run at higher than rated RPM. This condition will also produce high armature currents. To restore the speed of the motor to its normal range, reconnect the shunt field for **low** voltage.

  A note of caution: A shunt field connected (in parallel) for low voltage and then connected to a high voltage field supply will result in the shunt field burning out if adequate overcurrent protection is not provided. The manufacturer or the repair shop could NOT warrant such an overcurrent condition.

- **Reversed Series Field polarities** may cause compound–wound motors to run at above the nameplate RPM when the motor is under load. If the motor rotation is correct, go ahead and interchange the series field leads.
- **An incorrectly rewound armature** can also cause a DC motor to run above its rated speed. This will happen if fewer turns were used in the new armature winding.

  Another winding error can be that the repairman put the first coil lead down into the wrong commutator bar. Hence, all the coil ends in the top of the commutator bars are in the wrong position. This error will generally double, or halve the motors speed depending on the motors original connection, and which error was made.

PROBLEM: NEWLY INSTALLED MOTOR RUNS IN REVERSE DIRECTION

After a DC motor has been repaired, you will sometimes find that the direction of rotation has been reversed. Correct this problem by interchanging the armature leads.

PROBLEM: SPARKING UNDER THE BRUSHES IN NEWLY INSTALLED MOTORS

It is not uncommon to find sparking under the brushes in a newly installed motor. In most cases minor adjustments will correct the problem.

- **Brush holder alignment**
  Check that the brush holders align all brushes with the commutator bars and that equal spacing between the brushes is maintained.

- **Make sure the brushes are in the neutral position**
  In the neutral position, the line marking on the rocker ring must match the marking on the end bell. Make any adjustments necessary. If you suspect that the marking on the rocker ring is incorrect, you can determine the neutral position by following this procedure:
  1. Unlock the brush rigging so that you can shift it freely
  2. Disconnect the shunt field leads from the wiring
  3. Connect an AC voltmeter to the shunts of brushes on *adjacent* brush holders
  4. Apply single–phase power (110 VAC) directly to the shunt field winding
  5. Shift the brush rigging left, and right, while observing the voltage indicated by the AC voltmeter. The brushes are on neutral when minimum voltage is indicated (usually less than 1 volt AC)
  6. Lock the brush rigging securely and mark the rocker ring and the endbell to indicate the correct neutral position.

- **Relative polarity of main poles and interpoles**
  Check the polarity of all main poles and interpoles using a magnetic compass. The polarities are correct when the polarity of the interpole *is the same as that of the main pole preceding it in the direction of rotation.* Should the polarities not be in the proper relationship, interchange the two brush holder leads.

- **Brush grade:**
  Check to be sure that the brush grade is compatible with the environment in which the motor operates. All brushes must be of the same grade.

  Brush grade selection requires specialized knowledge of the carbon materials and fabrication methods used. Electrical Equipment Company can help you acquire the data needed to make informed decisions on specifying new brushes.

  If the cause of the motor failure cannot be determined using procedures described in this *Tech Note,* the motor should be brought to the Electrical Equipment Company location nearest you. We will have the equipment and "know–how" that you need.