2011

Introduction:

360° Test Labs has been retained to perform a comparison of electrical / mechanical measurements, and build quality, between motors manufactured by Brand-1 and Brand-2 to address reliability concerns.

Product Picture Omitted

The following products were provided:

- Three (3) 115VAC motors manufactured by Brand-2, model 2#;
- Three (3) 230 VAC motors manufactured by Brand-2, model 2#2E;
- Three (3) 115VAC motors manufactured by Brand-1, model 1#;
- Three (3) 230VAC motors manufactured by Brand-1, model 1#2;
- Three (3) gear boxes manufactured by Brand-2, model 2#3;
- Three (3) gear boxes manufactured by Brand-1, model 1#3; and
- Three (3) gear boxes manufactured by Brand-1, model 1#4

Appropriate starting capacitors and gear box mounting hardware was also provided.

Findings:

Four 15W motors from each vendor were evaluated. The following table lists the Device Under Test #, Part #, and Motor Operating Voltage:

Vendor	DUT #	Part #	Operating Voltage
Brand-1	1	1#	115V
Brand-1	2	1#	115V
Brand-1	3	1#2	230V
Brand-1	4	1#2	230V
Brand-2	5	2#	115V
Brand-2	6	2#	115V
Brand-2	7	2#2	230V
Brand-2	8	2#2	230V

Electrical Test Set Up and Methodology

The motors were wired with quick disconnect connectors for testing purposes. The supplied capacitors were soldered to the red and white motor wires and the red and black leads connected to a Statco Energy 1000W Variac via an 18 gauge lead and plug. The variac was used to allow varying the input voltage to the motors. The variac was connected to the mains via an isolation transformer.

A Yokogawa Model WT210 Digital Power Meter monitored the motor current and the motor voltage via a Kelvin connection at the motor to eliminate IR voltage drops at the motor due to cabling.

A high power LED strobe triggered by a Wavetek pulse generator was used to measure motor RPM. The period of the strobe pulses is monitored by a LeCroy oscilloscope and the period is converted into revolutions per minute.

Starting torque was measured by installing a collar on the rotor shaft with a 1 1/4” long rod extending 90 degrees from the shaft. A small hole was drilled in the rod at 1” from the center of the rotor shaft. A solid wire was inserted in the hole and secured while the other end of the wire was connected to a Extech 475044 Force Gauge that measures the force in pounds. The pound force inch (lbf in) was then converted to newton millimeter (N mm).

Motor Current versus Motor Voltage

Figure 1 is a graph of motor current versus motor voltage for the 115V motors and Figure 2 is for the 230V Motors. As can be seen the current rises until the motor starts rotating, then the motor current decreases due to the emf of the motor. As the motor voltage increases, the current starts increasing again. What seems like a gradual decay of current from when the motor starts turning is just the resolution of the motor voltage increments.

The Brand-1 motor has a higher degree of drag than the Brand-2 motor and therefore requires a higher starting voltage. The cause of this drag will be discussed later. The current at nominal operating voltages is also higher for the Brand-1 motor due the required increase in torque.

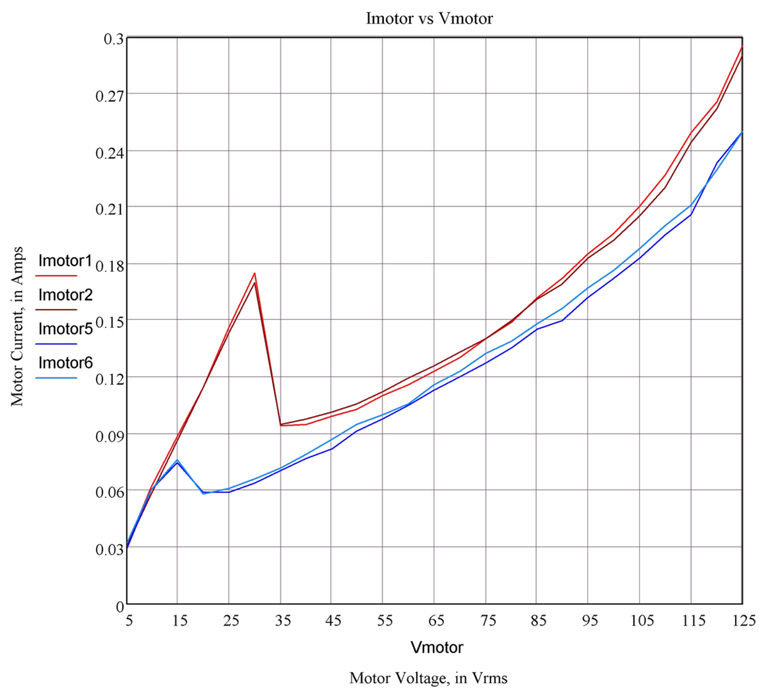


Figure 1

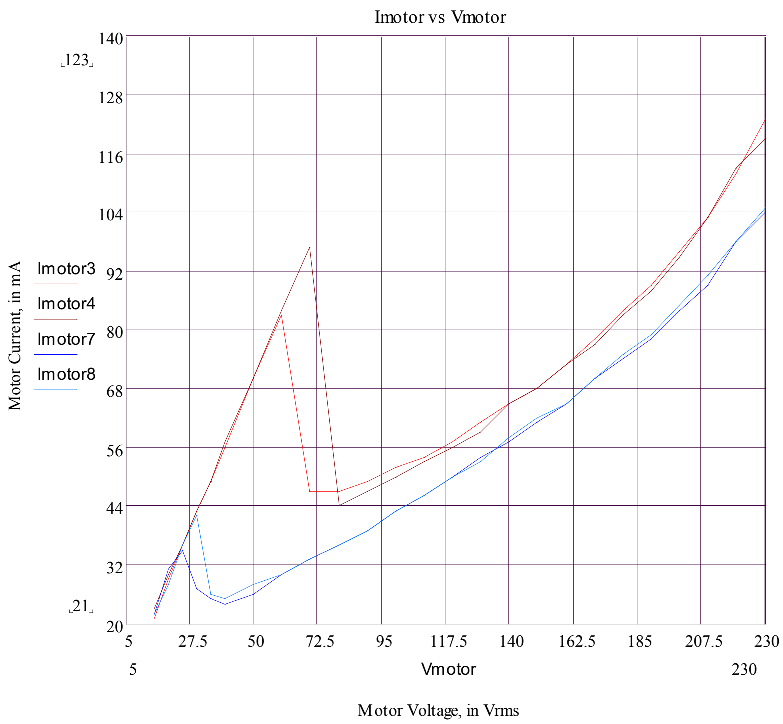


Figure 2

Stall Current

The stall current was measured by locking the rotor and measuring the motor current. Stall currents was found to be about the same for each motor type.

DUT	Stall Current, in mA
1	**670 @ Vmotor - 115V**
2	**662 @ Vmotor - 115V**
3	**316 @ Vmotor - 230V**
4	**325 @ Vmotor - 230V**
5	**650 @ Vmotor - 115V**
6	**654 @ Vmotor - 115V**
7	**326 @ Vmotor - 230V**
8	**324 @ Vmotor - 230V**

Dielectric Strength and Insulation Resistance

One 115VAC and one 230VAC motor from each manufacturer were subjected to these electrical tests (four motors total) per specifications listed in the Brand-2 data sheets (Brand-1 did not list similar specifications).

1500 VAC at 60 Hz was applied between the motor wires and frame of the motors for at least one minute. Leakage current due to the capacitance between the motor windings and frame was measured at between 150 and 175 μAmps on all four motors, indicating the effective capacitance of the windings to motor cases was between 1700 and 3200 pF. The leakage current remained constant within several microamperes throughout the tests, indicating no breakdown of the insulation between the windings and the motor frames.

Insulation resistance was measured by applying 500 VDC to the motor wires then measuring the leakage current to the motor frames. Each motor measured less than 1 μAmp leakage current, implying greater than 500 megohms insulation resistance.

Motor RPM vs. Motor Voltage

Figures 3 and 4 are graphs of the motor speed in Revolutions Per Minute (RPM) versus the voltage applied to the motor. The performance agrees with Figures 1 and 2 in that a higher motor voltage is required to overcome the “stiction” of the Brand-1 motors.

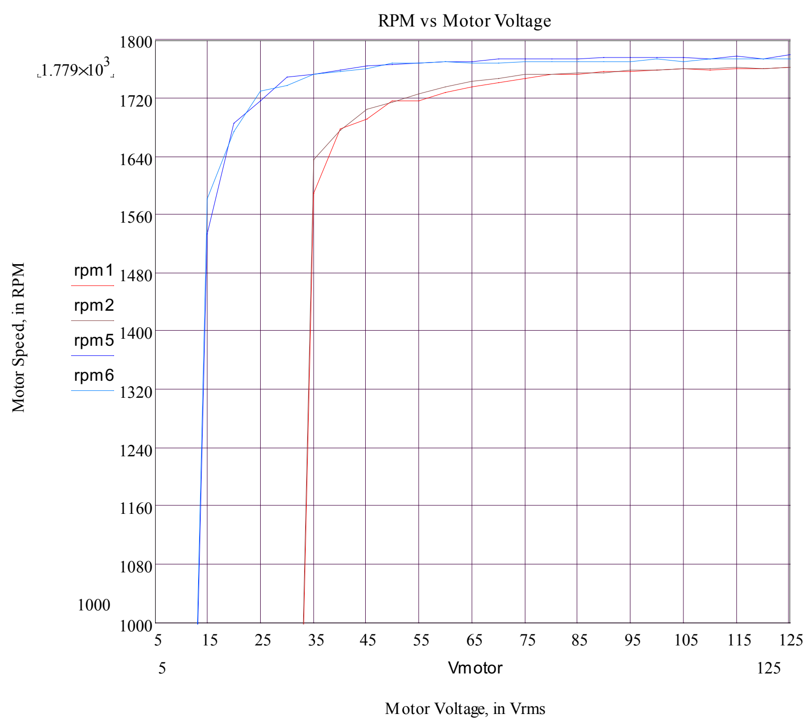


Figure 3

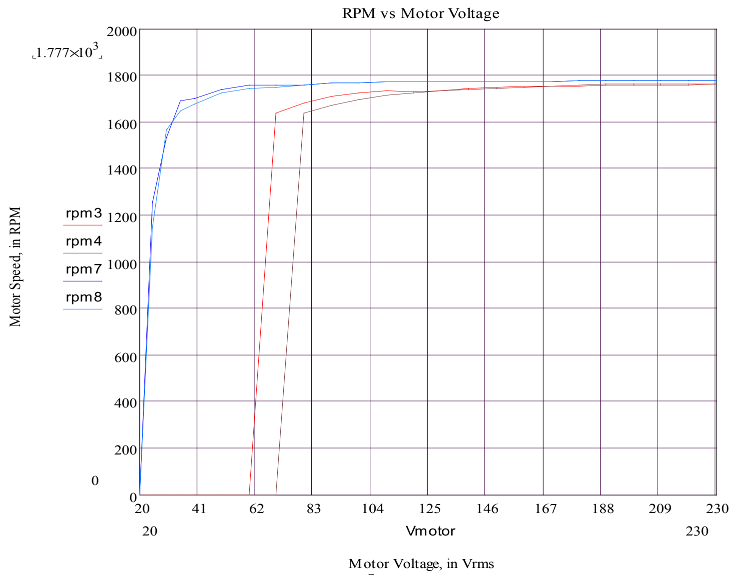


Figure 4

Starting Torque vs. Motor Voltage

Figures 5 and 6 are graphs of the starting motor torque versus voltage applied to the motor. No significant differences were observed.

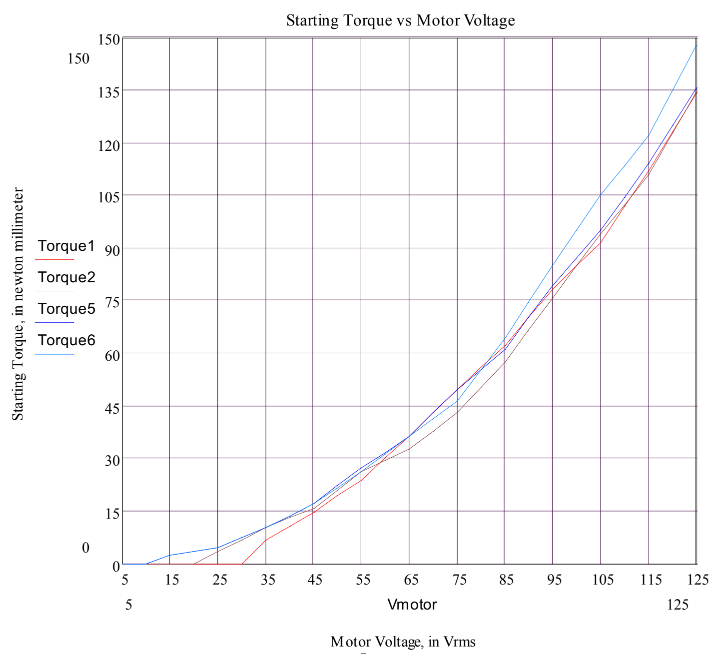


Figure 5

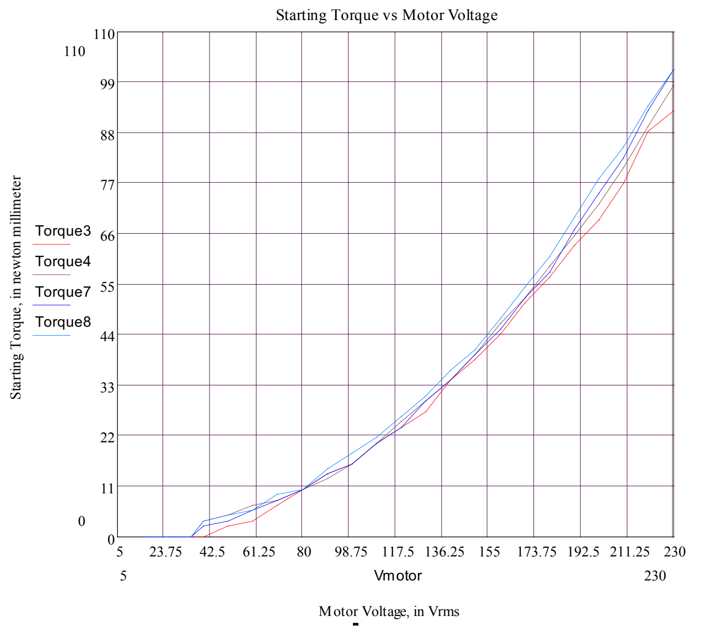


Figure 6

Temperature Rise:
The temperature rise of the motors during free-run mode was measured two ways:

- Using a Mikron “Midas” Infrared Thermal Imaging camera and software, the motor was allowed to stabilize at 125V/230V. A snapshot of the imaging properties was then taken to record the data. For each motor, the parameter of interest in the following images is under the frame “ROI 1” that gives the maximum temperature along the line “1” drawn along the motor case. The graph on the upper left shows the temperature of the case and surrounding air. The text in the lower right indicates the Measured Temperature Rise that is the maximum recorded temperature with the motor running/temperature stable, minus the original temperature with no power applied. For Brand-1 motor #2 and Brand-2 motor #6, a second line “2” was run through the shaft to measure the shaft temperatures.

- The winding resistance was measured using a Keithley Model 2000 Multimeter with no power applied and after power applied / temperature stable. The power was disconnected and the motor winding resistance quickly measured.

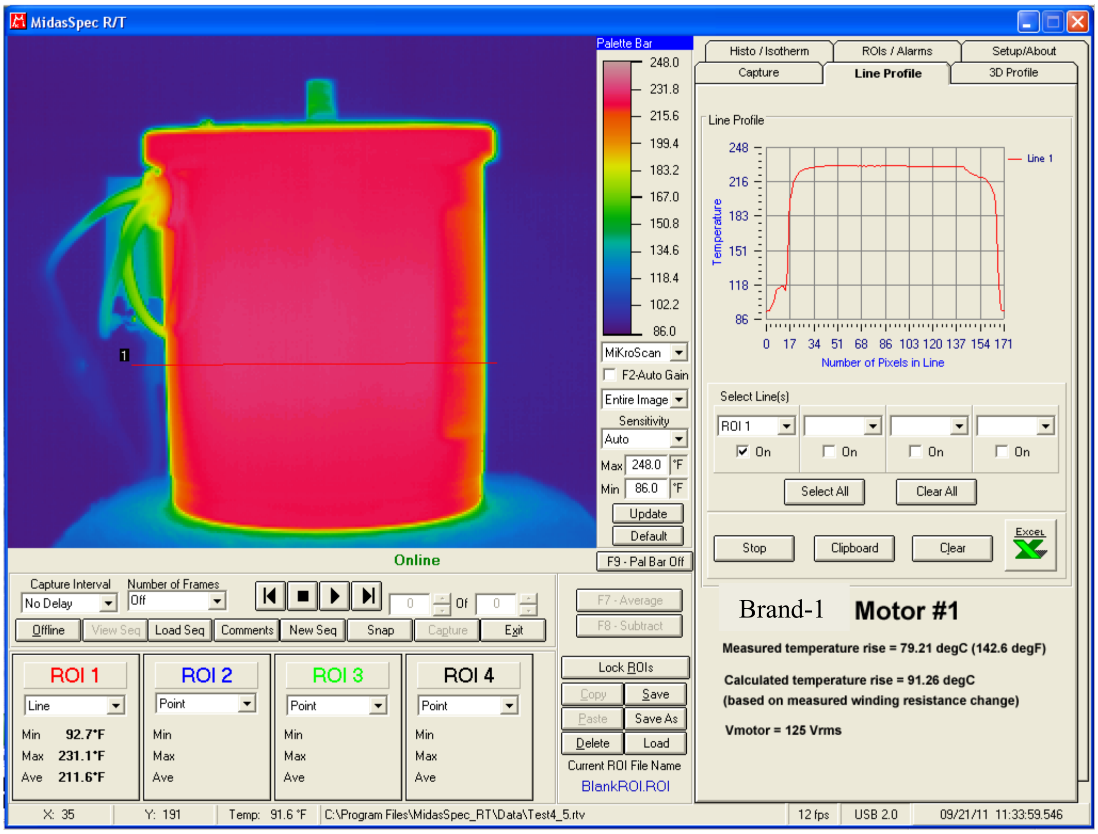


Figure 7

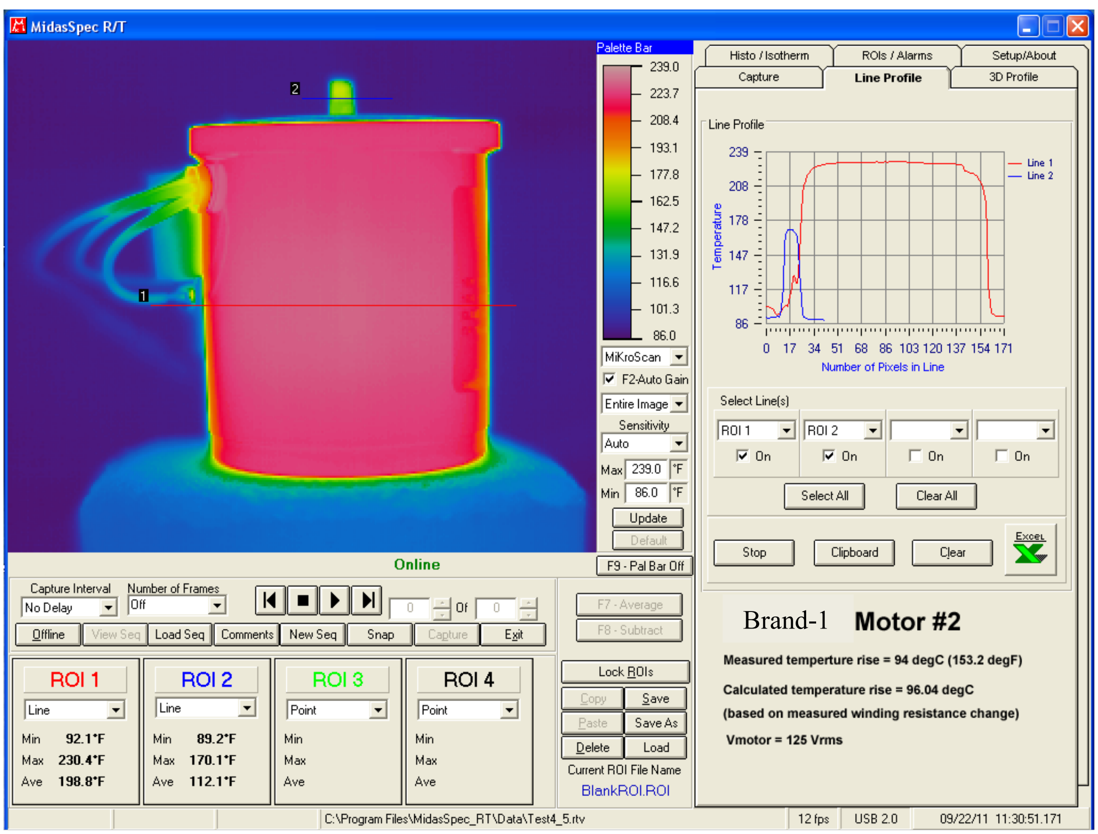


Figure 8

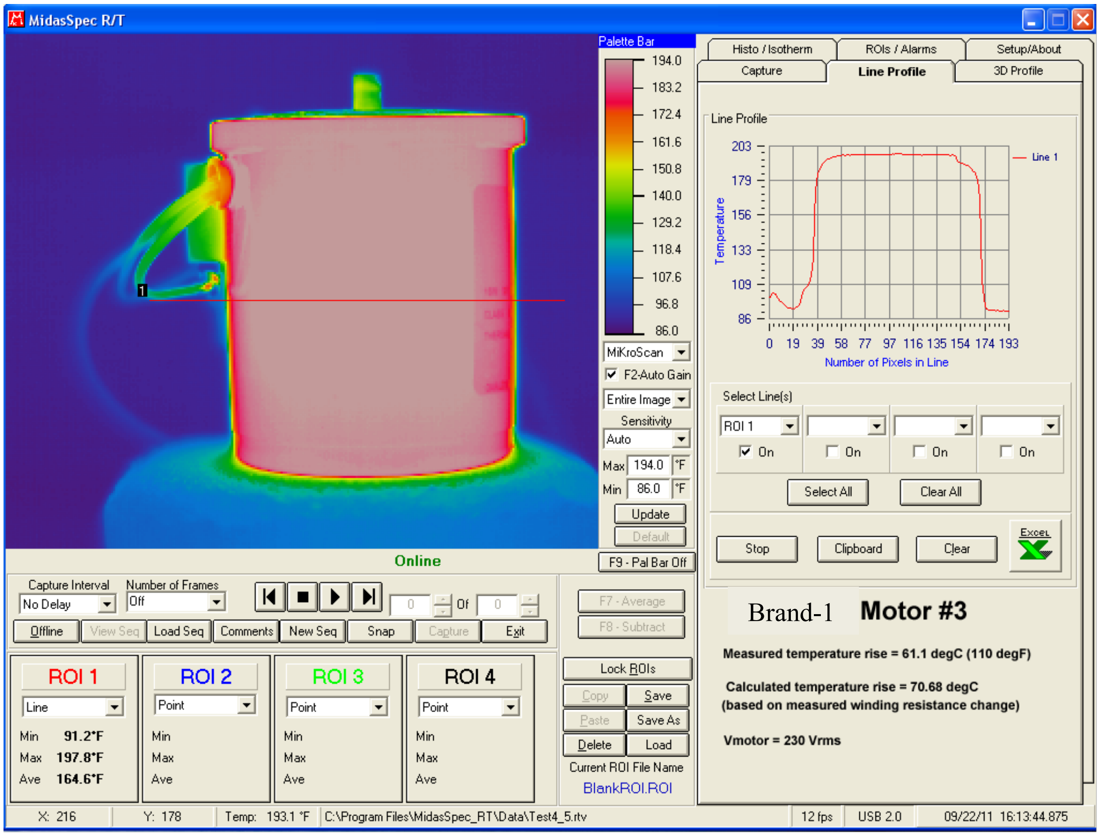


Figure 9

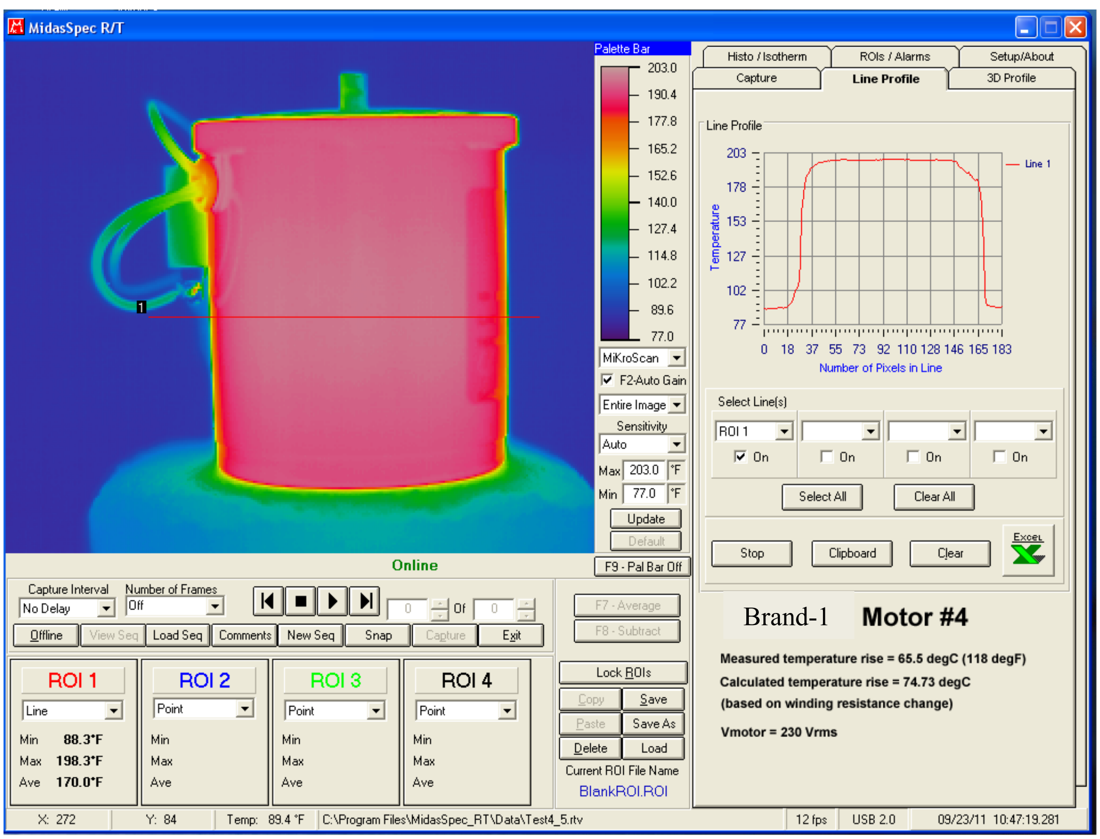
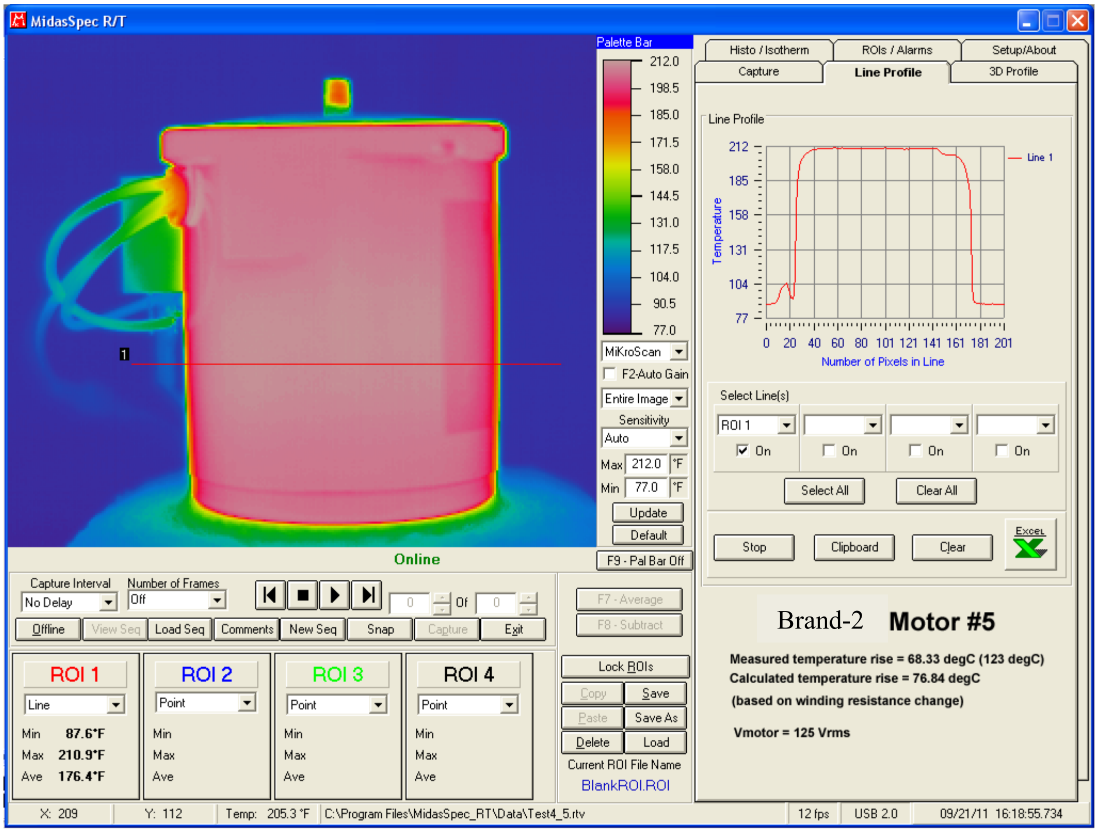


Figure 10



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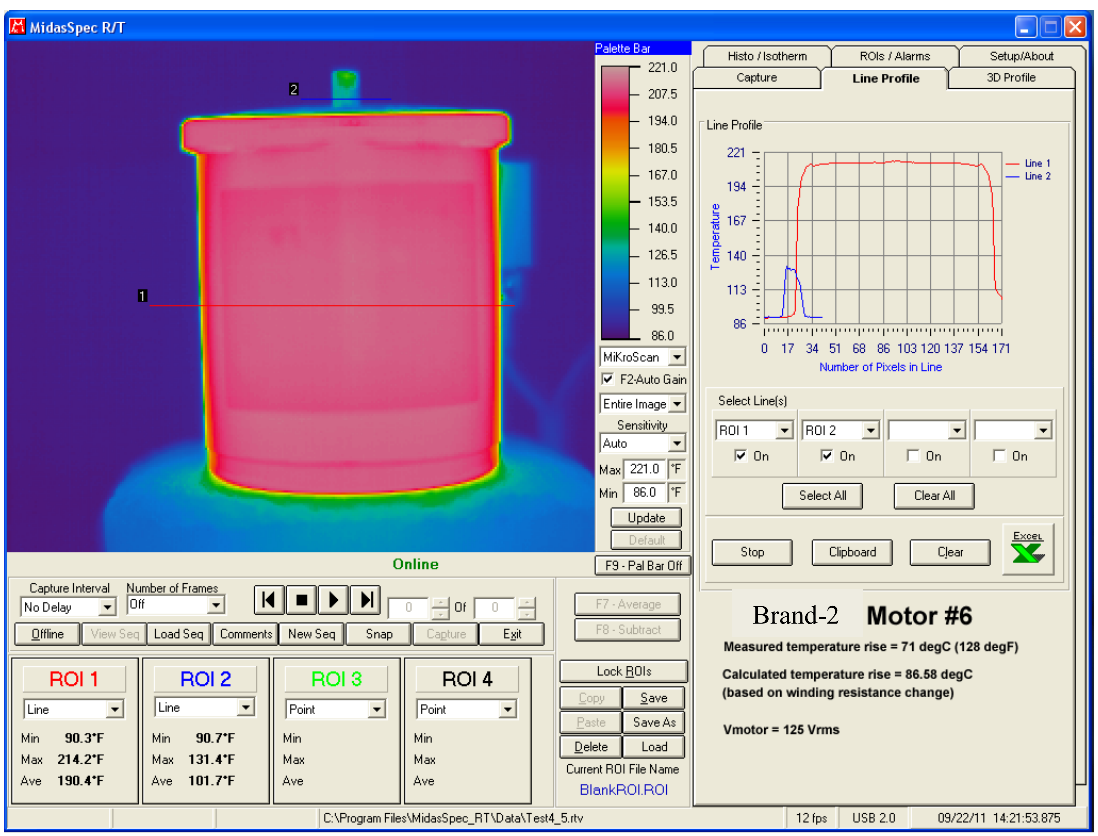

Figure 12

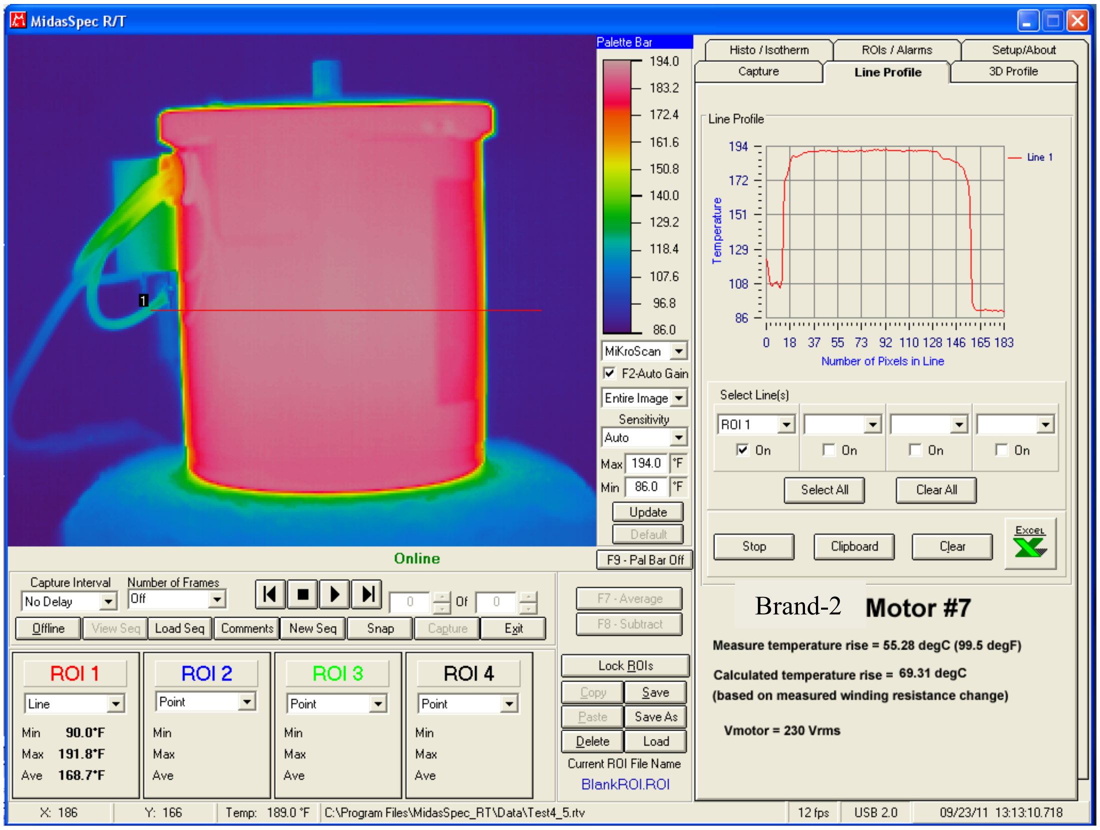

Figure 13

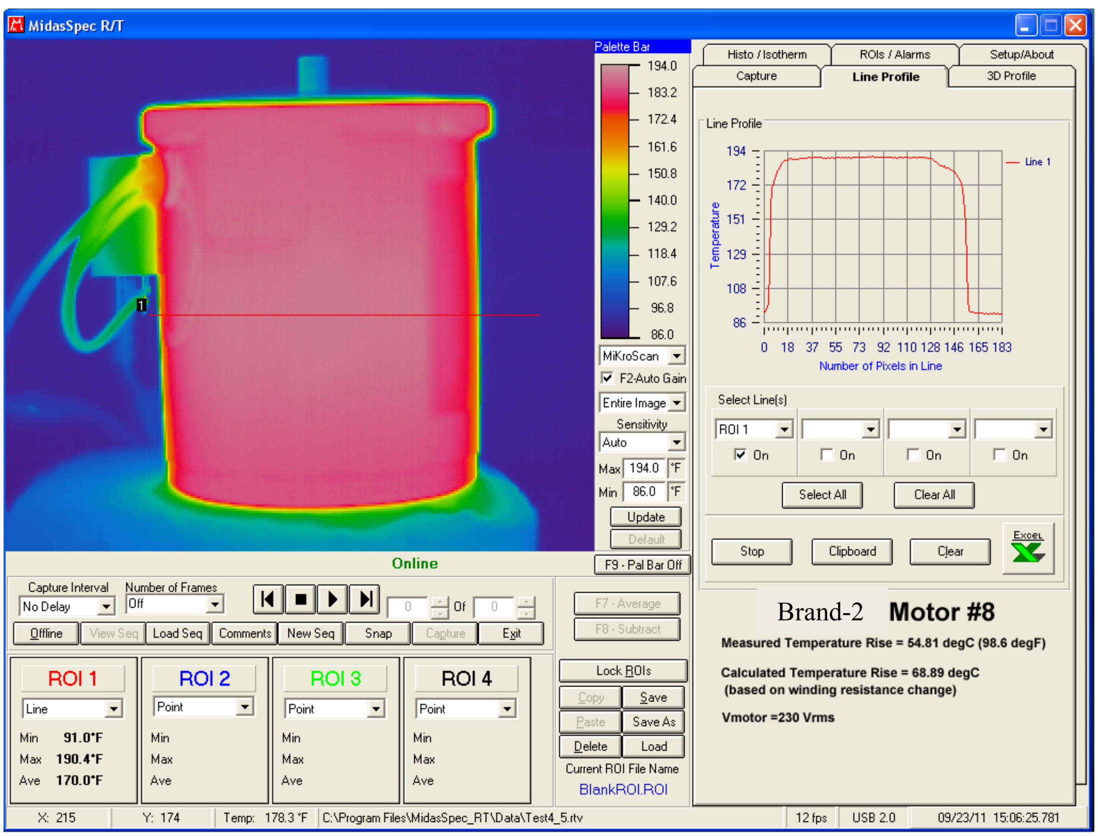

Figure 14

On average, the Brand-1 115V motors ran 17° C hotter than the Brand-2 115V motors, and the Brand-1 230V motors ran 8° C hotter than the Brand-2 230V motors. This has a direct effect on motor life as will be discussed later.

Motor Disassembly and Photographs:
After the motors were fully characterized, the motors were disassembled for inspection using a custom device to minimize damage to the motors. Motors 1, 4, 5, and 7 were selected representing one each from Brand-1/Brand-2 115V/230V. The following four photographs are front and back exploded views of the Brand-2 and Brand-1 motors

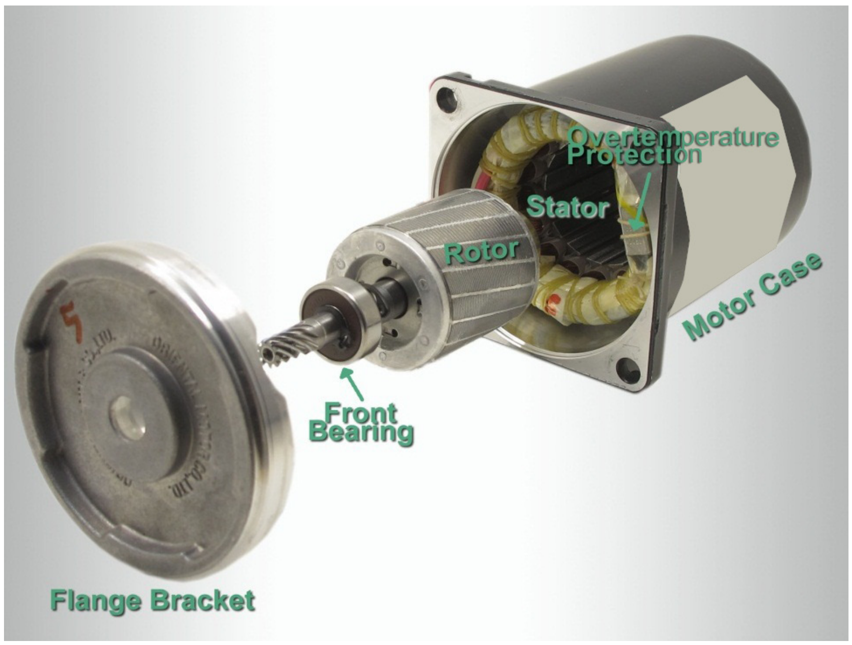

Figure 15 Brand-2 Motor

Figure 16 Brand-2 Motor

Figure 17 Brand-1 Motor

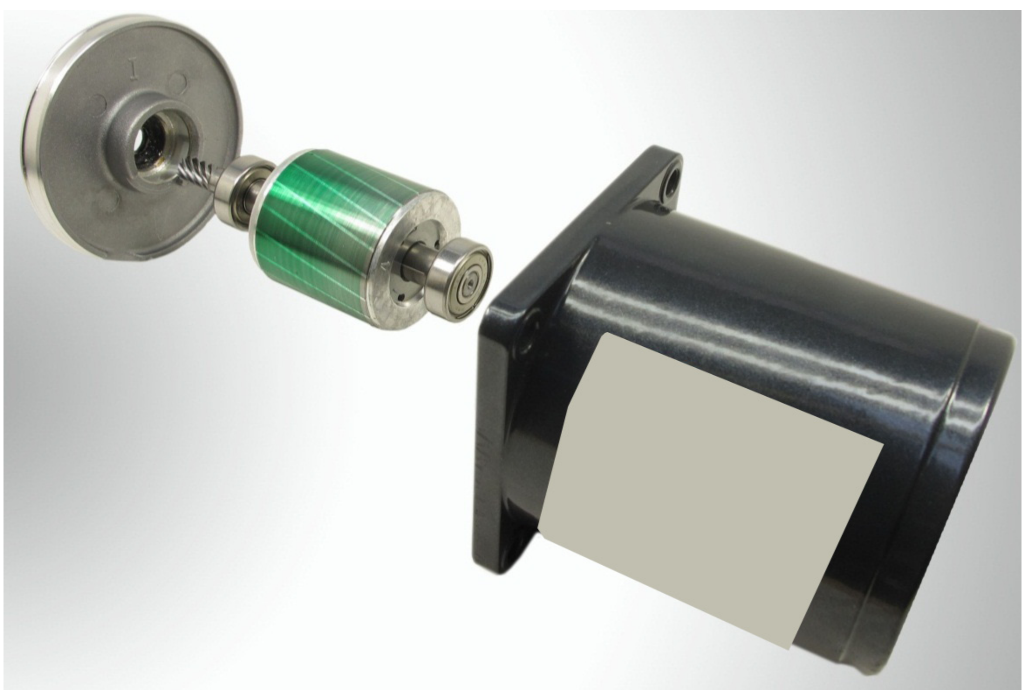

Figure 18 Brand-1 Motor

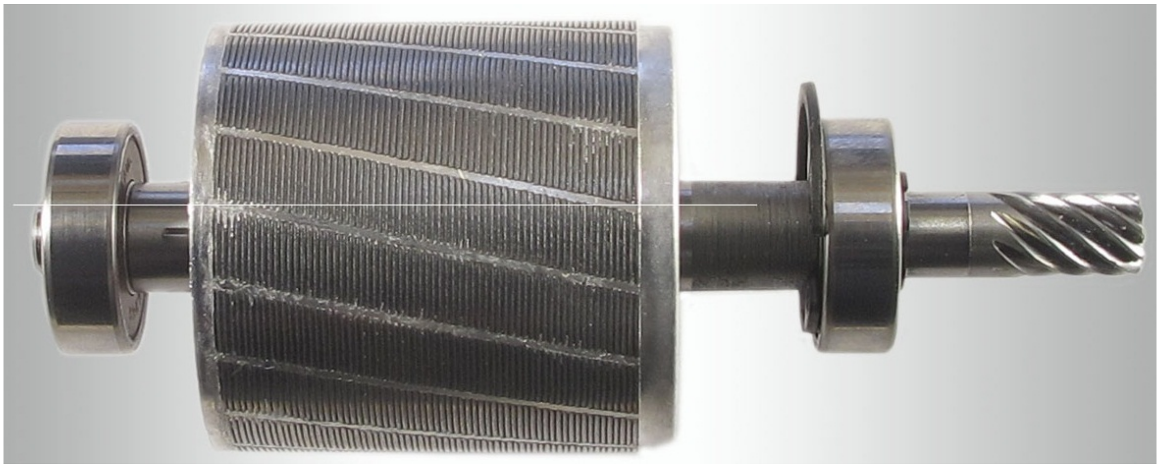

Figure 19 Brand-2 Rotor

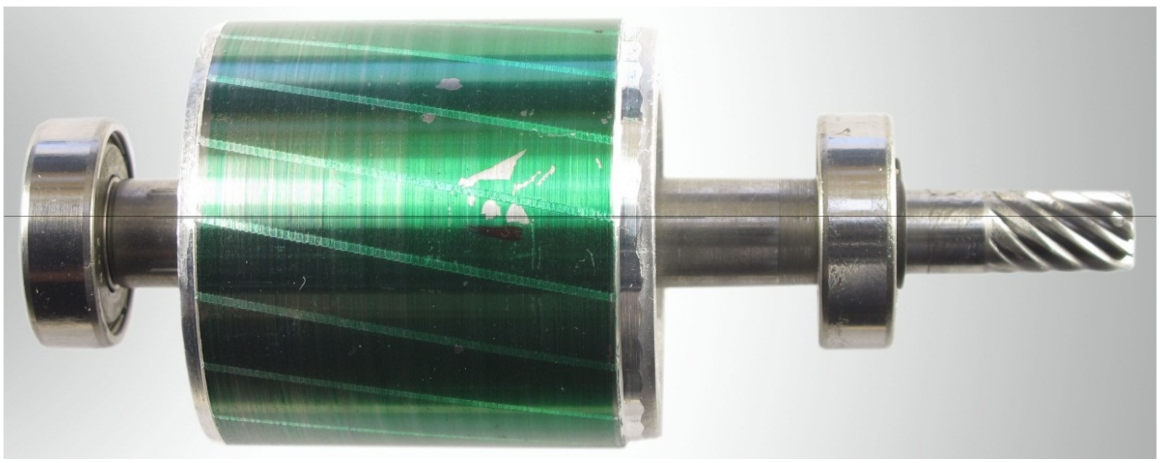

Figure 20 Brand-1 Rotor

Shown above are the rotors from the two vendors. The photos were rotated to ensure that the shafts were level. A reference line was then drawn through each rotor. This line helps show that the angle of the skewed slots are the same for both motors. A skewed rotor helps in the reduction of magnetic hum, thus keeping the motor quiet, and also avoids “Cogging,” i.e., locking tendency of the motor, plus other factors.

Over-temperature Protection:
The over-temperature protection turn OFF temperature could not be evaluated, due to a limitation of the laboratory equipment. (250 °F maximum), but engineers noted differences in build quality concerning the protectors between the two vendors.

FIGURE 21

Figure 21 is a photograph of the Brand-1 Stator. At the bottom left is the over-temperature protector. The black main lead is crimped to the protector.

Figure 22

The Brand-2 motor is shown in Figure 22 above. The over-temperature protector, seen at the upper right, has 1.5” leads that are part of the protector and are twisted together with the black main leads and then soldered. A hard plastic tube is then slipped over the joint. This connection is more reliable than a crimped connection with respect to vibration effects.

Also notice that the Brand-2 “stringing” around the top conductors is more robust as opposed to the hand-tied method used in the Brand-1 product.

Although not clear in the photos, the Brand-2 stator has an epoxy coating over the top as extra lead integrity.

Stator Wire Gauge:
The wire used in the windings of both motors measured 0.00866” using a precision micrometer, which is wire size AWG 32.

Bearings:
The motor bearing is the only part of the motor that sees any significant wear, and the motor bearing relies upon the grease inside the bearing to prevent wear. Before opening up the motor, a simple spin of the motor shaft (a qualitative observation) was made on each of the motors. The Brand-2 shafts would spin for several seconds, while the Brand-1 rotors would stop almost immediately.

Both motors used the same part numbers from the same manufacturer, NMB, except for the last alpha designators. The Brand-1 motor uses a model 607ZZ for the front bearing, while the rear bearing is a model 626ZZ. The Brand-2 motor uses a model 607SS and model 626SS, respectively. The ZZ designator means that the bearing has a metal grease shield, while the SS designator is for a rubber seal. The ZZ comes standard with these bearings, while the SS version is an extra cost option that should do a better job of sealing the bearings from contamination.

The excessive drag with the Brand-1 motors showed up on many of the tests as higher supply current; higher motor voltage to start rotating; and higher temperature rise. The root cause of the drag (and resulting lower torque and lower efficiency) could be the viscosity of the grease within the bearings, manufacturing tolerances, or misalignment of the rotor during manufacturing. It is often quoted that a 10° C rise in grease temperature can reduce its life by 50%. In the case of the 115VAC motors, the Brand-1 motor case temperature was 17° C hotter.

MISCELLANEOUS MEASURES –

Starting Capacitor:
Capacitance measurements were performed on the starting capacitors included with each motor using a BK Precision model 878 Universal LCR Meter. All 8 capacitors were well within specifications.

Capacitor #	**Capacitance, in uF**	**Delta % from nominal**
1	**4.404**	**-2.13%**
2	**4.418**	**-1.82%**
3	**0.981**	**-1.90%**

Capacitor #	Capacitance, in uF	Delta % from nominal
4	**0.991**	**-0.90%**
5	**4.563**	**1.40%**
6	**4.583**	**1.84%**
7	**1.023**	**2.30%**
8	**1.028**	**2.80%**

Motor Weight:
Weight measurements were made using a precision Arlyn Scale. Heavier weight (with the same materials) could mean sturdier construction.

DUT #	Weight, in pounds
1	**2.2**
2	**2.2**
3	**2.2**
4	**2.2**
5	**2.4**
6	**2.4**
7	**2.4**
8	**2.4**

Application Support:
Engineers anonymously called Brand-2 application support using their toll free number and found that the support was exceptional. 360° posed several technical questions and requests for diagrams, etc.; all questions were answered and 360° was provided with diagrams and life test reports available on their web site.

360° engineers could not find any number to call Brand-1, but did find an email address for technical support; however, no reply was received to our inquiries.

CONCLUSION

Internal inspection and research indicates that the Brand-1 motor is a copy of the Brand-2 motor. Although the motors are very similar, the build quality, electrical / mechanical performance, and customer support for the Brand-2 was superior.

Since the impetus for this evaluation was a concern for reliability, the better build quality and lower operating temperature of the Brand-2 motor indicates that this would be an excellent candidate for the application.