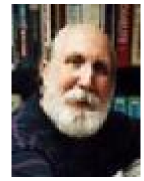
Shop "Tech Talk"   April 2008



Q. **I am a newcomer to the factory maintenance department of my company. Can you give me some basic information on troubleshooting electric motors of all kinds?**

Basic Electric Motor Troubleshooting-Part 2

In Part 2 below we will look into the various tests that can be done when investigating trouble with an electric motor.

There are human tests as well as electrical tests that can be administered.
What do I mean by human tests?
Well I urge you, upon approaching a motor troubleshooting incident, to first be acutely aware of what you can SEE, SMELL, TOUCH and HEAR.
If a motor smells burnt, the likelihood is that it is or has suffered a severe over temperature in which case it may need to be forwarded to an expert for determination of its life expectation (Occam's Razor Principle, paraphrased can be stated as "All other things being equal, the simplest solution is the best").

If you hear a different noise coming from the motor load combination, this noise is trying to tell you that something is different and it is probably not likely to be a good thing.

If you lay your hands on the motor you will get a great sense of motor heat problems, if any, especially if you have laid hands on it previously in its non problematic state.

Lastly if you look intently all over the motor installation , like you did when you first met your wife/girlfriend, then you may see something that will lead you to a clue as to the problem.

***NEVER approach a motor troubleshooting incident like it was just another day at the office*.**
Some days you might get away with it but in the interests of saving money and time I don't recommend it. Often it is what you decide in the first few moments of troubleshooting that determines how you spend the next few hours. Be ACUTELY aware of what your senses are telling you.
I have left out your sense of intuition as a faculty to depend on because I am assuming that you are a newcomer and that your intuition and experience have yet to develop.
Well after all this above, finally comes the moment when we must try and determine the electrical condition of the motor and its connections to the power supply and load.
From here on we use test instruments......
If you are still running the motor, measure all 3 line currents and all 3 line to line voltages.
Record them on a piece of paper for later reference.
What we are looking for here are 3 equal line currents, 3 equal line to line voltages not varying by more than 2%.
If you have any temperature measuring device, measure near the motor shaft end bearing, also the top of the motor near its center and if it is connected by a coupling to some other piece of apparatus measure the inboard bearing temperature on this load.
If we notice a high temp on the motor bearing, is the temp on the load inboard bearing higher or lower. Here we are trying to determine if the load is causing the motor bearing to heat up.
I have not mentioned the opposite shaft end bearing on the motor because so many motors today are TEFC (totally enclosed fan cooled) and it is almost impossible to get at the bearing to measure its temperature.
Once again write down your measurements, on the same scrap of paper. This point of writing the measurements down is not often done but should be done. In my opinion it pays to keep a pocket pad with you when you are working. This point may be reinforced as you get older and your memory less reliable. Ask your salesman for a notepad, we give 'em away regularly.
If the motor is NOT running, then we should measure the resistance between the motor phases. The easiest place to do this is probably from the motor starter or drive box. These resistance measurements have to be made with the starter de-energized so the motor is isolated from the power supply completely. These resistance readings will include the resistance of the wires from the starter to the motor also but this resistance will be very low and once again we are trying to get 3 equal resistance readings with very little difference between them. If it is easier to measure the readings at the motor junction box then this would be preferred. Once again write the readings down. Depending on the size of the motor the resistance values will vary considerably, see the table on the next page. What is important here is that our meter be able to measure this resistance accurately ie that the range of our meter allow us to expect an accurate reading.

Table 14.4 Winding Resistance of AC Induction Machines, Measured Line-to-Line (ohms)

Horsepower rating	Typical winding resistance for standard efficiency NEMA B design motors at various rater voltages			
	230 V	460 V	2300 V	4000 V
1	4.5	18		
5	0.88	3.5		
25	0.14	0.55		
50	0.06	0.24		
100	0.02	0.09	2.2	
200	0.01	0.04	1.0	3.0
400		0.02	0.5	1.5
1000			0.2	0.6
2000			0.1	0.3
5000			0.04	0.012
10,000			0.02	0.060

Note: These values are for a typical four-pole motor in a NEMA frame, given by Andeas in Ref. [39] for 1 to 200 hp. Higher horsepower and voltage values are extrapolated, assuming winding resistance varies directly with voltage squared, and inversely with horsepower.

You can see from the table that a 5 HP motor will have a resistance per phase of approx 3.5 Ω (ohms) @ 460v whereas a 100HP motor would have a resistance per phase of approx 0.09 ohms (90/1000). This is our dilemma. Our meter (DMM) will not have this capability of measurement over this range.
There are low ohm meters available but they are very expensive and not normally found ouside of motor shops. However I would like to recommend a pretty simple solution even though it involves purchasing a specialized meter.
The Extech LCR meter Model 380193 is my suggested solution. It costs approx $200 and has also the benefit of not only resistance but inductance and capacitance measurement. It will measure down to milliohms (a 1/1000 of an ohm) but no lower.

After measuring phase resistance of the motor we should now move on to the measurement of the insulation resistance of the motor. This is the resistance between the ground or outside casing of the motor and any motor lead. Here we are looking for a value as per the table below (created by Baker Instrument Co.).

Table 2 – Recommended minimum insulation resistance values at 40°C (all values in MΩ)

Minimum insulation Resistance	Test specimen
$IR_{1min} = kV = 1$	For most windings made before about 1970, all field windings, and others not described below
$IR_{1min} = 100$	For most dc armature and ac windings built after about 1970 (form-wound coils)
$IR_{1min} = 5$	For most machines with random-wound stator coils and form wound coils rated below 1 kV

NOTES
-IR_{1min} is the recommended minimum insulation resistance, in MΩ, at 40°C of the entire machine winding

From this table we can see that we are looking for a minimum insulation resistance of 5 megohms for most modern machines.
To measure this insulation resistance we use a megger. A 500v rated megger is all that is required for a motor with a voltage rating of 600v or less.
This can be a rotary generator type or an electronic megger. One is as good as the other.
A rotary costs approx $100 on ebay, an absolute bargain. An electronic megger sells for about $500 but it does not need 'cranking.'

Further testing of the electric motor windings can be carried out by using a motor winding surge tester, a very expensive instrument used in electric motor shops. Obviously our motor shop technician can come to your plant with his surge tester and do an onsite check of the condition of the motor windings and, depending on the motor and what is involved in taking it out, this may prove to be the correct thing to do if you are not sure.

I would like to offer a word of caution at this point concerning DMMs (digital multi-meters).
Motors today operate in an electronic world. They are powered by electronic variable speed drives, inverters, and the voltages and currents that the motor draws are composite sine waves NOT pure sine waves.
When we measure these composite waveforms and are looking for an accurate reading we should use what are called True RMS reading meters . They are more expensive than their other counterparts, average responding meters. If the meter manufacturer does not say that it is a true RMS reading meter then you can safely assume that it isn't.
I would strongly recommend that you only purchase True RMS meters if you are working in an environment where you are likely to be working around electronic loads.
If you are directly concerned with drive servicing then I would recommend one of a new breed of true rms meters that incorporate specialized filtering techniques that permit accurate measurements of these complex signals. You can accurately measure the frequency (motor speed) and the frequency measurement will not be affected by the drive's carrier frequency
Such a meter is the New Fluke 87V
Awesome meter!
Also if you are measuring currents in a drive system as long as your DMM is true RMS then your current reading will be true RMS ie the meter determines this, not the current clamp.