

What To Do When You Don't Have Advanced Instrumentation Part 2 Basic Electric Motor Testing With a Amp Meter

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Introduction

In Part 1, we discussed how to use a Voltmeter for troubleshooting electric motor systems. In Part 2, we will discuss using an Ammeter (Amp Meter) for troubleshooting AC induction motor systems which will also build upon Part 1.

Both analog and digital ammeters have their application, special features and capabilities of some ammeters will provide different capabilities. However, we will assume average instruments.

Analog Ammeters

The analog ammeter uses an electro-mechanical deflection of a needle that is directly proportional to the value of current that is being measured. Hand held meters will normally have a clamp and a display while panel mounted analog meters will have a Current Transformer (CT) providing a percentage of the actual circuit current to the display. The display is then incremented so that it shows the actual full value of current.

The purpose of these meters is to provide a relative idea of existing load. However, they also provide some additional troubleshooting capability. For instance, because an ammeter measures the 'real time' value of current, with some delay that is related to the CT winding and the coil in the display, it can provide the ability to detect such things as broken rotor bars and torsional load problems.

In the case of broken rotor bars, the needle will deflect at a rate that is similar to the pole pass frequency of the operating motor. As this frequency is often around a fraction of a Hz to several Hz, the movement of the needle will be easily visible to the technician. The result would be a ticking motion that will have a magnitude related to the operating current based upon the severity of the number of broken rotor bars. Unfortunately, this can also occur in applications that have a regular varying torque.

Digital Ammeters

Digital ammeters come in two types: Averaging and True RMS. The averaging ammeter has a built-in algorithm that compensates for applications that include harmonic distortion, such as variable frequency drives or systems that have a lot of electronic systems connected on the circuit. True RMS (Root-Mean-Square) meters have a built-in circuit that provides readings based upon the real power of the circuit. In a harmonic environment, an averaging meter and an analog meter will not read correctly. However, a True RMS meter will provide an accurate value.

The power of True RMS digital ammeters, hand held or panel, is the ability to compensate for these harmonic conditions and to provide an easily measurable value. Other features can include a min/max capture capability and datalogging capabilities.

Load Measurements

Knowing the percentage of load can help determine if a motor is being overloaded. The value will change depending upon voltage unbalance and the supply voltage versus nameplate voltage. The effective load can be calculated, when the motor is operating above 50% of load, by considering both the voltage and current. The average phase to phase voltage (Equation 1), the average phase current (Equation 2), the nameplate voltage (V_n) and the nameplate current (A_n) are required.

Equation 1: Average Voltage (V_a)

$$V_a = \frac{V_1 + V_2 + V_3}{3}$$

Equation 2: Average Current (A_a)

$$A_a = \frac{A_1 + A_2 + A_3}{3}$$

Equation 3: Percentage of Motor Load

$$\% Load = \left(\frac{V_a}{V_n} \right) \times \left(\frac{A_a}{A_n} \right) \times 100$$

In an application where the motor nameplate is 460 Volts and the nameplate current is 38 Amps. The measured phase to phase voltage is $V_1 = 475$; $V_2 = 482$; and, $V_3 = 485$. The measured phase to phase current is $A_1 = 33$; $A_2 = 36$; and $A_3 = 38$. If you were to consider the current values only, it would appear that the motor was operating less than 100% of full load. By using current only, the average current would be 35.7Amps, and the load would be considered 93.9%. If using Equation 3, the average voltage would be 480 Volts and the resulting percentage load would be 98% load, over 4 points of efficiency different.

If the motor is rated at 1.15 Service Factor, the motor would be required to have nameplate voltage and frequency supplied. In the example, above, the motor is operating at 4.3% over voltage and 1% Voltage unbalance (reference Part 1 of this series). The actual load at 98% would be satisfactory. If, however, the voltage unbalance was greater than 2%, then the motor would be experiencing overload.

Current Unbalance Conditions

The NEMA MG-1 calls for a maximum current unbalance of 7% when a motor is being factory tested. However, when a motor is being tested in a plant motor system, there are

a number of reasons that can cause current unbalance. Some of the issues can include changes to the circuit impedance, phase unbalances, etc.

A high current unbalance, with relatively low voltage unbalance, can be caused by conditions of a failing motor winding, loose connections or bad power factor correction capacitors. For instance, in one application, a 100 horsepower motor had current draw of 109 Amps, 109 Amps and 72 Amps. The motor user kept removing the motor and sending it in for rewind (which the repair shop was happy to do). After the third time, it was noticed that the system had power factor correction capacitors. They were tested and it was determined that one of three power factor correction capacitors had a blown fuse. The three capacitor leads were removed and the motor was retested with currents of 102 Amps, 101 Amps and 99 Amps.

Due to other electrical conditions in the distribution circuit, such as single phase loads that cause power factor conditions, and unbalanced loads, not only can there be significant voltage unbalances, but current unbalance can be excessive. Where an unbalance of up to 7% unbalance is acceptable in factory conditions, unbalanced distribution power factor can cause unbalances far beyond that value. Additionally, this can be exaggerated when the motor is lightly loaded (less than 50% or idle). An idle motor will often have a current draw 20 to 40% of full load current.

Other Current Conditions

Some ammeters have a min/max capability. This allows the operator to determine the actual peak current on each phase, when determining the maximum load. You can also determine the peak inrush for an electric motor by setting the ammeter to capture the peak current and starting the motor. This can be compared to the kVA Code of the motor.

Table 1: kVA Code AC Induction Motors

Code	Multiplier	Code	Multiplier	Code	Multiplier
A	0- 3.15	G	5.6 – 6.3	N	11.2 – 12.5
B	3.15 – 3.55	H	6.3 – 7.1	P	12.5 – 14.0
C	3.55 – 4.0	J	7.1 – 8.0	R	14.0 – 16.0
D	4.0 – 4.5	K	8.0 – 9.0	S	16.0 – 18.0
E	4.5 – 5.0	L	9.0 – 10.0	T	18.0 – 20.0
F	5.0 – 5.6	M	10.0 – 11.2	U	20.0 – 22.4

Equation 4: Calculating the kVA/HP (3 Phase Motors)

$$\frac{kVA}{HP} = \frac{\sqrt{3} \times Amps \times Volts}{HP \times 1,000}$$

The locked rotor current can be calculated from knowing the nameplate information and the kVA/HP code (often listed on the nameplate as ‘Code.’).

Equation 5: Calculating the Locked Rotor Amps (LRA)

$$LRA = \frac{1,000 \times HP \times kVA / HP}{\sqrt{3} \times Volts}$$

For instance, if there is a 10 horsepower, Code F motor at 460 Volts and a nameplate current of 11.2 Amps, the LRA would be ~70 Amps. When testing the motor on startup, the max capture of the ammeter should fall close to 70 Amps. If it does not, then it can indicate a rotor defect or winding problems, especially when commissioning a new or repaired electric motor.

With ammeters that can datalog or operate and log the min/max over a long period of time, then the loading can be determined over a full operation. For instance, if a motor starts tripping unexpectedly, the loading can be monitored to see if something has changed in either the loading or driven equipment. This type of reading can be used as a trendable value and as a proof test by maintenance to indicate if changes have been made to the system that need to be investigated.

Conclusion

Basic tools such as voltmeters, ammeters and other testing tools are quite powerful when evaluating the condition of your electric motor system. The combined use of a voltmeter and ammeter can be used to identify potential problems such as motor loading, power factor correction capacitor problems, rotor and winding problems and commissioning new and repaired electric motors. In Part 3 of this series, we are going to cover the application of resistance testing.

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