What To Do When You Don't Have Advanced Instrumentation Part 1
Basic Electric Motor Testing With a Volt Meter

Howard W Penrose, Ph.D., CMRP
President, SUCCESS by DESIGN

Introduction

Just because I don't have a budget for test equipment, am I lost? Do I always need advanced technology to accomplish my maintenance tasks?

The answer is: No. You do not need advanced technology to accomplish general maintenance tasks. The newer technologies will allow you to identify problems that are difficult to find, before they fail, and will provide more data than standard hand-held instruments. While I have spent many years discussing the advanced technologies, I am constantly asked what can be done with the traditional electrical maintenance test equipment. The purpose of this article is to discuss some of the 'tricks of the trade.'

For the purpose of these articles, we will assume that we have a True RMS multi-meter, a True RMS current clamp, an Analog current clamp and a 500/1,000 Volt insulation tester with an analog display with a range from 0.01 to 1,000 MegOhms. The systems that we will be testing will be across the line, AC induction electric motors, with future series covering DC and other machines. This first article will discuss Volt Meter testing.

It is assumed, in this article, that you are following all appropriate safety and PPE requirements during testing.

The Power of a Volt Meter

For most applications, in modern electrical environments, a True RMS digital volt meter is important to give you accurate values. This is because older averaging volt meters would display inaccurate, non-repeatable, values on digital displays or the needle would bounce in voltage harmonic situations. The True RMS meter compensates for these variations and harmonics. You will also want a meter with a range 10 times more accurate than the value you are looking for. For instance, if you are looking for values to the nearest 1 Volt, you want a meter accurate to at least 0.1 Volt.

The most obvious methods of voltage testing are to check the voltage value and phase balance. In both cases, the proper method of taking voltage readings is to go phase to phase, which provides more accurate test values than phase to ground. The pattern is also important, if you are going to compare test results or analyze a system. A common pattern is Phase A to Phase B, Phase A to Phase C, then, Phase B to Phase C.

Table 1: Phase to Phase Voltage Test Results

Phase	Voltage
A - B	460
A - C	458
B - C	466

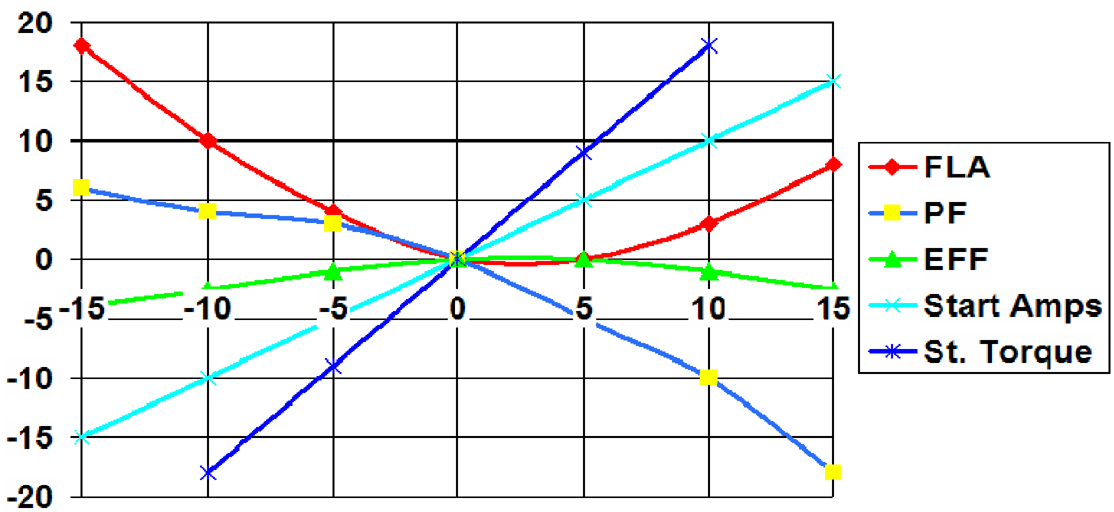
These three values can provide important clues as to the condition of the system and help identify some problems. For instance, over/under voltage conditions can change the operating conditions for the electric motor. NEMA identifies the maximum deviation from the nameplate of an electric motor as +/-10% for design purposes. In order to determine the maximum deviation, you determine the nameplate voltage and take the measured value that is the furthest from the nameplate.

Formula 1: Voltage Deviation (460 Volt Motor)

$$\frac{466V - 460V}{460V} * 100 = 1.3\%$$

The impact as the voltage deviates from the nameplate can be significant, see Figure 1, with the maximum recommended deviation for energy purposes as 5%.

Figure 1: Impact of Voltage Deviation



The next concern is Voltage Unbalance, which results in unbalanced currents and magnetic fields in the motor. As the unbalance becomes greater, the temperature rise of the motor increases, generating the need to de-rate the motor.

Formula 2: Voltage Unbalance (1) Determine the Average Voltage

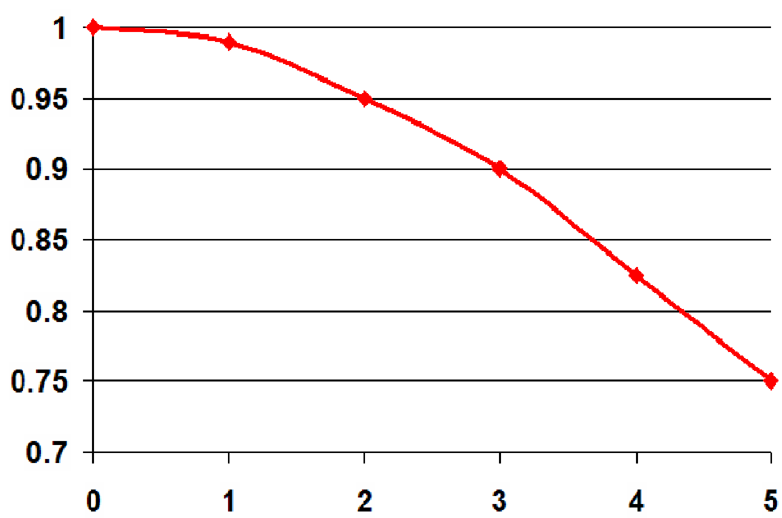
$$(460V + 458V + 466V)/3 = 461.3V$$

Formula 3: Voltage Unbalance (2) Determine the Unbalance

$$\frac{466V - 461.3V}{461.3V} * 100 = 1\%$$

The unbalance is then compared against Figure 2, which provides a multiplier against the motor horsepower. The electric motor is designed to work within 5% voltage unbalance, with an energy application recommendation of not more than 2% voltage unbalance.

Figure 2: Voltage Unbalance Multiplier



NOTE: It is important to note that the motor may not be operated into its service factor in either condition. The motor service factor is only to be used at the motor nameplate voltage and frequency values.

Checking Contacts with a Volt Meter

One method of testing contacts in a motor starter is to use a volt meter. When an infrared camera is used, the operator is looking for the I^2R losses which show as Watts or Heat. Damaged connections show as a loose connection and related resistance, as do conditions of glazing that can occur in some operating environments.

One way of detecting contact and connection problems without the use of an infrared thermometer or imager is to perform a voltage drop survey. When performing a survey, it is important to start with the volt meter set at a voltage equal to or larger than the circuit voltage. Check to ensure that voltage is being supplied to the starter or contactor by performing a phase to phase test on the supply side of the starter or contactor, as described above. Next, place one lead from the volt meter on the Phase A input side of the starter and one lead on the Phase A output side of the starter. Adjust the value of the volt meter down, if no value shows, until you get to a value or less than one volt.

A good contact will have a value less than one volt. A poor, or failed, contact will have a value of one volt or greater. Perform the same steps across each phase of the starter or contactor. Once completed, check to ensure that you still have phase to phase voltage by re-testing the supply side phase to phase.

Checking Fuses with a Volt Meter

Testing fuses while equipment is running is a straight forward process. There are two steps that are performed including the phase to phase and line testing.

The phase to phase test for fuses involves 'cross checking' the fuses. Start by measuring phase to phase on the supply side of each fuse, as noted in the phase balance test. You place one lead of the voltmeter on the supply side of the Phase A fuse and the load side of Phase B fuse. You should see a full phase to phase voltage value. If you do not, then there is a problem with the Phase B fuse. Repeat the steps by placing one lead on the load side of the Phase A fuse and the supply side of Phase B fuse. Repeat the steps between Phase B and Phase C. Once finished, re-check phase to phase on the supply side.

A less accurate method of checking fuses, but important for control circuit fuses or single phase applications, is to measure across the fuse. The steps and resulting values should be performed and evaluated in the same way as starter or contactor testing, as described above.

Conclusion

While industry is moving towards higher technology testing, the older tried and true test technologies can still provide valuable troubleshooting data. In this first article of the series, we are covering voltage testing using a standard True RMS volt meter. The volt meter can be used to test for voltage unbalance and variation, which can shorten the life of an electric motor, or cause it to run less efficiently, as well as check for loose connections/poor contacts or the condition of fuses.

In the next article, we will discuss current testing, which supports voltage testing.

About the Author

Howard W Penrose, Ph.D., CMRP is the President of SUCCESS by DESIGN Reliability Services and the Executive Director of the Institute of Electrical Motor Diagnostics, Inc. For additional information contact Dr. Penrose at howard@motordoc.net.