What Every Operator Should Know About Electric Motors and Troubleshooting

Fred Edgecomb

Knowledge	Principle	Practical Considerations
Electrical Safety	First and foremost, know your limitations. Most operators do not work on electrical systems or electric motors. Operators need to know how electric motors work to provide essential information to the Qualified Electrician assigned to investigate electrical equipment problems. As with any equipment, follow lockout–tag out procedures and ensure that stored energy has been released.	When an electric motor fails operator actions will be limited. Take note of the conditions of the failure as well as any symptoms that may be apparent. In some cases, the operator may be advised to try to reset the circuit breaker using the reset button on the outside of the breaker cabinet. Do this only after consulting a qualified electrician. Operators should never open an electrical panel unless they have been trained and have donned the proper personal protective equipment.
Qualified Electrician	"A *Qualified Electrician* shall be trained and knowledgeable of the construction and operation of equipment or a specific work method and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method," according to NFPA 70E® article 110.2(D)(1)(e), titled *General Requirements for Electrical Safety-Related Work*. However, most operators meet the definition for *unqualified* persons — that is "a person is said to be trained in, and be familiar with, any electrical safety-related practices necessary for their safety." This is a very limited role.	In some cases, utilities have provided training to operations staff members so that some may perform some basic electric troubleshooting. But when it comes to electrical equipment, *unqualified persons* should not attempt to assess electrical systems if this requires opening panels or using test equipment.

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Electric Motor Basics	An electric motor converts electrical energy to mechanical energy.	The electricity fed to an electric motor reverses the poles of an electromagnetic coil 120 times a second (60 Hz). Coils wound into the stator of the motor create a rotating magnetic field. The magnetic field flowing through the windings induces current to flow; this creates a magnetic field that causes the rotor to spin. Bearings at the ends of the rotor hold the rotor in place.
	Voltage	Voltage is the pressure from an electrical circuit's power source that pushes charged electrons (current) through a conducting loop, enabling them to do work. Voltage = pressure, and it is measured in volts (V). ■ Low: up to 1,000 volts ■ Medium: 1,000 to 35,000 volts ■ High: 35,000 to 230,000 volts
	Amperage	Amperage (usually abbreviated *i*) is the measure of electric current flowing through the motor. As the load demand on the motor increases, more electricity must flow through the motor, and the amperage increases. Monitoring the amperage of the motor can indicate abnormal conditions in the motor or the equipment driven by the motor.
	Power	Power is measured by Watt (W). The power consumed by a single-phase electric motor is calculated as Watts = Amps × Volts ($W = iV$ or W = AV). Watts usually are expressed as kilowatts (kW) where 1 kW = 1,000 W. Motors often are designated by horsepower (hp) on the nameplate, so it is useful to know that 1 hp converts to 0.746 kW.
	Phase	Voltage to a motor can be supplied in single phase where there is one "line" wire supplying voltage and one "neutral" wire allowing the return flow of electricity. In a three-phase motor there are three lines supplying voltage that rotate in phase. A three-phase motor will supply 1.732 (square root of 3) times the power of a single-phase motor, so the power equation becomes W = 1.732 AV.
Housing, Frame, Fan	Electric motor components are contained in a structure to hold the parts together and provide a base for mounting and connecting the motor to the electric power supply. This is sometimes referred to as the motor housing and frame.	There are different configurations of the housing depending on the size of the motor, where the motor will be installed, and the heat created by the motor. The housing is designed to allow air to enter the motor to provide cooling. A fan is normally provided to draw air through the enclosure for cooling. The National Electrical Manufacturers Association also designates frame sizes that provide standard mounting and clearance dimensions.
Stator	The motor stator is commonly referred to as the motor winding. These are the electric coils that cause the rotor to spin.	The motor windings are composed of slotted sections of soft iron wound with insulated copper wire. Over time, the insulation will break down and the motor will have to be rewound or replaced.

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Rotor	The rotor is the rotating part of the motor.	The rotor is supported by bearings at each end set into the motor enclosure. The rotor is also called the shaft, and is attached to the rotating equipment (pump, blower, etc.) by a coupling system.
Bearings	Bearing support the rotor and allow it to spin freely.	There are many types of bearings, but they all have common elements, including lubrication. Lubrication may be provided either by oil or grease. Some bearings are sealed, while others have an oil reservoir or openings to provide fresh grease or oil.
Circuit Breaker	A circuit breaker is the device that connects electric energy from electrical switchgear to the electric motor.	Simple circuit breakers have built-in protections against ground faults or overcurrent. Most motor circuits add the protection of a motor starter. A motor starter is an electromechanical device that provides overload protection. A magnetic contactor is operated electromechanically without manually operating a switch. Many overload devices have a built-in trip indicator to indicate to the operator that an overload has occurred. Overload relays can have either an automatic or manual reset. An automatic reset allows the motor to restart automatically after it has cooled off. Before using a manual reset the operator should attempt to determine the cause of the overload. Overloads can occur as a result of a problem with the motor or a problem with the connected load. An operator should always consult with a supervisor or qualified electrician before resetting a motor that has failed due to an overload or other trip conditions.
Routine Operation	Generally speaking, electric motors are reliable and have a long service life. Operators, however, must pay attention for signs of failure. Early detection can save the motor from extensive damage and prevent the failure of the associated equipment and any resulting process issues.	As an operator makes inspections he or she should pay close attention to all electrical and mechanical equipment in their assigned area. Observations should include examining the physical condition of equipment as well as using senses to monitor the sound of pumps and motors, the visual condition (including signs of leakage), changes in coloration, or unusual smells. The motor should run smoothly and the sound should be consistent from one day to the next. Check motor oil reservoirs for the correct level and note any sign of discoloration of the oil. Greased bearings should not leak grease or make excessive noise. Bearing temperatures may be monitored for signs of wear. Some motors may have amperage readings available through the control system. If you have access to amperage readings, they should be recorded daily. Excessively high or low readings indicate a problem with either the pump or whatever the motor is driving. If you see out of normal readings, report them to your supervisor and/or consult with a Qualified Electrician.

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<tr><th>Knowledge</th><th>Principle</th><th>Practical Considerations</th></tr>
<tr><td>Motor Troubleshooting</td><td>When a motor fails it can be because electrical protection features have engaged or there may be process-related failures caused by the control system to prevent the motor from running due to high or low tank levels or control conditions that caused the motor to shut down.</td><td>If a motor that is supposed to be running is not, check that there are no conditions in the facility that would cause the motor to stop such as low or high tank levels or other conditions that indicate the driven unit is not needed such as high dissolved oxygen levels for a blower.

Once you have verified that the motor should be running, check the circuit breaker that supplies power to the motor. If the breaker is in the trip position or there is an indication of a failure at the circuit breaker, notify a qualified electrician to investigate the failure. When you do be sure to note the following information to help them diagnose the problem.
■ Was the motor making noise before it failed?
■ Was the driven unit working normally before the failure?
■ In some cases, the problem may be the driven unit failing such as a jammed pump or bearing failures in the driven unit.
■ Is the motor discolored or have signs of excessive heat such as smoke or a smell like burned wire?
■ Was the lubricant at the proper level?
■ Is there any sign of leakage from sealed bearings?
■ Was there any noise from the circuit breaker before the failure?
■ Do you know the latest amperage reading for the motor?

Once a Qualified Electrician is available, work with the electrician to be sure that the equipment is properly locked out and other equipment has been started to make up for the loss of the failed motor.</td></tr>
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