Electrical safety in the winery

How to save life, limb, and expense in your power distribution system

BY Ken Arthur,
Arthur Engineering

Electricity is the one utility that is capable not only of bringing your production to an immediate halt upon its failure, but worse still, it can wreak great havoc upon your personnel and property. That is why it never ceases to amaze me how little concern is given to electrical safety in the winery.

One reason for the not-always-benign neglect of electricity is perhaps because it is, for the most part, invisible. Unlike a break in a water line, refrigerant line or even a hydraulic line, the break or open exposure in an electrical circuit lies dormant until something or someone completes its circuit, usually to ground.

Often ignored is the fact that those generally, least qualified to be in contact with an industrial strength electrical power distribution system are those whose daily tasks require this contact.

Figure I – Since this receptacle provides a means to disconnect a portable pump from its source of electrical power, it is by definition a "disconnecting device." The National Electrical Code states that any such device in a motor circuit must be "horsepower rated." This pin-and-sleeve device is not.

Plugging and un-plugging portable pumps, using pushbutton controls, handling portable lights and portable tools, clearing jams or removing foreign objects from screw conveyors after just turning off the motor's controller — these and many more such dangerous jobs are usually the purview of the cellar worker or seasonal worker in large wineries. In smaller wineries, these jobs often fall to the owners or close family members.

Electricity's destructive power

Our company once designed a new electrical power distribution system for a small winery that had the potential for becoming a major producer in the near future. The owner rejected a 480-volt three-phase power distribution system design because he was afraid to have his winemaker/son exposed to such high voltage.

It seems the son often liked to try to "fix" electrical problems that occurred in the winery, so the father did not want him exposed to a system with more than 120 volts to ground. Statistically, however, more people are killed or injured at 120 volts than at any other voltage — probably because they have dealt with that voltage in their homes all of their lives and they tend not to be afraid of it.

Being afraid of electricity is a good thing. Its care and keeping — regardless of the voltage level — should *always* be left to those with the required skills and training. Remember: it's the current (not the voltage) that kills you.

In fact, even those with skills and experience are not immune to being injured or killed from a momentary lapse in caution. Usually they're in a hurry, perhaps under pressure to fix a system that is down in the middle of harvest, while there are truckloads of grapes lined up in the hot sun.

I recall one skilled electrician with many years of experience who was killed when working on an electrical panel with a cover that lifted up (like most home-type electrical service panels) and secured in the up position with some type of latch or hook. Unfortunately, the latching mechanism was missing on this panel and since he was under pressure to solve the problem, he rested the panel cover on top of his head rather than take the time to rig

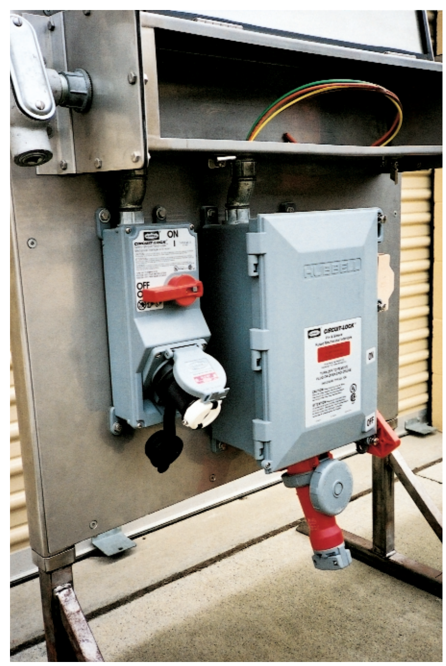

Figure II – This "sample"was constructed to demonstrate several safety issues when grouping portable pump outlets. Two versions of interlocked receptacles are shown: pin-and-sleeve (right) and a form of Twistlock (left). To drain water that gets into all winery conduit systems, the overhead conduit enters the side of the wireway above the switches and the bottom of the TEE is left open.

Figure III – This power switchboard burn-down probably started as an arching ground fault and escalated to a phase-to-phase fault before the main circuit protective device opened. It is testimony to the destructive force of "available short circuit current" that can be supplied by your serving utility, and why the National Electrical Code says that your electrical system must be capable of handling it.

something to hold the cover up. Probably among his last thoughts were, "This will only take a sec."

He somehow got in contact with a live part somewhere in the panel and the cover provided a perfect, low-resistance path to ground right through his heart and brain. He might have survived that mistake by not being so well grounded, or at least grounded through a much higher impedance (his shoes for example) than he got from resting the cover on his head.

Managing "available short circuit current"

It's important to remember that your electrical system is capable of delivering large amounts of current.

A short circuit, or the unintentional connection of two or more phases of your electrical system, looks like you have turned on a big load, so the utility sends in a large volume of current to satisfy that load.

Let's use an analogy here: If you open the racking valve on the bottom of a 30-foot diameter, 35-foot high tank filled with grape juice, the pressure and volume of juice flowing out of that valve is significantly greater than when there are only a couple of feet of juice above the valve.

In an industrial facility, the electric service is larger, the feeders are larger, the distribution panels are capable of carrying larger currents, and the branch circuits are larger than those in your home. As a result, the electric utility company, which you could look at as an infinitely large tank, can, for better and worse, deliver lots of juice through your electrical system.

It's called the "available short circuit current," and its magnitude is dependent upon the size of the electrical power distribution system from the utility's source generator right down to your portable pump outlet. Since your electrical power distribution system pipeline tends to get smaller the closer it gets to each individual load or outlet, the total short circuit current available at your service switchboard is reduced throughout the system.

Another good analogy is to visualize your electrical power distribution system like the sprinkler system in your lawn — the farther you get away from the water source, the lower the pressure. The National Electrical Code, however, requires that every component in your electrical power distribution system be capable of withstanding and/or interrupting the level of short circuit current that is available at its (the component's) particular connection point in the system.

Using our sprinkler system analogy, this is similar to calculating the pressure at each sprinkler head and connection point in the system, and then choosing components that will withstand those various pressures. In a sprinkler system however, the pressure is limited by a pressure regulator somewhere in the supply system, so you can select all of the components to exceed that maximum pressure. The costs would be prohibitive to do that in your electrical distribution system.

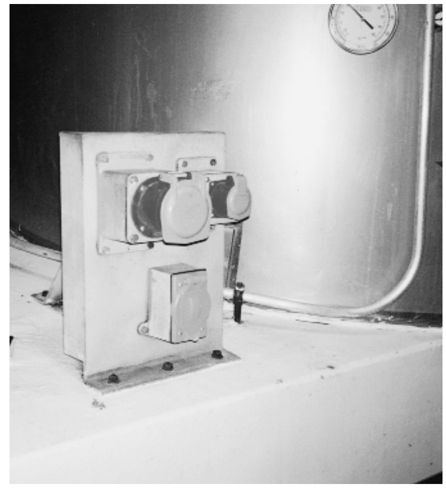

Figure IV – A typical portable pump outlet station found in old and even new winery construction. Note the absence of a horsepower-rated disconnecting device ahead of the outlets.

Short circuit currents in the magnitude of 50,000 to 60,000 amps at 480 volts, three-phase, are possible at the service switchboards in some larger wineries. As stated above, electrical equipment chosen for components of your electrical distribution and utilization system, by code, must be capable of handling and interrupting these large volume currents (the "available short circuit current").

Choose the right circuit breaker

How does available short circuit current relate to safety in your winery? It represents the greatest hazard to your property and personnel if the components of your electrical power distribution system have not been properly selected and applied.

Circuit breakers have three application ratings: a voltage rating, a current rating, and an interrupting rating. Proper circuit breaker selection requires applications that meet, or are within, all three ratings. For example, let's consider a circuit breaker with the following ratings:

1. Voltage Rating – 277/480V
2. Current Rating – 20 amps
3. Short circuit "amp interrupting rating" (AIR) – 14,000 amps symmetrical at 480 volts

The proper application of this circuit breaker would require:

1. That the circuit voltage would not exceed 277 volts to ground and 480 volts phase to phase

2. That the circuit load would not exceed 20 amps continuously at 480 volts, three phase

3. That the available short circuit current does not exceed 14,000 amps at the point of installation.

I cannot tell you how often, in more than 30 years associated with the wine industry, I have looked at a switchboard or electrical panel and found circuit breaker(s) that were installed at some point after the initial installation that have a significantly lower interrupting rating than the original breakers.

For example, it is not unusual to find a circuit breaker with a 14,000 amp interrupting rating (AIR) has been added to a panel where all of the original circuit breakers have a 65,000 AIR. Chances are good that the original designer would not have specified the more expensive 65,000 amp breakers if ones with a lower and less expensive AIR would have been sufficient.

If the short circuit calculation determines that the "available short circuit current" at this panel could be as high as 50,000 amps, installing a circuit breaker that has only a 14,000 AIR puts both personnel and property at risk if the device is used to "interrupt" 50,000 amps.

To help avoid the problem associated with improper installation of underrated circuit breakers after the initial installation, our specifications require that the panel manufacturer install a sign within the panel advising that "Only circuit breakers with minimum XXXXX short circuit interrupting ratings are to be installed in this panel."

Beware amateur installation

What should you do? Don't let anyone but a well-trained electrician or electrical contractor install electrical devices in your winery. If in doubt about the adequacy of any equipment being installed or that you plan to install, consult with a professional engineer who can run a short circuit analysis of your system to determine the necessary equipment ratings. Figure III shows what can happen when improperly applied electrical equipment fails.

One of the areas in the winery where we find the greatest hazards (and most incorrect installations) is electrical outlets. Think about it — this is the one location in a winery where the least skilled worker comes in direct contact with the electrical distribution system. It needs to be as fool-proof as you can make it. Figures I and IV show what we often find — even in recently constructed facilities. This is a code violation that very often even building inspection officials miss.

The National Electrical Code requires that every disconnect device in a motor circuit be horsepower-rated. This is because an electric motor is an "inductive" device. It requires magnetizing current to function, and without getting technical, when you try to break its supply circuit, it arcs across the contact points of the disconnect device until the points are far enough apart to extinguish the arc. This arc releases lots of energy, and if the contact points are not (horsepower) rated to withstand the energy of the arc, they can fail — often violently.

Pin-and-sleeve plugs and receptacles like those shown in Figures I and IV, are current-rated — not horsepower-rated. For example, they may have a rating such as 30 amps at 480 volts. That means they are rated to continuously carry 30 amps at that voltage. When examining your 10-horsepower pump motor and its nameplate, you will find the full load current at 480 volts, three-phase, is somewhere around 14 amps.

No problem for a plug and receptacle rated 30 amps, you say. You are correct — except when you try to disconnect the motor from its supply by pulling apart this plug and receptacle while the motor is running. Then, the "circuit breaking" current momentarily flowing through this device, can be six to10 times greater than its running current. Since the pins and sleeves of this connector are not rated to carry this level of current, they can sometimes fail — literally right in your hands.

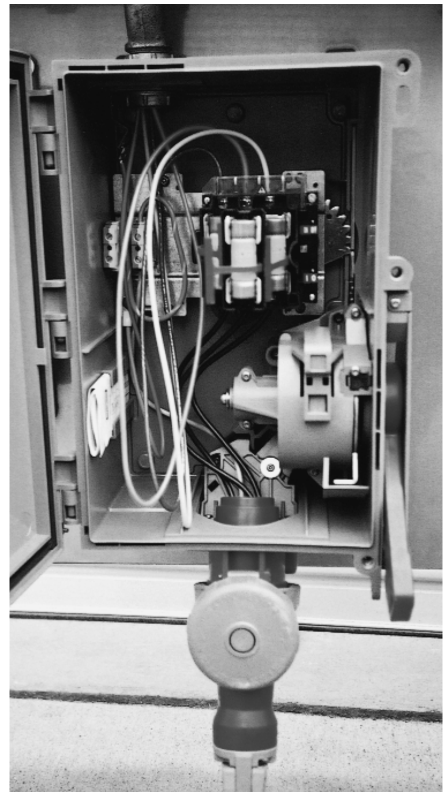

Figure V — This demonstrates the correct way to terminate the incoming power circuit. Note that the incoming conductors form a "drip loop" before their termination at the top of the fuses. This allows any condensate or casual water that enters the switch enclosure by "wicking" down the conductors to drip off into the bottom of the enclosure rather than onto the energized terminals at the top of the fuses.

But, you say, "I always turn off the pump at the starter on the pump cart before I unplug it,"— or you instruct your cellar workers to do it that way. In most tank alleys however, the portable pump outlets are clustered together in groups between tanks, with groups repeated on some spacing within the typical cord lengths on your portable pumps.

It is easy to imagine that in an active tank alley where there are several pumps operating at the same time with cords and hoses intertwined on the alley floor, that you or a cellar worker could turn off the pump at the cart and mistakenly unplug the cord of another operating pump.

Some will contend that the plug on the end of a portable pump cord is not a "disconnecting device" and therefore not required by code to be a "horsepower-rated" device. Common sense says that if it can be used as a disconnect device it should be called one and therefore rated as one.

Foolproof interlocked switch pin-and-sleeve receptacles

Fortunately there are now several manufacturers who can provide pin-and-sleeve receptacles that are mechanically interlocked to a horsepower-rated disconnect switch in a common enclosure. This makes as foolproof a connection point as you can get for your cellar and other locations within the winery (see Figure II and V). The plug cannot be inserted into the receptacle nor withdrawn from the receptacle unless the disconnect switch is in the "open" or "off" position.

Using the scenario above as an example — where the wrong plug is pulled in a busy tank alley — now it doesn't matter because a horsepower-rated switch has interrupted the still operating pump motor. If your winery is using anything other than interlocked receptacles for your portable pumps, your operation is not as safe as it could be.

Summary

These safety issues are only two of many with which you as the winery owner/manager need to be concerned. An electrical power distribution system properly designed and installed provides not only a safe working environment for your employees (or family), but also reliability.

There is nothing that is harder and more wearing on a winery's electrical distribution system than full use at close-to-capacity for two or three months, then light loads the rest of the year.

In discussions with my clients, I have always found myself repeating the cliché — which was probably first uttered even before Thomas Edison — that doing it right the first time is much less expensive than returning to fix it later. ■

Ken Arthur is the President of Arthur Engineering, Inc. His company has provided elecrical and control system engineering and design expertise to wineries for over 30 years.