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PROFESSIONAL ENGINEERING SERVICES FOR *MISSION CRITICAL* INDUSTRIES

Facilities Engineering Associates, Inc. is committed to the design of mission critical facilities in the financial, industrial, credit processing, health care and broadcast industries.

As part of our mission, we realize that it is necessary to inform and educate our clients in the specialized mission critical design philosophies of redundancy, capacity, 7x24xForever and fault tolerance. Over the years, we have also expanded our expertise in energy efficient, sustainable and maintainable design concepts. To this end we publish a quarterly designPLUS Newsletter to keep our clients current on trends in the mission critical industry. We also meet with clients and present the various design philosophies to assist them in making informed decisions for hardening their current and future mission critical facilities.

We hope you find this issue interesting and informative, and we encourage you to email us with suggestions for topics that you would be interested in seeing in the future.

## Planning Ahead in a Recovering Economy

by Edward L. Gutowski, P.E., LEED AP

Shortly after the 2008 global financial crisis, many data center managers put a hold on expansion and postponed major upgrades. We are quickly approaching the two year anniversary since the downturn began and still experts are uncertain about the state of the recovery. The seesaw of economic good news and then bad news again leaves no clear cut answer about where we are now and when things will truly be back to normal again. Everyone is watching economic indicators and looking for signs of hope that we are back on the upswing. Many in our industry are still on the fence about their expansion and upgrade plans and those that have moved forward are doing so cautiously. Once you do decide to move ahead, what should your organization expect? Will vendors, suppliers and contractors be there in full force when you call? Many companies have scaled back their workforce, inventory, and overall capacity. Even if the vendors you contract with directly are fully staffed and ready, that doesn't mean they will not see delays of their orders for you. In our interconnected global economy the slowdown has been far reaching. Trucking and shipping companies are just one of the bottlenecks currently causing delays and in some cases increasing the price. Low inventories and raw material stocks are also pushing back delivery dates for

those that haven't planned ahead. Demand is slowly ramping back up while the supplies are still low. Here are just a few things that you can do to keep your upcoming project on time and within budget once you do decide to move forward.

1. **Start Planning Early:** Once the decision has been made to go forward with a project, don't let the planning phase become prolonged. Start the design phase early so you have ample time to complete it and gain extra time for the construction phase.
2. **Project Schedule:** A project schedule is an invaluable tool to keep any job on track. Early in the planning phase, task a team member into creating a schedule and solicit feedback from all parties involved. Make your best guess during this phase if you don't have solid data yet and continue to refine the schedule as the design and planning phase evolves.
3. **Investigate Long Lead Items:** Call manufacturers and suppliers you expect to do business with to see if they have been affected by shipping and material delays. Add a cushion in your project schedule to avoid the cost of quick ship premiums.
4. **Pre-purchase Equipment:** If you know certain equipment will require extended delivery time, plan to pre-purchase these major components.

Proper planning can save costs and reduce delays on any project. This will be especially true as the battered supply chain ramps up to keep pace with future rising demand.

## Arc Flash Mitigation

By Brian T. Soucy, P.E.

Existing facilities have few options to limit arc flash hazards where live work is concerned. The very best protection techniques require additional controls, instrumentation and current sensors. This is especially true for low voltage equipment where CTs (current transformers) internal to the circuit breakers are generally used. The additional hardware required for mitigation can be difficult or impractical to install as a retrofit. Other techniques or approaches can be more easily implemented on existing systems but may compromise protection, reliability or both. This article will introduce and help explain some of the arc flash mitigation techniques available today.

### Hazard Zone Avoidance -

Keeping the worker outside the flash hazard boundary is the simplest way to mitigate risk to personnel. A disadvantage of course is that certain tasks must be performed within close proximity of the equipment. Electrically operated circuit breakers that can be remotely operated and remote racking devices are two features that can limit exposure for common tasks. Unfortunately, these design features would be difficult to implement on existing switchgear. However, something as basic as a hot stick for voltage testing or breaker operation or even defined approach limits for IR scanning can help workers maintain a safe distance from energized parts.

Reduced Let-Thru Modes - Many manufactures offer a secondary over current protection scheme that,

when manually activated, will temporarily reduce over current settings during maintenance activities. Often this protection is activated by a key switch or other manual control and will change the main circuit breaker's instantaneous, short time and/or ground fault settings to minimum values. This approach makes use of protection already in place (circuit breaker trip units) so it is relatively simple and low cost. It can also be used to protect downstream loads. The disadvantage is that it really only applies to new equipment purchases and most likely the system would not be coordinated while the reduced let-thru mode is active. Also, depending on the electrical system's characteristics (available fault currents and breaker tripping characteristics) they may not significantly lower the arc flash hazard.

Bus Differential - A faster method of detecting and therefore clearing faults is "bus differential protection." In this scheme CTs are used to measure current entering and leaving a switchboard. If the currents sum to zero (equal currents entering and leaving) all is well. If the sum of currents does not equal zero then there is a fault on the bus, or within the zone. This protection acts without intentional delay and can clear a bus fault much quicker than standard over current protection, protecting personnel and equipment. However, this comes at the cost of more instrumentation, complexity and commissioning required. For these same reasons, it is best to implement bus differential on new installations.

Zone Selective Interlocking (Fast Bus Trip) - In the cases of very high

fault currents, a race condition can occur between the main breaker and its feeders. It is for this reason that instantaneous over current protection is often not included on main breakers. And for lower fault levels, a main breaker's short time setting may have a large time delay to allow feeder breakers time to clear faults. This has the adverse effect of increasing the arc flash hazard of the switchboard bus. Zone selective interlocking (ZSI) can be used to circumvent this limitation. If a feeder breaker senses a fault, it will send a block signal to the main breaker indicating that it will clear the fault. A time delay is applied to the main breaker allowing the feeder breaker time to operate. If the main senses an over current with no blocking signal, it will trip immediately. This may be difficult to implement on existing equipment especially if the equipment is 480V or below as the existing trip units may not lend themselves to this application.

Arc Flash Detection - A relatively new protection scheme is now available called arc flash detection. This scheme consists of a current sensor and a fiber optic cable whose purpose is to sense the intense light from an arc flash. Both the flash and high current must be detected to trip a breaker. The fiber optic sensor can take the form of a point detector for installation in a cubicle or a cable for installation around and through sections of bus. Arc flash detection is available for retrofit and new installation applications. Being relatively new, there is some consternation on the part of switchgear manufacturers as to how it is applied at the factory and how to address

issues such as shipping splits. For retrofit applications we recommend engaging the arc flash detection manufacturer for installation assistance.

In most cases the schemes described above would require additional instrumentation and controls to implement, especially on low voltage equipment. The simplest solutions are not always the best but there is a tradeoff between complexity or cost and protection. There may be little that can be done for existing installations but certainly arc flash mitigation should be considered when specifying new equipment.

## Caring for VRLA Batteries

*By John Lane, P.E.*

Periodically, we hear of premature failure of Valve Regulated Lead Acid Batteries (VRLA) which could have been avoided with proper system design, installation and periodic preventative maintenance. Most battery problems result in an increase amount of internally generated heat. Thermal runaway occurs when the rate of heat internally generated in the battery exceeds the rate of heat that can be discharged to the environment. The condition worsens exponentially as the condition persists. The battery electrolyte will eventually evaporate if there is no intervention. The resulting excessive internal battery temperature can deform or rupture the battery housing. Damage to the battery is irreversible. Damaged cells, if not removed, will dramatically shorten the life of the remaining batteries in the string.

Conditions that singularly or in combination can cause a thermal event:

1. High float voltage: (caused by a battery charger or UPS rectifier malfunction / or with an incorrect set point)
2. Excessive recharge current
3. Excessive Battery Charger AC ripple voltage / current: (Battery charger / UPS rectifier malfunction)
4. High ambient temperature operating environment: (Loss of room air conditioning / loss of enclosure ventilation, inoperable equipment fans / clogged enclosure filters, batteries stacked too tightly together)
5. Excessive discharge - recharge cycles
6. Shorted cells on the same battery string. (possibly caused by long term storage without charge, continuous undercharge, continued operation past useful life)
7. Low level ground fault (weeping electrolyte in contact with an uninsulated enclosure or support.)

In summary, the best way to avoid thermal events and preserve the useful life of your batteries is to have the UPS and /or the battery vendor provide the initial start-up on the UPS system. Set float voltage in accordance to the battery vendor's recommendations, remembering the float voltage should be lower if the batteries are going to be in an environment hotter than 80 degrees F. Provide periodic (at least annual) battery preventive maintenance (PM) by a competent battery / UPS vendor. Log / trend battery data. Periodically thermal scan batteries. Monitor room temperature and battery charger / UPS alarms. Keep charge / discharge cycles to a minimum and promptly replace failing cells. Replacing battery strings is expensive but these steps can help extend your batteries' longevity.

## Coordination Studies

An important, but often overlooked, technical aspect of an electrical distribution system is the circuit breaker coordination study. The purpose of the coordination study is twofold:

1. Adequately protect cables, transformers, motors and generators.
2. Establish selective coordination so that faulted circuits are isolated before protection further upstream operates causing a larger outage.

Properly coordinated circuit breakers are the unseen sentries protecting your facility's availability and reliability.

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