Critical Power Systems in Water Processing Plants

How to maintain the long term reliability of water treatment plant power systems.

The critical applications in water and wastewater processing plants require high quality, uninterruptible power. The most basic systems utilize automatic throw-over switches. The most advanced systems include UPS (uninterruptible power supply) and generator equipment that maintain the continuity of power without one cycle of interruption. Designing "uninterruptible" power comes at a significant premium in cost. But the laws of physics dictate that an absolute uninterruptible power is not obtainable. This is because of the natural tolerances in components, manufacturing processes, and installation practices. Therefore, we have to speak in terms of probabilities.

Reliability pertains to the probability of the system functioning properly over time. Creating multiple redundant power paths increases reliability. Also, selecting equipment with inherently higher built-in reliability will increase the overall system reliability. But system reliability decreases as equipment ages. Ultimately, at some point in time, the reliability of the system—any system—will decrease to zero. The only way to combat this loss of reliability is by an organized system of maintenance.

It is commonly assumed that system reliability declines exponentially over time. Figure 1 illustrates this principle in simple terms. Once equipment is installed, reliability begins to decline and will continue to decline until breakdown occurs. Equipment is then repaired and reliability is increased. This is followed by a new cycle of deterioration to breakdown. Proper maintenance can prevent these breakdowns, restoring reliability to high levels and keeping the system operational.

In Figure 1 we divide the total life of the system into two broad areas—uptime and downtime. This gives us the definition of system "availability." An availability of 99.9 percent means that 99.9 percent of the total time is uptime. Average industry data are typically used in the availability calculations. The calculations ignore variations in maintenance practices. However, the quality of the maintenance process can significantly reduce or increase the actual long-term system availability.

Originally, the principles of reliability engineering were developed to fulfill the need for economic design of power systems. Early on, engineers realized that they must evaluate the *total owning cost* over the useful life of the equipment instead of the *first cost* of the system. System designers must be aware of the maintainability of the system in addition to its reliability. This applies to any power system—especially mission critical systems.

Maintainability is the aptitude of the system to be easily maintainable. This requires consideration of equipment isolation for access, working clearances, and equipment handling, to name a few. Other factors pertaining to maintenance include equipment spares, personnel training, maintenance schedules, and inspection checklists. All of these factors should be in place before turning the system over to a maintenance department.

As soon as new equipment is installed, a process of normal deterioration begins. In addition to normal deterioration, there are other potential causes of equipment malfunction that can be detected and corrected through the maintenance process. Among these are:

- Load changes or additions
- Circuit alterations
- Improperly set or improperly selected protective devices
- Changing voltage conditions
- Changing environmental conditions

The design stage is the appropriate time to evaluate the requirements for process uptime as it affects the maintenance process. The higher the expected reliability of the facility, the more rigorous the design of the maintenance program must be.

Startup Versus Commissioning

Industry's terminology for startup and commissioning are rather confusing. Often these terms are used interchangeably but they refer to different sets of activities.

Testing agencies and equipment manufacturer service organizations have developed checklists for electrical equipment startup. These checklists are essentially much the same. Their main focus is to bring the equipment to a point where it can be energized without the risk of damage to the equipment and personnel. Trained technicians using standard checklists perform equipment startup.

Commissioning, on the other hand, pertains to the set of activities that ascertain the adequacy of the system to deliver the expected level of reliability. Commissioning is an engineering based activity and it requires custom developed checklists for each specific system. As no standard exists in the electrical industry in this area, commissioning of mission critical systems remains more of an art than a science; and the experience of the equipment manufacturer plays a major part in the success of the commissioning process. In selecting equipment vendors, consider the following factors:

- Does the equipment supplier have a dedicated mission critical group, which is focused on the special needs of these installations?
- Do they have engineering expertise covering the entire power system?
- Have they developed standardized methodologies to assure a complete system commissioning and to verify that the power delivery to the critical load is not jeopardized with individual component outages.

Importance of Benchmarking

Data from startup testing must be rigorously documented. Take the case of the electrical power cable plant. During annual maintenance, several cable parameters are measured. Typically, these values are compared with the manufacturer's recommendations or the industry averages to establish a pass/fail criteria. But such examination does not reveal the true condition of the cables. For example, a gradual increase in insulation power factor may be due to contamination, deterioration, or aging. However, a sudden rise in the insulation power factor justifies immediate corrective action even if the absolute value of the power factor is not considered excessive.Therefore, maintenance is concerned with trends—not just absolute values. To establish a trend, benchmarks must be established. The best time to establish the benchmark is during the startup testing of the system. A computerized maintenance management program, such as the one used by Square D Services (www.us.SuareD.com), is needed to keep track of the readings year after year and identify potential problem areas.

Emergency Procedures

Emergency procedures should list, step by step, the actions to be taken in case of emergency or for the proper shutdown or start-up of equipment. Optimum use of these procedures is made when they are bound for quick reference and posted in the area of the equipment. Some possible items to consider for inclusion in the emergency procedures are interlock types and locations, interconnections with other systems, and tagging procedures.

Accurate single-line diagrams posted in strategic places are particularly helpful in emergency situations. The production of accurate one line diagrams is essential to a complete electrical maintenance program. Diagrams are a particularly important training tool in developing a state of preparedness. Complete and up-to-date diagrams provide a quick review of the emergency plan. During an actual emergency they provide a simple, quick reference guide when time is at a premium.

Arc flash calculations must be up to date per NFPA 70E and the OSHA requirements. An arc flash occurs when insulation or isolation between electrified conductors is breached or can no longer withstand the applied voltage. As employees work on or near energized conductors or circuits, movement near or contact with the equipment may cause a phase-to-ground and/or a phase-to-phase fault. Temperatures well over 5,000 degrees Fahrenheit and a powerful explosion can be produced by this arc flash.

Where electrical equipment requires inspection and maintenance the level of hazard must be identified. This determines the necessary personal protective equipment to be worn by the maintenance personnel when they work on the equipment. It is much easier to prevent an accident than to fight the ensuing emergency.

Are All Circuit Breakers Equal?

At the heart of power system protection, circuit breakers are the most complex of the power distribution apparatus. They are used in switching operations, which transfer loads between utility sources, generators, and UPS modules. They also protect power distribution components and loads from faults. A properly designed protection system using circuit breakers will isolate power system faults and maintain continuity of power to critical loads by switching to alternate sources.

As circuit breakers are dynamic devices, they comprise the most important components of the electrical distribution maintenance process. Older design power circuit breakers employed dashpot actuated trip units and required regular maintenance of the circuit breaker bearings, arc chutes, and contacts. Modern circuit breakers, however, utilize microprocessor based trip units, which provide a high level of accuracy and reliability. Additionally, employing advanced alloys and lubricants has significantly reduced the maintenance

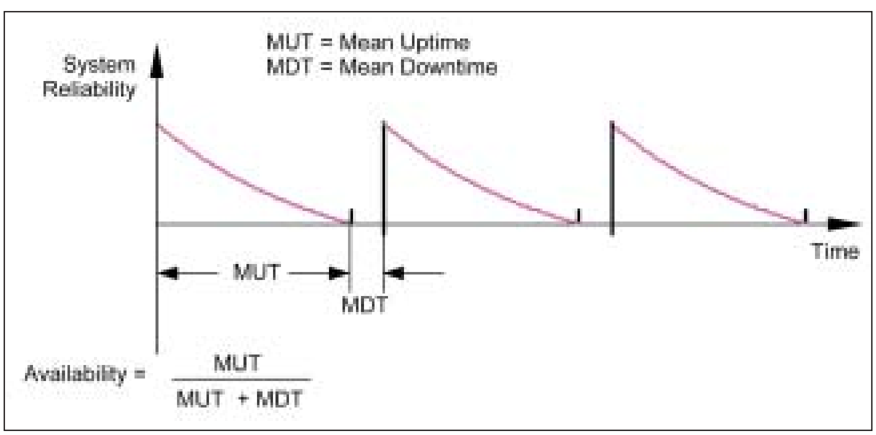

Figure 1. System Reliability and Availability. Reliability decreases exponentially to the point of equipment breakdown. Downtime can be reduced by using equipment that is "maintainable" and by an organized system of maintenance.

needs of the contacts and bearings.

The best way to address circuit breaker maintenance is at the design and specification stage. Consideration should be given to the "total owning costs" over the equipment life cycle, including the maintenance costs. Where only the "initial costs" are considered, reliability and maintainability will be compromised. The most advanced circuit breaker technologies offer:

1. High interrupting capacity (up to 200,000 amps) without fuses. Fuses are a major maintenance problem, as they can not be "reset." Additionally, fuses are discarded after each operation, which increases the maintenance costs.

2. Large number of operations without maintenance. Do not limit your power distribution availability by using components that are designed to the American National Standards Institute (ANSI) standard minimum number of operations. One manufacturer's circuit breaker can handle up to five times the ANSI specified number of operations without maintenance.

3. Employ technologies that predict contact wear due to fault interruptions and report that information over building management system communication lines. This offers a major advantage from the maintenance point of view as a database of contact wear can be easily established and a true "predictive maintenance" program can be developed for the circuit breakers

Conclusions

Any well designed power system will not provide reliable operation unless it is properly managed. As the system becomes larger, the problem of system management increases. Dependability can be engineered and built into equipment and the system, but effective maintenance is required to keep the system dependable. Experience shows that equipment lasts longer and performs better when covered by an effective electrical maintenance program.

The best maintenance programs start during the design of the facility. This includes specifications for complete system start up and benchmark testing. System commissioning is an engineering driven activity and must be specified separately. In the case of mission critical systems, the investment in a complete system commissioning is small compared to the cost of production losses associated with an unexpected equipment shutdown.

Modern circuit breakers are designed for reduced maintenance requirements. For maximum maintainability, specify circuit breaker technologies that can handle a larger number of operations between maintenance cycles. The ANSI standard recommended number of operations should not be a limiting factor for your critical power system.

New OSHA rules mandate arc flash calculations and proper labeling of the equipment. No amount of fire fighting equipment will assure prevention of loss. Loss must be truly "prevented" by prudent operational practices. GE

The preceding was furnished by Schneider Electric (www.us.SquareD.com).