You Just Experienced an Electrical Failure, What Should You Do Next?

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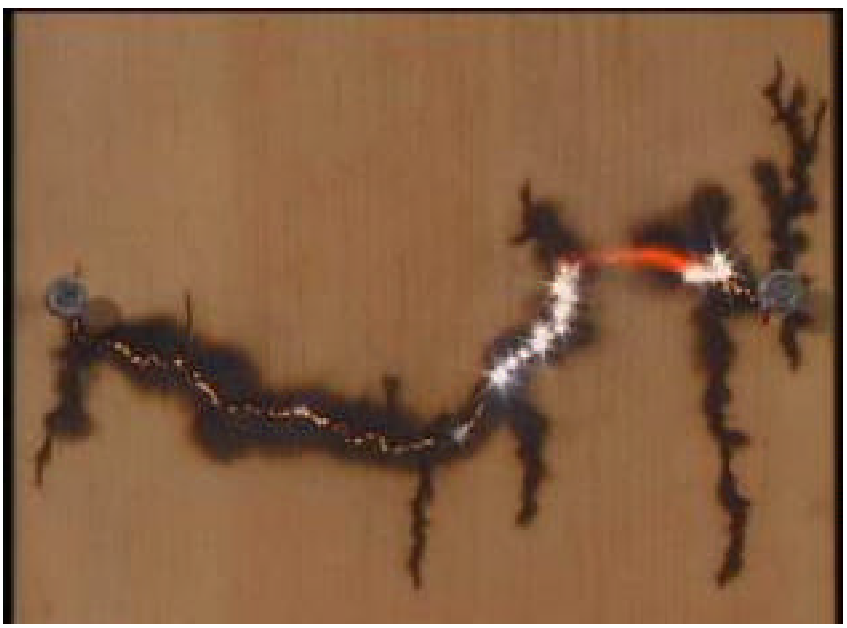
Why Failures Occur

Insulation Failure **-** Every electrical component is comprised of electrical insulation and almost every electrical failure involves failure of the insulation. Electrical insulation provides a means of restraining the voltage from getting out of control, similar to how a pipe keeps water from spraying everywhere. When the insulation is compromised, a violent release of electrical energy occurs.

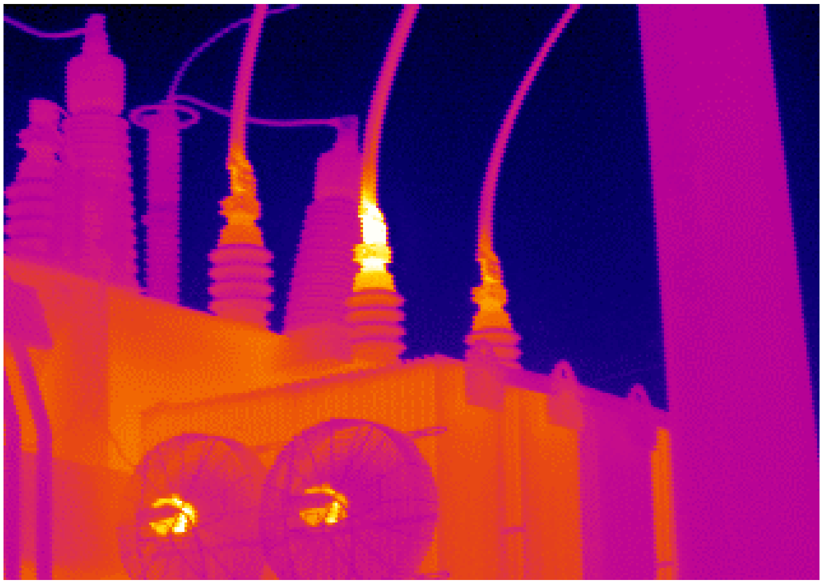
Just after new equipment is installed, a normal deterioration process begins. This deterioration can progress more rapidly if the operating conditions are severe. Factors such as environment, load and or duty cycle can all contribute to premature failure. By performing regular testing and maintenance, the insulation condition can be monitored and the lifetime prolonged. Additionally, a new technology known as partial discharge testing is a very good tool that is used to detect the condition of medium and high voltage equipment. More information about this new test is included later in this article.



Close-up photo of active partial insulation failure due to tracking. This type of partial failure can occur anywhere within switchgear, transformer or cable insulation and will continue until complete failure occurs. Fortunately, a new technology known as partial discharge (PD) testing, can be used to detect these partial failures so that repairs can be conducted before it's too late. PD testing is performed while your electrical system remains in service, so it doesn't interrupt operations.

Loose Connections - A major insurance carrier estimates that 25%, of all electrical failures originate from improper connections. Loose connections generate heat, which leads to eventual failure. Fortunately, loose connections can be detected by

a technology know as infrared thermography. An infrared survey is performed while the electrical system remains in service, so that the electrical system is under load. An experienced technician views the connections through an infrared sensitive "camera" which converts the object being viewed to a colored image of the object's thermal profile. In this manner, the complete electrical system can be evaluated to detect problem areas.



This infrared image shows heat build-up on the center-phase secondary bushing connection on an oil-filled transformer. The use of infrared technology prevented a catastrophic failure from occurring.

Dangers Involved

Personnel Safety – When an electrical failure occurs, a great deal of destructive energy is released suddenly. The resultant force can create a deafening noise and an arc-blast with temperatures that exceed those of the sun. This high-temperature arc can vaporize any material in the vicinity. Anyone in close proximity of this blast is at risk of severe injury or death.

Facility managers must also be aware of the related risk to occupants when an electrical failure occurs. These risks can range from a loss of lighting that can make facility evacuation perilous, to the aerial launching of manhole covers or the spewing of burning oil into the sky. The potential dangers of an electrical failure should never be underestimated.

Interruption of operations - although secondary to personnel safety, the affect of an outage on operations can be devastating. Collectively, U.S. industry loses an estimated $164 billion annually due to electrical outages. Variations in the actual cost of an outage may vary significantly from facility to facility. One independent study estimated that the average facility loses $7,795 for a one-hour outage, although the costs may be as high as several hundred thousand dollars for certain types of facilities. Thus, the direct economical impact of an electrical outage alone usually justifies the cost related to performing preventive maintenance.

There are also some less measurable but very significant problems associated with power outages including reduced employee morale, reduced productivity and facility insurance coverage difficulties.

What should be done immediately after the failure occurs

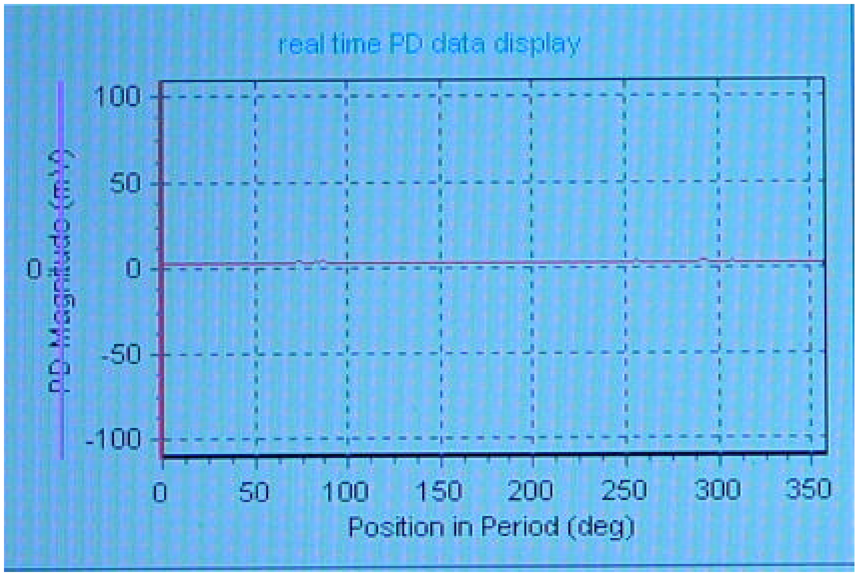
Forensics **–** if personal injury or death has occurred, possible loss of production or loss of operation claims are applicable or suspected manufacturer's product liability issues apply, then a complete and thorough forensics evaluation must be performed. Unfortunately, the damaged electrical components cannot be repaired or replaced until the investigation has been completed. The facility's insurance carrier should be contacted immediately and the area should remain undisturbed.

If these items are not applicable, a failure investigation should still be performed to determine the cause of the failure. Photos of the components should be taken and any witness accounts of the failure should be recorded. Sometimes the failure cause can be obvious but often much of the equipment has been destroyed and assessment can be very difficult. At a minimum, the cause of the failure should be determined so that attempts can be made to prevent similar failures.

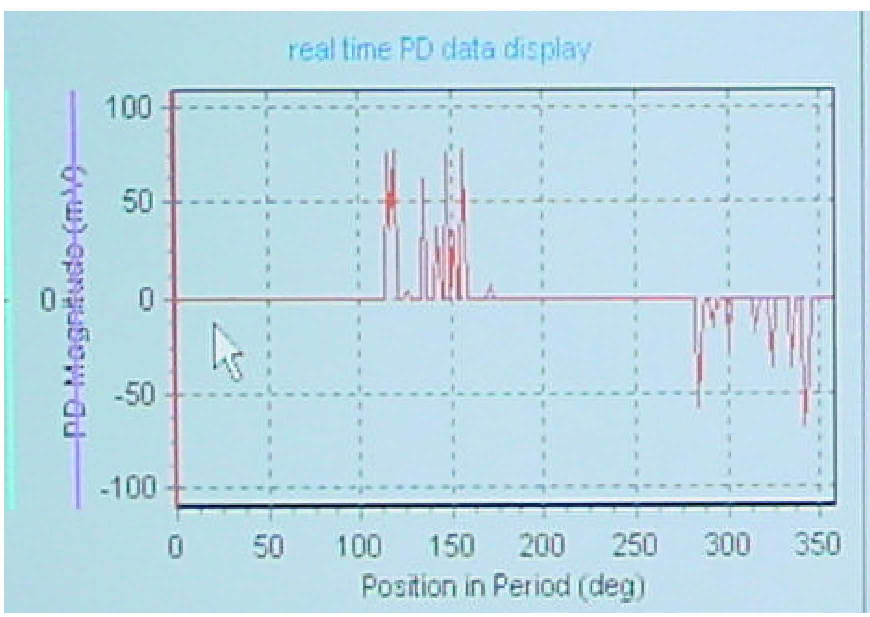
Repair the faulty component – generally, the first priority is to access the damage and to begin immediate repairs.

Partial Discharge – if you have medium or high voltage equipment that is still in service and has not been affected by the failure, the condition of this equipment should be evaluated using partial discharge testing. Partial discharges are created by the partial failure of the electrical insulation contained in cables, switchgear, transformers and other equipment. This new technology can detect these partial failures before complete failure occurs. The test is relatively low cost and does not require a power shutdown. All medium and high voltage equipment should be tested immediately to avoid another costly failure. This test is so effective that it should be performed annually to ensure electrical system integrity.

Photo of a sensor being used to test a medium voltage cable. The technician safely clamps the sensor around the grounded cable shield while the electrical system remains in service.

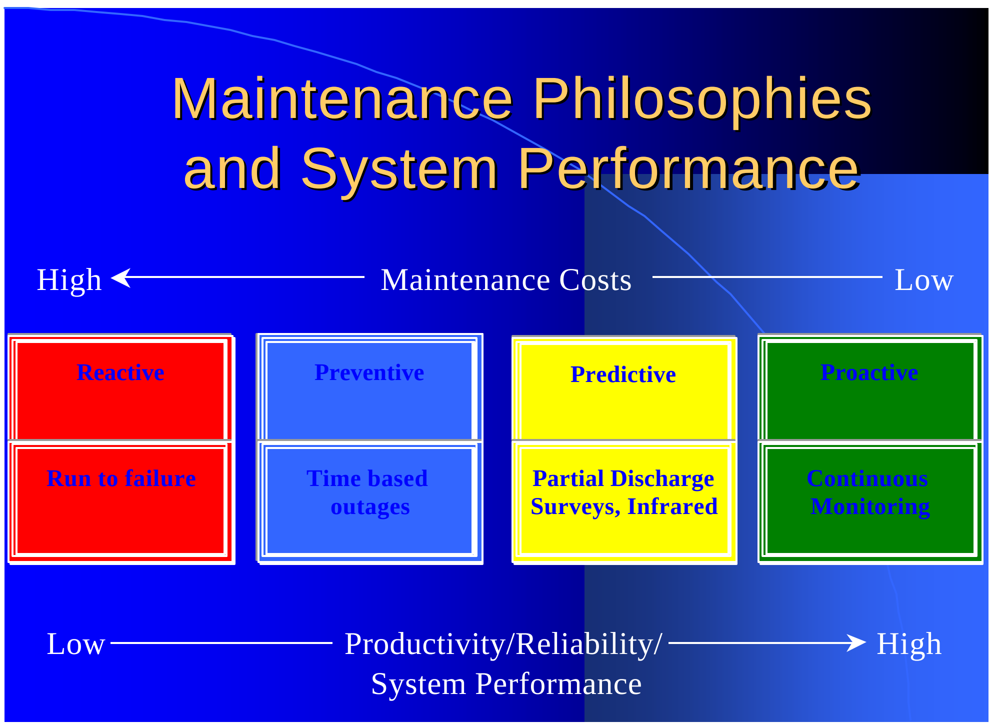


This photo shows the results of PD testing of good insulation.



This photo shows the results of PD testing of poor insulation.

***Testing and Maintenance* –** if there is any other equipment that is down because of the failure or if any other equipment can be shut down for service, now is the best time to perform thorough preventive maintenance and testing activities. When a failure occurs, the other equipment on the electrical system is also suspect. Additionally, the fault often creates voltage surges that can severely stress other electrical components. Additional component failures will often occur immediately upon re-energization and create even more difficulties for facility managers. Servicing the equipment ensures suitability for continued operation.



This graphic clearly displays the cost and reliability differences associated with the different types of maintenance philosophies. Facility managers wishing to maximize system reliability and minimize life cycle and downtime costs should utilize the new predictive and proactive maintenance technologies as much as possible.

Infrared thermography - infrared surveys are probably the single best test that can be performed on low voltage systems and this test does not require a power outage. Infrared testing should be performed annually.

What should be done very shortly thereafter

Single-line drawing **–** the single-line drawing is a vital tool for every facility. Up-to-date, accurate and complete drawings are the foundation to successful operation of the entire electrical system. The single-line drawing provides an electrical "map" of the facility that shows how all of the electrical equipment is connected together. Without it, determining electrical equipment location or where equipment is fed from would be very difficult. When a failure occurs, not having an accurate single-line will result in unnessary lost time attempting to restore power. Additionally, inaccurate single-lines can be a personnel safety risk.

Short circuit, coordination & arc-flash study - often after a fault occurs, the facility's main breaker or several upstream (towards the utility source) breakers from the fault will trip. This usually creates a much wider-spread outage than necessary which results in much greater loss of facility power and much greater danger to the occupants. If an electrical system is properly coordinated, only the first upstream breaker will trip and the outage magnitude will be minimized. Circuit breakers have adjustable settings so that coordination can be achieved. If an up-to-date coordination study has not been performed or if the breakers have not been tested and set to proper values, then the system will not be coordinated.

A short circuit study is performed to ensure that the equipment is not stressed beyond it's rating, should a fault occur. This short circuit study is performed in conjunction with the coordination study and will help reduce the damage to the electrical component that is subjected to the fault. This will also enhance personnel safety.

The arc-flash study utilizes results from the short circuit and coordination studies to calculate the available incident energy at each location and resulting personal protective equipment that must be worn to work on the specific electrical equipment.

Three-year maintenance agreement **–** a three-year maintenance agreement is the best solution to ensuring electrical system reliability. This agreement combines the most effective "no-outage" tests such as partial discharge testing, infrared thermography, visual inspections and insulating fluid testing along with outage-based preventive maintenance and testing activities. The program can be customized based upon specific customer needs and cost can be spread out over the three-year period with a quarterly payment plan. Additionally, the customer will receive discounted parts and labor rates and top emergency response priority, should an emergency occur.

Emergency Power Restoration Plan - every facility should have an emergency plan, this holds especially true for a facility that neglects testing and maintenance, for these facilities will statistically suffer the worst consequences. The emergency plan should be developed with the assistance of a responsible electrical service contractor that has resources available to deal with the worst possible scenario that could occur. An agreement should then be obtained with that contactor for future emergencies.

Further information

There are many good references available to learn more about electrical reliability, testing and maintenance including the following:

> NFPA (National Fire Protection Association) Standard 70B
> INETA (InterNational Electrical Testing Association) MTS Standard
> IEEE Standard 493 Power Systems Reliability