

# A Predictive Approach to Electrical Maintenance: Run-to-Failure versus Predicting Failure

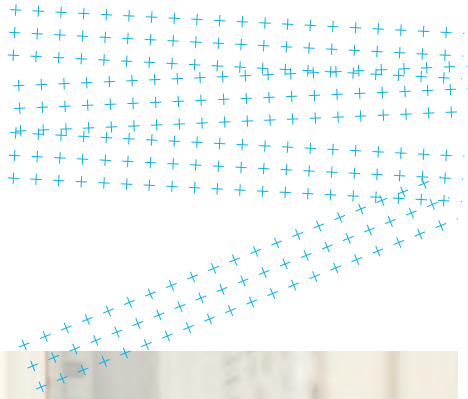
by **Nick Schiltz**

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Every facility across the globe relies on electrical power today. Most industrial and commercial facilities solely rely on their utility power feeds and transformers while other mission critical facilities depend on generators and uninterruptible power supplies for their back up power redundancy. A common factor in determining the reliability and uptime of an electrical system is the condition and

the availability of the power distribution equipment such as medium voltage and low voltage switchgear, transfer switches and MCCs used in the downstream. Historically, all preventive maintenance strategies have been put in place on the cable connections, joints, busbar splices and other movable parts that shows physical symptoms of major wear and tear and stress.



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*Most facility owners and operators follow either a three-year or five-year electrical maintenance routine or in many cases only react to an unplanned power outage.*

Compared to other types of rotating equipment, the power distribution equipment makes significantly less noise or no noise during their normal operation and perhaps the reason why they get less to no attention. Additionally, the availability of skilled and trained personnel to perform the maintenance related activities combined with production pressures

that intervene to perform the maintenance routines make it more difficult. Most facility owners and operators follow either a three-year or five-year electrical maintenance routine or in many cases only react to an unplanned power outage.

Often overlooked with the electrical power distribution equipment is the

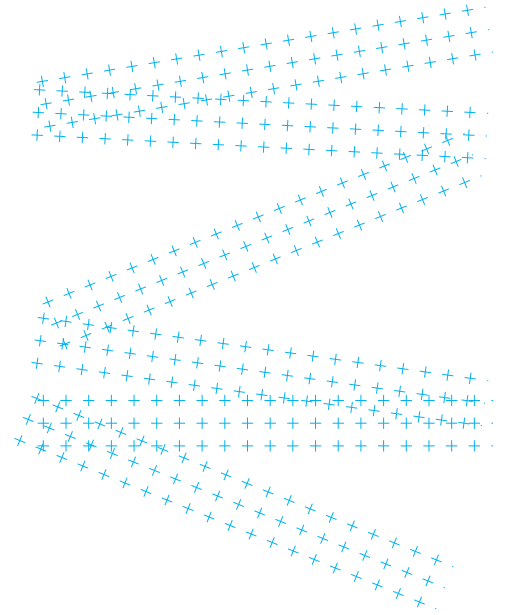
progressive addition of loads and their effect on the overall system.

For example, a system designed and commissioned with a 2000 Amps calculated load a decade ago in a collocation data center or an industrial manufacturing facility might be running well over 30-50% above the designed parameters today.

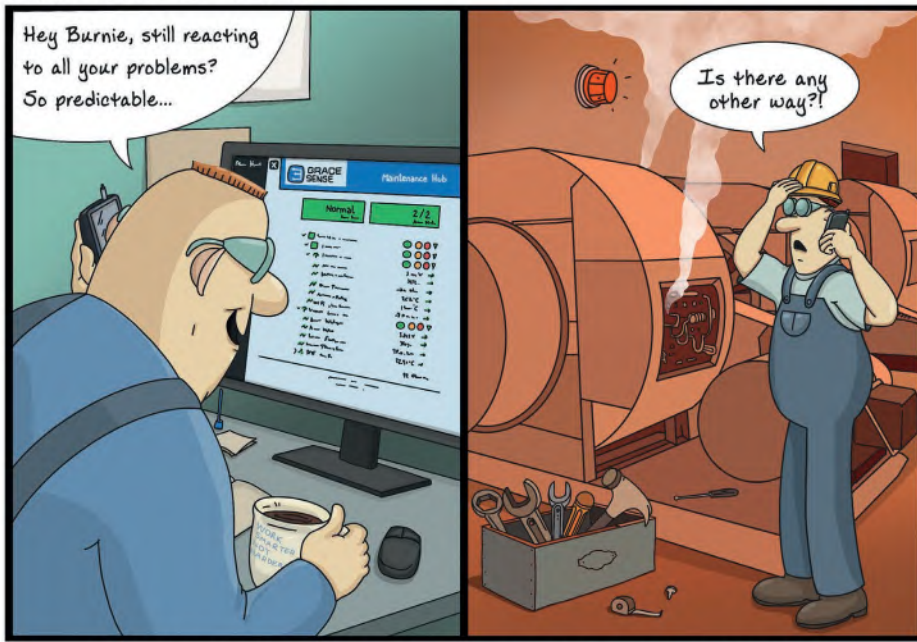
Since most systems are already designed conservatively considering the marginal future load, this may not create a major problem in the short run. However, the same trends of adding additional loads over time without considering their effects like surge characteristics and duty cycles will negatively impact the insulation and performance characteristics that could potentially lead to an unplanned outage.

### What causes your electrical equipment failure?

The percentage of total electrical failures by cause type published by a renowned industrial and facility insurance provider indicates that loose connections/parts contribute to over 30% of all electrical failures and a major cause for power outages, followed by 17% for moisture and 10.4% for line disturbance.



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PREDICTIVE MAINTENANCE VS. REACTIVE MAINTENANCE

*NFPA in 2014 noted 95,700 incidents due to arcing or shorted electrical equipment, and 23,600 incidents due to overheated motor or wiring that contributed to almost one-third of all the reported incidents.*

The inconvenient truth about preventable failures of power distribution equipment is that it takes down an entire production line or in some cases the complete facility shuts down. In contrast, many processes are still operable in the event of a failure in just one single piece of downstream equipment such as a pump or motor in a manufacturing process.

Electrical system breakdowns are a leading cause of equipment and business interruption losses. It is a growing problem, and the losses can be substantial – electrical systems constitute a major percentage of a property's total value.

### Electrical maintenance prioritization: Where to start?

Electrical maintenance prioritization is one of the major concerns that many facility owners and operators encounter. In many instances, the equipment is neither brand-new nor age-old. For example, a twenty-five-year-old facility can have electrical equipment from 3 to 20 years old. How should I prioritize maintenance on my equipment?

IEEE 493 Gold Book standards paint an overall picture of how your equipment rank given the installation and reliability statistics of the various types of electrical equipment.

According to this data, many product failures occur during the infant mortality period or early-stage period because of product manufacturing defects, quality issues, followed by useful life where the failures are either stress related, human error or due to improper maintenance, and wear out failures due to aging. A simple rule of thumb is to always start with critical equipment within your facility which creates a single point failure or take the overall system down, followed by any equipment that shows impending failures. Consider the economic loss factor due to a power outage and the cost of avoidance while prioritizing your equipment.



Equipment operating temperature significantly impacts the overall useful life. Most electrical systems are designed for 40°C - 45°C ambient temperature. Every 10°C rise in temperature shortens the average reliability of electrical components by 50% percent.

Thermography methods use aiming an IR Camera at the electrical connection or potential hot sources inside the electrical equipment to measure the temperature. Open door thermography inspections demand heavy PPE, certified thermographers and personnel working in the proximity of the energized components.

Closed door thermography utilizes an IR viewing window(s) installed on the equipment through which the IR camera is directed at the hot spots. It is often difficult to inspect all critical connections in an electrical panel with the IR window's limited field of view (FOV) due to the location of the window, equipment complexity, and busbar construction. Though most IR windows are available in sizes ranging from 2" – 20" diameter, larger FOV is unattainable without using bigger/more windows or highly expensive custom windows. IR windows installation in arc rated equipment further poses a threat to the arc rating of the gear, structural integrity and raises many warranty concerns over the equipment from the manufacturers.

## Routine thermography inspections

Most of the electrical equipment failures occur in power distribution equipment either due to loose connections (30.3%) or insulation failure (9.9%). While insulation breakdowns of the equipment can be identified through partial discharge surveys and tests. It is particularly difficult to identify the cause of loose connections as they could be due to both mechanical and electrical issues.

An electrical failure due to a loose connection is a current fault and it could be due to under torqued

connections, mechanical load on the terminals, varying load conditions, duty cycles, cable crimping, and training. Most of these connections fail because of the excessive heat rise because of increased resistance at the connections. Both these events can be monitored without interrupting the facilities. While Infrared Thermography inspections are a most common method for predicting temperature anomalies, it is important to understand the transitivity settings of the connections monitored and proper calibrations of the Infrared (IR) Camera.



IR Thermography is a great tool to identify the temperature anomalies but requires qualified and certified thermographers to perform the work. Most insurance companies and standards require the IR inspections to be performed on systems under an energized condition that replicates the normal operating load or at least on 40% of the rated load.

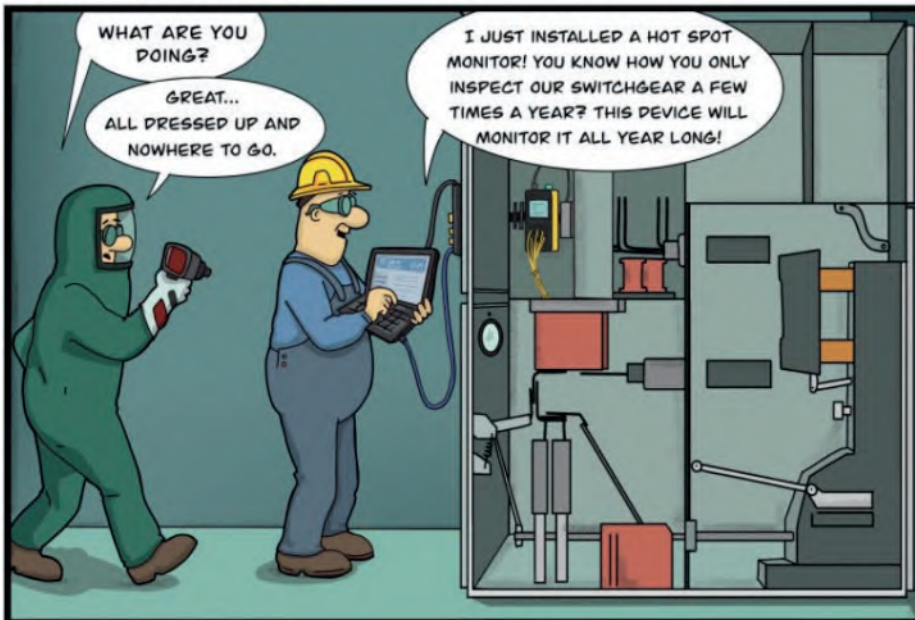
Inspections performed at non-peak hours due to the facility and personnel availability also affect the relevancy of the measured data. As a result of inspections, thermographers typically issue a detailed report identifying the equipment with the corresponding image, temperature rise finding and recommended actions. Few high-end loss prevention insurance providers and thermographers provide detailed repair estimates and cost avoidance details while taking the production downtime into consideration.

7,770 structure fires. Of all the structure fires, Electrical distribution and lighting equipment were involved in 24% and heating equipment was involved in another 16% of these fires. Another report of non-fire, non-rescue electrical incident data published by NFPA in 2014 noted 95,700 incidents due to arcing or shorted electrical equipment, and 23,600 incidents due to overheated motor or wiring that contributed to almost one-third of all the reported incidents.

Avoiding a catastrophic electrical equipment failure will not only save the equipment and the downtime but can greatly help to avoid significant damages to the property and personnel. Electrical equipment failure and bearing failure that resulted in motor overheating triggered two large-loss fire incidents. The financial losses were listed as \$17.6 Million and \$13 Million (NFPA Large-Loss Fire Report 2016).



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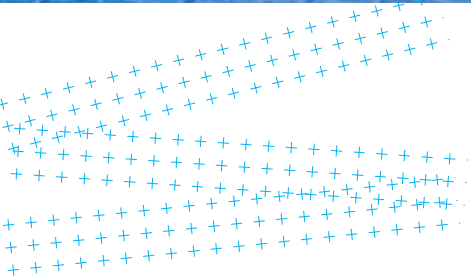
### Damages beyond equipment and downtime

A research report published by National Fire Protection Agency (NFPA) in 2017 noted that 37,910 fires in industrial and manufacturing properties were reported for the period 2011-2015 which included

### The predictive approach

Continuous temperature monitoring devices available on the market today can spot temperature abnormalities in electrical connections of power distribution systems such as busbars, MCCs, drive panels, switchgear, bus ducts, etc. These predictive

*Predictive maintenance smart devices will monitor, log, alarm, and enable users to trend temperature variations that are indicative of a potential fault.*



maintenance smart devices will monitor, log, alarm, and enable users to trend temperature variations that are indicative of a potential fault. When integrated with a facility's electrical preventive maintenance program (EPM) as defined in NFPA 70B, these devices allow maintenance personnel to plan and schedule maintenance tasks that will avoid unplanned shutdowns and monetary damages.

Maintenance is an enforceable code under OSHA. NFPA 70E states that equipment owner shall be responsible for maintaining the equipment and documenting the maintenance records to reduce workers exposure to electrical hazards. The standards also state that the maintenance shall be performed per manufacturer recommended guidelines or industry consensus standards such as NFPA 70B, or ANSI/NETA MTS.

As referenced in Dept. Of Energy, O&M Guide, top-performing facilities utilize 45-55% predictive maintenance programs, compared to 25-35% preventive maintenance and 10% reactive or run-to-fail maintenance. While a top performing facility and an average facility both spend about the same on preventive maintenance programs, the major difference is on how they compare on the predictive and run-to-failure metrics.