



The Costs and Risks Associated with Improper Service and Maintenance of Electrical Systems

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Buildings run on power. They require miles of wiring and networks of electrical circuits, breakers, panels, switches, meters, controls and other equipment to operate safely and efficiently. These networks need care, monitoring and maintenance to minimize hazards and prevent costly incidents. Improper service or maintenance can put building occupants and maintenance personnel at risk, drive up costs, damage equipment and undermine operations. It can also have a significant bottom line impact.

An expensive lesson

At the end of 2010, the Occupational Safety and Health Administration (OSHA) charged an employer with “willful and serious” electrical safety violations at 30 of its facilities across the country. Over the course of the year, OSHA inspectors uncovered numerous violations of OSHA standards related to testing on live electrical equipment, untrained or unqualified workers performing tests, and inadequate warning signs and Personal Protective Equipment (PPE). OSHA also cited the employer for failing to instruct workers on proper procedures. With these violations, the employer exposed workers to serious and potentially fatal hazards of shock, electrocution and arc flash.

OSHA issued fines totaling more than \$5 million for violations across more than 25 facilities. OSHA found that the employer failed to adequately train workers to recognize electrical hazards and also failed to train them how to work safely around such hazards. The employer was also cited for not providing workers with the appropriate tools and PPE to avoid injury or death while working around and on electrical equipment. OSHA has ordered the employer to correct electrical violations at all of its facilities, conduct training on safe electrical practices, provide PPE to affected employees and withdraw flawed management orders and instructions regarding safe electrical work. It is estimated that total fines for the employer could exceed \$10 million.¹

Categories of costs and risks

The costs and risks related to improper electrical service and maintenance fall under five key areas:

1. Employee safety
2. Non-compliance
3. Damage to equipment
4. Increased energy costs
5. Downtime

The service and maintenance of electrical systems and equipment is one area where it does not pay to cut corners. The risks are too great and the results can be nothing short of catastrophic.

1. The price of employee safety

The risk to life and limb can be significant when working with electrical systems and equipment. Safety must be top of mind and paid much more than lip service. As the codes and regulations state, employers are responsible for creating and maintaining a safe environment for employees and technicians. This requires extensive safety training, the identification of qualified personnel, and the supply of proper equipment and protective apparel to do the job. Failure to meet these requirements may place people at risk and result in significant costs related to fines, investigations, lost productivity and potential litigation.

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For individuals working with electrical equipment, most hospital admissions stem from arc-flash burns rather than electrical shock. Each year there are about 30,000 arc-flash events and 7,000 burn injuries. Every workday, arc-flash incidents hospitalize five to seven workers in North America. Of those 7,000 burn injuries, more than 2,000 people enter burn centers with severe arc-flash burns and about 300 of these cases result in death.² Given these grim statistics, OSHA has stepped up its enforcement of electrical standards.

When a technician is injured by an arc-flash or other electrical incident, the employer bears the costs associated with lost productivity, reduced competitiveness, employee rehiring and retraining and increases in workers' compensation premiums. Depending on the situation, litigation and further safety investigations can further drive up costs.

In published data from the state of Washington for 2000 to 2005, 350 workers were hospitalized for serious burn injuries that occurred at their place of employment. Thirty of these injuries were due to arc-flash/blast explosions. For just these thirty claims, total workers' compensation costs exceeded \$1.3 million, including reimbursement for almost 1,800 days of lost work.³

A 2010 article titled "The Case of the Deadly Arc Flash" from *Electrical Construction and Maintenance* (<http://ecmweb.com>), relates the story of how defective test equipment and poor training led to tragedy for workers at a shopping mall. The incident resulted in one injury, two deaths, significant property damage, lawsuits and citations. Based on an investigation of the incident, OSHA fined the electrical contractor that employed the electrician for multiple training, PPE and work practice violations. In the aftermath of the deadly accident, various parties filed lawsuits against the electrical contractor, the department store at the shopping mall, the equipment manufacturer and insurance companies.⁴

Even experienced electricians and technicians need to continue their training to help ensure their own safety and the safety of those around them as regulations and equipment change.

Safety training must be a continuous effort. Safe work performance begins with each technician knowing the right PPE for a job. Under OSHA right-to-know laws, maintenance electricians must also have access to material data sheets that provide detailed information on equipment contents, safety procedures, toxicity, spill-containment procedures and safe methods for the handling of a wide range of cleaners, lubricants, coolants and other chemicals.

2. The costs of non-compliance

Electrical services must be performed in accordance with numerous codes and regulations because of the inherent dangers related to electrical systems and equipment. Regulatory bodies in the electrical services market include OSHA, which sets the law, and independent safety and standards organizations that can heavily influence codes and regulations.

The mission of OSHA is to prevent work-related injuries, illnesses and occupational fatalities by issuing and enforcing standards for workplace safety and health. OSHA safety and health standards are the law and failure to meet these standards can result in citations, fines, sanctions and even shutdowns. There are several specific OSHA regulations that directly impact electrical services including:

- 29 CFR 1910 Subpart I – sets standards for personal protective equipment (PPE).

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- 29 CFR 1910 Subpart R – covers the operation and maintenance of electric power generation, control, transformation, transmission, and distribution lines and equipment.
- 29 CFR 1910 Subpart S – the key electrical rule that addresses design safety standards for electrical systems, safe work practices, maintenance requirements and safety requirements for special equipment. This regulation also covers training requirements, sets guidelines on energized parts, outlines lockout/tagout procedures and provides rules for the use of PPE in electrical work.
- 29 CFR 1926 Subpart K – addresses electrical safety requirements that are necessary for the practical safeguarding of employees involved in construction work.

Independent safety and standards organizations that impact the electrical services market include:

- The Institute of Electrical and Electronics Engineers (IEEE) – provides information on reducing arc flash hazards.
- The National Fire Protection Association (NFPA) – sets standards and requirements for fire prevention and suppression activities, training and equipment. The NFPA publishes NFPA 70 which is referred to as the National Electrical Code. NFPA 70 provides standards for electrical installations in buildings and is typically adopted as part of local building codes and regulations. Compliance with NFPA 70 is mandatory.
 - NFPA 70B addresses recommended maintenance for electrical equipment.
 - NFPA 70E provides standards for electrical safety in the workplace.

Understanding the many safety codes and regulations and ensuring compliance can be challenging and costly but the failure to comply and create a safe environment can be disastrous. In a typical year, OSHA issues more than 40,000 citations for code violations.⁵ Many of these violations can put front-line maintenance and engineering technicians at serious risk. The second most common area for OSHA violations and citations concerns

electrical hazards. A 2010 article titled “Worker Safety: The 10 Most Common OSHA Violations” on the website www.facilitiesnet.com stated that the top ten most common OSHA violations were related to:

1. Personal protective equipment (PPE)
2. Electrical hazards
3. Machine guarding
4. Hazard communication
5. Flexible extension cords
6. Fall protection
7. Lockout and tagout on energized equipment
8. Obstructed fire extinguishers
9. Welding and compressed gasses
10. Documented training records⁶

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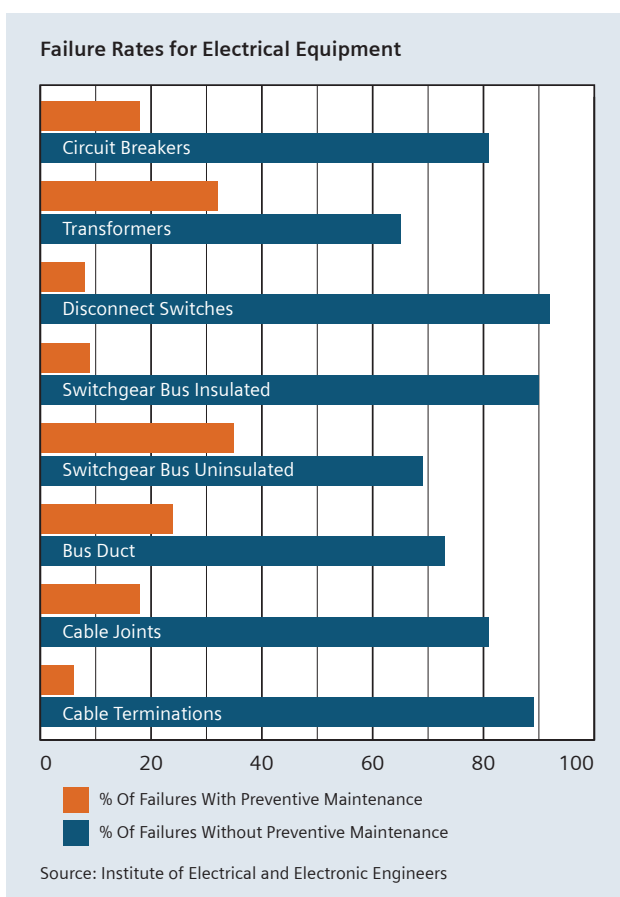
To avoid citations and fines and avoid injuries to electrical technicians, employers must develop a plan for worker safety that complies with OSHA and creates a safer environment for maintenance workers and electrical technicians. OSHA has the power to inspect facilities, investigate accidents, levy significant fines and even shut down operations if code violations are not addressed to their satisfaction.

3. Damage to equipment

Electrical systems require care and attention to ensure safe, optimal performance. They represent a significant investment in any facility that deserves to be maintained and protected.

The primary reason for performing electrical system maintenance is to keep equipment operating at or near its designed conditions so that it will efficiently deliver the performance required when needed. The reliability of electrical systems can be greatly improved with proper maintenance practices and procedures, starting with effective system startup and acceptance testing. The next chart provides an overview of the failure rates for specific electrical equipment with and without preventive maintenance and shows how the failure rate can be cut by more than half with a proper maintenance program.

As soon as new equipment is installed, the normal process of deterioration begins. With minimal maintenance, this process can progress to cause malfunctions or electrical failures. According to a survey for Hartford Steam



Boiler, breakdown repairs cost three times the price of a comprehensive maintenance program. Depending on the condition of equipment, implementation of a balanced preventive maintenance program can reduce previous program operating costs by 20% to 40%.⁷ Most manufacturers and the NFPA-70B standards recommend that electrical equipment that requires high reliability be serviced regularly. Recommended service schedules for high reliability equipment are:

- Quarterly for equipment that is older or is in poor condition
- Twice a year for older equipment that is in average condition
- Every nine months for older equipment that is in good condition

While many companies view maintenance as an overhead cost, studies have shown that when properly performed, maintenance can return \$5 for every \$1 invested.⁸ By accurately assessing the condition of electrical equipment, failure modes and times can be predicted and corrective measures can be scheduled at a cost that is much less than reacting to unscheduled shutdowns.

When it comes to electrical system maintenance, cutting costs one day can lead to greater costs later. Examples of potentially expensive cost-cutting measures include:

- Deferring maintenance by skipping scheduled inspections and tests that can result in unexpected failures
- Reducing training programs which can result in risks to people, operations and assets
- Run-to-fail maintenance policies that allow equipment to run with minimal maintenance to the point of break down which can result in unplanned downtime and severely damage equipment

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Treating maintenance as a safety concern rather than simply an overhead cost can help protect assets and reduce overall risks. For example, a 2011 article titled “When Maintenance Becomes a Safety Issue” on the website <http://ecmweb.com>, illustrates how the lack of proper maintenance led to catastrophic failure in an electrical system. A company installed new switchgear, a transformer and a reactor. A new self-contained substation was also installed which included a battery bank and charger. When installed, the contract did not require the installing company to test the molded-case circuit breakers in the panel that fed the battery charger. These circuit breakers probably cost less than \$100 each and it would cost more than that to test them. Plus, considering that the equipment was brand new, maintenance personnel did not check them often. One night, the underground feeder cable from this new switchgear failed. One of the circuit breakers feeding the battery charger was defective and tripped. The fault caused considerable damage to the switchgear, transformer, and reactor. The incident caused more than \$5.2 million in damage, all because a \$100 circuit breaker was not tested during installation.⁹

Industry statistics suggest that the average cost of an arc-flash incident in terms of physical damage is approximately \$50,000 and the potential business interruption costs are approximately \$85,000 per incident (source International Association of Electrical Inspectors, IAEI).¹⁰

Proper maintenance supports overall facility performance and production. It reduces unplanned outages, extends the life cycle of expensive equipment and systems and helps protect your capital investments. Properly maintained equipment also eliminates the costs that can be associated with purchasing and installing replacement equipment in an emergency situation, often at a premium price.

4. The cost of wasted energy

The lack of preventative maintenance or poor service can degrade the performance of electrical equipment and drive up energy costs.

Within the industry, it is common knowledge that proper maintenance and service is required for equipment and systems to operate at peak performance. Systems and equipment that operate efficiently can save both money and energy. The Energy Forum Report 1996 found that simply by improving maintenance practices, rather than spending money on new equipment, organizations can reduce utility bills between 6% and 27%.¹¹

An example of the need for proper maintenance is the issue of loose or improper electrical connections. One of the major threats to safe, ongoing operations is poor electrical connections. These faulty connections can be caused by improper installation, equipment vibration, temperature cycling, and the failure to tighten connections properly after repair work. Electrical connections can also be deformed by over-tightening. Improperly torqued connections and bad contacts can cause amperage draw and power loss as well as heating and arcing, which is both energy inefficient and highly dangerous. Beyond the safety issues and outright system failures, an additional problem that is often overlooked is that loose connections can cause power loss from increased contact resistance. If current and contact resistance is high enough at these loose connections, they can cause a significant increase in energy costs over the course of a year.

While finding loose or improper connections that unnecessarily drain power can pose a significant challenge, fixing them can deliver significant economic benefits. There are specialized tools and technologies that can be used to scan large areas of electrical equipment for abnormally high temperatures which can pinpoint problem areas. This is another area where well trained technicians with the proper equipment are critical to getting the job done right and helping increase energy efficiency.

5. Business downtime

Unplanned shutdowns or outages due to electrical equipment failure have the potential to paralyze businesses, cost millions of dollars and end careers. It has been estimated that 70% to 80% of all unplanned shutdowns are due to human error, with only 20% to 30% of unplanned shutdowns due to equipment malfunction or poor design.¹²

The costs per hour for downtime vary widely by industry sector with the energy and telecom industries facing costs of more than \$2 million per hour. The chart below illustrates the cost of downtime across various industry sectors. It is based on estimates from leading *Fortune 500* businesses on the revenue losses that would occur as a result of one hour of downtime at their organization. Figures provided are the average downtime per business estimated for that industry.

Potential Downtime Costs per Industry Sector

Industry Sector	Revenue Loss/Hour
Energy	\$2,817,846
Telecommunication	\$2,066,245
Manufacturing	\$1,610,654
Financial Institution	\$1,495,134
Information Technology	\$1,344,461
Insurance	\$1,212,444
Retail	\$1,107,274
Pharmaceuticals	\$1,082,252
Banking	\$996,802
Food & Beverage	\$804,192
Consumer Products	\$785,719
Chemicals	\$704,101
Transportation	\$668,586
Utilities	\$643,250
Healthcare	\$636,030
Metals/Natural Resources	\$580,588
Professional Service	\$532,510
Electronics	\$477,366
Construction and Engineering	\$389,601
Media	\$340,432
Hospitality	\$330,654
Average	\$1,010,536

Source: META Group, Stamford, CT¹³

Electrical system reliability is often a critical performance measure for facility engineers and managers. The salaries and job security of facility managers may be directly impacted by electrical system downtime and related business costs.

A 2010 study by the Factory Mutual Insurance Group stated that an average of 56% of all electrical fire losses were due to a lack of preventive maintenance.

Fire is another significant risk associated with improper electrical service or maintenance that can cost lives, reduce uptime and damage or even destroy a business. This risk crosses building types and industries. A 2010 study by the Factory Mutual Insurance Company stated that an average of 56% of all electrical fire losses were due to a lack of preventive maintenance.¹⁴

Reasons to consider an electrical services partner

In addition to the potential costs and risks associated with improper service and maintenance, other factors influence companies to rely on partners for electrical equipment servicing and maintenance. One key driver is a shortage of resources. Maintenance staffs are continuously being asked to do more with less. They may not have enough qualified staff to stay on top of maintenance and other day-to-day issues. They may not have the training, the specialized skills or the right equipment to adequately perform the work that needs to be done to ensure safe, productive operations.

Organizations often turn to outside help when projects are too large, complex or dangerous for in-house staff. The decision to use outsourced staff is usually made on a case-by-case basis and most emergencies are handled by the same service provider that handles preventive maintenance.

As systems and regulations become more complex, the costs associated with performing service and maintenance internally continue to increase. Organizations need to invest in proper training, PPE and testing equipment to meet these changing demands. To protect lives, equipment and operations, it is critical that maintenance and service be done right the first time. This is why the use of outsourcing for operations and maintenance is projected to increase by 30% from 2006 to 2014, according to the Construction Management Association of America (CMAA).¹⁵

What to look for in a service partner

Across industry segments, a major challenge when evaluating service providers is locating technicians that can understand the intricacies and design of a facility. These technicians are adept at diagnosing and fixing problems quickly and effectively the first time. Providers that were involved in the initial installation or sale of electrical equipment at a facility often have an advantage based on this level of familiarity.

Customers want to work with service providers that are reputable, reliable and provide good value. Service customers strongly desire:

- Prompt response to all service requests (support available 24/7)
- Effective communication
- Familiarity with installed equipment
- Cost-effective utilization of labor and materials
- Thorough explanations of problems and how they will be fixed
- Technicians that are highly qualified, licensed and dependable
- Technicians that can easily read and understand electrical infrastructure plans
- Technicians that receive regular training and are up-to-date on codes, regulations and new technology

For many customers, it is also important that service providers be able to provide maintenance and service for a wide range of electrical equipment from different manufacturers including:

- Arc and ground fault circuit interrupters
- Busway systems
- Circuit breakers
- Conductors
- Lighting controls
- Meters
- Panelboards
- Power monitoring equipment
- Relays
- Supply systems, UPS and generators
- Switches and switchboards
- Transformers

Many customers also insist that their service provider have experience with their industry and have a local presence. Customers may also rely on service providers to strategically offer input on how to develop and manage their electrical infrastructure. Customers may want to consider additional services to support their employees and organization including:

- Arc flash hazard analysis
- Emergency, on-call services
- Power monitoring
- Power quality testing
- Spare part replacement & renewal
- Startup and commissioning
- Thermography
- Upgrades, reconditioning and retrofits
- 24/7 technical support

Due to the significant costs and risks that can be related to improper service and maintenance, it is critical that service providers be carefully screened. Providers need to be reputable, responsive and able to address your needs. They should be willing to work closely with your team to ensure the safety of your people and the productivity of your equipment and operations.

Footnotes

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