

Electrical Fire Hazards (USA and Canada)

Introduction

Electrical systems and equipment are installed in essentially all commercial and industrial buildings, making it imperative to control fire loss exposures through proper installation and system maintenance.

Industrial electrical systems are not normally considered a high fire risk; however, any location where electrical energy is distributed or used can become a potential fire ignition point.

The following information covers electrical fire hazards as well as grounding systems, power surge protection, and electrical preventive maintenance. It reviews electrical hazards specific to commercial and industrial properties and some methods of minimizing these hazards. Electrical hazards such as personal injury from shock and burns are outside the scope of this document.

Key Causes of Property Loss

Fire – Electrical malfunction is a common cause of fire in the workplace. Fire frequently results from excessive heat that is produced by above-normal resistance in wiring and, more commonly, at connection points. High resistance connections occur when wires are improperly spliced or connected to components such as receptacle outlets and switches. Connections can also become loose over time causing excessive resistance and heat. Defective or deteriorated electrical equipment or a misapplication or misuse of electrical equipment are also common causes of excessive resistance.

Explosion - Explosions can occur when electricity provides a source of ignition for an explosive mixture in the atmosphere. Due to hazardous processes in industrial occupancies, explosive atmospheres are created from the accumulation of flammable vapors or gases, combustible dusts and combustible fibers. Ignition can result from overheated conductors or related equipment, or normal arcing at switch contacts.

Controlling Electrical Fire Hazards

Each electrical system has the potential to be the source of ignition causing a fire or explosion. Fire and explosion hazards can be minimized through a combination of proper installation techniques, utilization of UL listed equipment, installation of proper protection devices, and adequate maintenance of electrical systems and equipment.

Mechanical protection devices - Protection devices are designed to shut off the flow of electricity in the event of a ground fault, overload or short circuit in a wiring system. The most common examples of over-current devices include fuses and circuit breakers.

Fuses and circuit breakers basically monitor the amount of current that a circuit carries and are intended to protect conductors and equipment. These devices automatically open or break the circuit in the event of excessive current flow. Fuses are designed to melt, while circuit breakers trip the circuit open when there is excess current flow.

Guarding - Proper guarding and clearance of electrical equipment can be provided by locating equipment in designated rooms, vaults or enclosures accessible only to qualified personnel; use of permanent partitions or screens; or by locating equipment on an elevated platform or mezzanine.

Equipment grounding - "Grounded" is generally defined as being "connected to the earth or some other conducting body that serves in place of the earth. The earth as a conductor is assumed to have a potential of zero.

Electrical systems are grounded for three main reasons:

1. To provide a path to facilitate the operation of over-current devices
2. To prevent excessive voltages due to lightning, line surges or unintentional contact with higher voltage lines
3. To stabilize voltages relative to ground during normal operation

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The main functional objective from a safety and property protection standpoint of the grounding system is to minimize the resistance to ground so that stray current can easily travel to the ground. The reason is to maintain electrical connection boxes, metal equipment enclosures, metal conduit, etc. as close to earth potential as possible to reduce shock hazards. In addition, it is to ensure that over-current protection will operate in the event of a line-to-ground fault. Failure of over-current protection can result in severe over-heating or sparks and flames discharging from the electrical connection where the short circuit has occurred.

To be effectively grounded, electrical equipment must be intentionally connected to earth through a sufficiently low impedance connector. Normally this is accomplished with securely attached connectors and adequately sized wire that terminates at a properly sized grounding rod or plate. However, there are a variety of ways to accomplish a proper grounding system. Refer to applicable electric codes for proper installation procedures.

Electrical connection to existing water and gas piping systems was often considered to yield low ground resistance; however, recent design changes utilizing non-metallic pipes and insulating joints have made this method of obtaining a low resistance ground questionable and, in many instances, unreliable.

Temporary wiring - The most common method of temporary wiring is via flexible "extension" cords, which can be a source of fire. There are several basic fire safety rules regarding the use of extension cords, the most important of which is extension cords should not be used as a substitute for permanent wiring. Extension cords should only be used for applications that are truly temporary. Extension cords should not be used where heavy foot, vehicle or industrial truck traffic might damage the cord. Worn or frayed cords should be discarded or repaired immediately.

Motors - Motors cause many fires at industrial sites and should be installed in areas where a minimal amount of dust, dirt or other foreign materials is present. Motors should be installed in ambient temperatures and ventilated in accordance with manufacturer's specifications. An arc or sparks may cause the ignition of motor insulation or nearby combustibles from the motor winding short circuits or grounds, or from malfunctioning brushes. Bearings may overheat due to improper lubrication or motor overloading. Excessive bearing wear may allow the rotor to rub on the stator, creating ignition sources.

Transformers - All transformers produce heat and require proper cooling. Transformers using a combustible oil liquid coolant increase the fire hazard significantly. An oil leak could result in a hot, rapidly spreading oil fire. A transformer fire can cause the case to rupture and sudden release of hot or burning oil.

Static electricity - Static electricity is produced when two different materials, usually nonconductors, are placed in intimate contact with one another and then separated. The energy expended to overcome the attractive force created through the transfer of electrons is manifested as a voltage difference between the two materials. Since the electrical potential difference can reach thousands of volts, a sparking discharge can occur if a grounded object is brought near the non-conducting material with the static buildup. Such sparking discharges have enough energy to act as a primary ignition source of fire under the proper conditions.

The area of most concern regarding static electrical arcing is where flammable liquid vapors or flammable gases may be present. These gaseous fuels are easily ignited and great care must be taken to prevent a fire or explosion. The ignition of combustible dusts by static electricity is possible, but requires higher energy levels than for flammable liquids.

Dangerous static charges can be controlled by several methods. Some of the more common methods are:

- Maintain proper humidity levels
- Strategically place static combs connected to ground so that static energy can be safely dissipated
- Maintain proper bonding/grounding of flammable liquids containers
- Provide specialized clothing and shoes for workers in areas containing flammable vapors

Power surge protection - A disruption in operations, system stoppage and delays, premature failure of computer boards and power supplies, and expensive repair and replacement of critical systems can be prevented with adequate surge protection. This bulletin is designed to give you a start in adequately protecting your facility from electrical power surges.

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Power surges are usually temporary over-voltage or over-current power line disturbances typically lasting microseconds. They are some time called spikes or transients. Some common causes of power surges are:

External Sources:

- High power switching at sub station levels
- Direct and indirect lightning strikes

Internal Sources:

- Heating and cooling systems
- Switching motors on and off
- Equipment - e.g. lights, copiers

Throughout business today, most equipment relies on solid-state circuits. Chips and transistors are very vulnerable to power surges. Electrical surges can damage computer equipment by burning its wires, or over time gradually wearing down the device's internal components and can even wipe out saved data. Power surges can shut down your equipment, cause loss of memory and damage the internal circuitry.

Installing surge protection devices, or transient voltage surge suppression devices, can control both external and internal power surges. The Institute of Electrical and Electronics Engineers Emerald Book recommends applying surge protection in a zoned approach.

The three zones of protection are:

- The service entrance panel
- The distribution circuits or branch panel
- At the point of use for critical loads

Properly sized suppressors at the service entrance will divert most of the energy from external transients, but much of the energy remains and travels to downstream loads. The next level of protection, at the branch circuits or distribution panels, reduces the energy further. The final level of protection is found at the point of load use and diverts the remaining energy. The equipment that is typically installed to provide the final level of protection is a power strip with surge protection device or equipment with built in surge protection devices.

Surge protectors installed in the branch circuits and distribution panels, combined with surge suppressors located at the point of electrical load also help in controlling internal power surges.

What Is a Surge Protector?

A surge protector is a device that shields computers and other electronic devices from surges in electrical power, or *transient voltage*, that flow from the power supply. Standard voltage for home and office buildings is 120 volts. Anything over this amount is considered transient and can damage electronic devices that are plugged into an outlet.

Even though power surges are so brief that they are measured in nanoseconds (a nanosecond is equal to one billionth of a second), they can cause considerable damage to electronic equipment.

Surge protectors are also commonly called *power strips*, *surge suppressors* and *transient suppressors*, and they can also protect telephone and cable lines as well.

How Does a Surge Protector Work?

A surge protector works by channeling the extra voltage into the outlet's grounding wire, preventing it from flowing through the electronic devices while at the same time allowing the normal voltage to continue along its path.

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Surge protectors most commonly protect equipment from low-voltage surges that occur frequently in modern electrical wiring. For example, devices such as refrigerators and air conditioners require large amounts of energy to switch motors and compressors on and off, creating surges in power that disrupt the steady flow of voltage. Faulty wiring, downed power lines and faulty equipment at the power source (utility company) can all cause power surges as well. Surge protectors can help protect against these power surges.

Lightning - Lightning is an example of static electricity on a massive scale, generated by the contact and separation of air, water and ice in storm clouds. Lightning protection systems are designed to intercept and direct a lightning strike to the ground. Lightning protection systems consist of air and ground terminals (rods), conductors, overhead ground wires, arrestors and connectors. Also, to protect transformers from high voltage surges, lightning arrestors direct excess voltage to the ground.

It is a common misunderstanding that surge protectors will protect systems from a direct lightning strike, the most familiar source of power surges. Even the most effective surge protectors cannot protect equipment from the sudden increase in electrical pressure of millions of volts that lightning can supply.

The best way to prevent damage from a lightning storm is to unplug devices that could be irreparably damaged. Surge protectors can help prevent damage from distant lightning strikes, but it is not guaranteed.

A direct hit with lightning is fairly rare, but there is another lightning-created risk that more commonly affects power systems. Due to the enormous amount of electricity involved in a storm, a strike near your building - near meaning within several miles/kilometers - can induce currents in metal objects. Any wire that comes in from the outside and attaches to your electrical system can become a conduit for a pulse of destructive energy.

Loss Prevention and Reduction

Protection from electrical fires can include multiple methods such as:

- Protection against fire through good fire prevention and construction design.
- Physical separation of critical equipment, limiting potential fire spread, physical damage and interruption of operations.
- Early detection of a fire through the use of listed fire detection systems, facilitating rapid response by building and fire department personnel, reducing loss severity.
- Automatic and manual fixed fire protection systems to suppress fire once detected, such as automatic sprinkler systems, approved gaseous extinguishing systems. Portable extinguishers should be installed for incipient fires.

Management's Role

By taking a proactive approach in controlling electrical fire hazards, management can reduce the potential and severity of an electrical system malfunction or failure. A key component of an effective fire safety program is the implementation of an Electrical Preventive Maintenance (EPM) program.

Electrical preventive maintenance is beneficial in many different ways. First, it is more economical to repair equipment before it can fail. When electrical equipment fails there can be ensuing subsequent damage to other components in the system. Sometimes this equipment failure can lead to catastrophic events, such as explosions or fires. Often damaged equipment cannot be replaced easily with exact replacement equipment and newer more expensive equipment must be used. Often times, expensive modifications must be made to accommodate the newer equipment.

Electrical equipment failure can lead to unplanned outages that can be quite costly, especially if replacement equipment cannot be easily acquired in a timely fashion. Also, emergency repairs can be expensive due to the urgency of the situation where temporary work is required before permanent repairs can be completed. An effective EPM program can shift downtime to a more convenient and economical time, thus producing an overall savings.

Furthermore, a properly developed and implemented EPM can improve equipment efficiency and reduce electrical consumption. Loose or dirty connections, as well as improperly operating equipment, can be inefficient. Over a period of time, these inefficiencies can add up to a significant sum of money.

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Developing an EPM Program

A properly developed and implemented EPM program provides for inspection, testing and maintenance to be performed on a scheduled basis. An effective EPM program can help you find and repair/replace worn, deteriorating or malfunctioning equipment. It can also help to extend the life of electrical equipment and improve the efficiency of the electrical system. An EPM program needs to be specifically tailored to fit each facility, managed by qualified personnel and periodically updated to account for changes that may occur.

A good EPM program should begin with a thorough survey of a facility to identify and record all electrical equipment, including transformers, switchgear panels, motor controllers, motors, important cable runs and bus systems, etc. An assessment should be made of each piece of equipment to determine which is most important, critical and costly in terms of repair and in loss of production. The manufacturer's guidelines for maintenance procedures and frequency for each piece of equipment should be obtained. From this information, a unique set of maintenance needs can be developed, resulting in a full and complete maintenance program.

Documentation

Once the core EPM program is established, a system should be developed to schedule, monitor and document all inspection, testing and maintenance activities. This EPM documentation should be kept up-to-date and maintained for an extended period of time for historical reference.

This record-keeping system can help keep the EPM program cost-effective by ensuring that all the work is being done when needed and that all equipment is being covered. In addition, tracking activities and results over time can often help identify a potential failure that can be corrected before it even happens.

General EPM Guidelines

The following are general guidelines to use to assist with establishing an effective EPM program. This list is not all-inclusive.

Semiannual

Cycle all infrequently operated circuit breakers to loosen up the mechanisms and help avoid having them stick in the closed position, if needed.

Inspect all electrical panels. Equipment should be de-energized. Check for: fuse/breaker tampering, corrosion, missing covers, missing knockouts, unidentified switches/circuits, loose/missing connectors that expose bare wires.

Clean all electrical panels and other electrical equipment. Equipment should be de-energized. Use a vacuum or low-pressure compressed air to clean equipment.

Annual

- Inspect, test, and recalibrate (if necessary) all meters and relays.
- Inspect all panels that contain copper contacts for oxide film buildup.
- Inspect major breaker panels. Be certain all bolts, nuts, pins, rods, levers and links are in place and properly tightened (torque check). Also check for proper grounding.
- Inspect cable runs and bus duct systems for damaged seals, insulation, etc., where moisture could enter.
- Check to ensure electrical loading is within design capability/capacity.
- Perform an infrared thermographic survey. Frequency will depend on critical nature of equipment, operating environment, available resources and other factors. See the section below for more information.

Infrared Thermography Surveys

One of the first steps when implementing an EPM program is to perform a complete infrared thermographic survey of all electrical equipment. This type of survey should also be performed on a periodic basis - usually annually. Infrared thermography works on the principle that electrical equipment normally gives off heat, but malfunctioning or overloaded electrical equipment will give off excessive heat due to increased electrical resistance. This heat can be detected with the

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use of infrared imaging equipment. Detecting electrical hot spots allows for repair or replacement of the affected equipment before failure occurs, which can help save the much greater costs associated with manufacturing downtime, production losses, power outages, fires and catastrophic failures.

Not all failures can be detected using infrared thermography because sometimes the process of heating and failure occurs too rapidly to be detected. But a regularly scheduled infrared thermographic survey can help prevent many electrical failures. Thermographic surveys should be scheduled prior to a major scheduled shutdown. This allows the greatest flexibility in resolving problems found during the survey. Fully trained, competent personnel should perform the infrared surveys. A good contractor will use licensed electricians that are at least Level 2 certified infrared thermographers using ANSI (American National Standards Institute) training standards. They also should be using modern equipment that produces a full radiometric image for complete analysis of any trouble spots that are detected.

Contractors will normally require the assistance of facility maintenance staff familiar with the building, equipment and who can provide access to all areas in a facility. A contractor should first meet with facility people to discuss the production process, review electrical diagrams, identify key pieces of equipment and develop a planned route through the facility. The survey should be performed while electrical equipment remains energized at normal operating load. Equipment should run for at least one hour before scanning. Generally, equipment covers must be removed to ensure effective scanning. However, because busway conductors are so close to enclosures, the covers may not need to be removed.

In addition to an Electrical Preventive Maintenance program, another component that can enhance the fire safety program is the development and implementation of a fire emergency "pre-plan." Proper planning can provide valuable information about a facility, improving the ability of emergency personnel to respond effectively to a fire. The plan should identify all key electrical system installations and related equipment, as well as fire protection and detection systems protecting this equipment.

Conclusion

From an electrical safety standpoint, it is obvious management's most important responsibility is to ensure the health and safety of employees. To support this endeavor and to reduce property loss exposures from electrical fires, electrical systems and associated equipment must be properly installed and maintained in accordance with manufacturer's specifications as well as nationally recognized standards and codes.

References

- National Fire Protection Association:
 - > NFPA 70, The National Electric Code
 - > NFPA 70B, Recommended Practice for Electrical Equipment Maintenance
 - > NFPA 780, Standard for the Installation of Lightning Protection Systems
 - > Industrial Fire Hazards Handbook
- Canadian Electrical Code, CSA, C22.1
- *Judging Electrical Hazards*, Alliance of American Insurers
- *Supervisor's Safety Manual*, National Safety Council



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