COMMENTARY PAPER

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Electrical fires: the importance of subrogation and the role of forensic engineers

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Introduction

Electrical faults are a common cause of fires in residential, commercial and industrial buildings. In many cases, the resulting fires can lead not only to property damage but injury or death. Electrical faults are often caused by faulty equipment, improper installation, abuse or misapplication. In such cases, the insurance carrier can potentially subrogate and seek compensation from the responsible party.

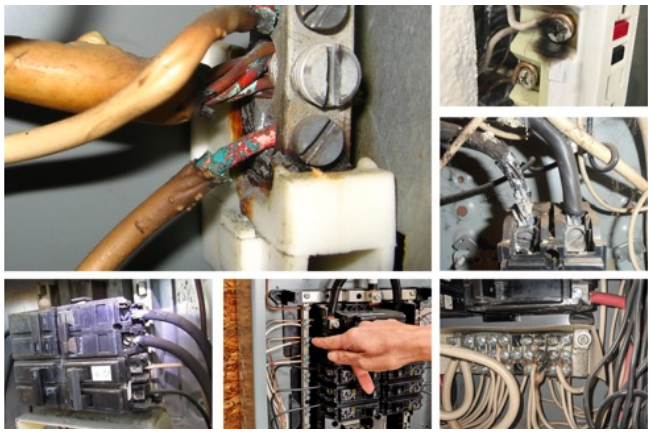
Subrogation is the right of an insurance company to seek reimbursement from the responsible party for the damages suffered by their policyholder. For fires that are believed to be electrical in nature, it is important to have trained professionals determine the cause and if any subrogation potential exists. In many cases, time is of the essence to ensure evidence and data are collected and preserved, and witnesses are interviewed.

There are various types of electrical faults that can cause fires, including electrical overloading, faulty wiring, malfunctioning appliances and outdated equipment. Below are some examples of electrical fires or potential failures.

Electrical overloading

An electrical overload occurs when excessive current flows through an electrical circuit, exceeding the rated capacity of the breaker or electrical wiring. In general, this occurs when the conductor's supplying current to a device(s) is undersized. The resulting failure is the wiring overheats, causing the insulation to melt or burn. An overload can also result if the circuit breaker is oversized or bypassed, and fails to trip and shut off power to the circuit. In this situation, a fire can result. An indication of an overloaded circuit is heat damage along the length of the conductors.

Electrical overloads can be prevented by ensuring that the electrical wiring is up to code and is rated for the electrical load required by the equipment and devices on that circuit.



Faulty wiring and installation

Faulty wiring is a common cause of electrical fires because it can result in overheating and arcing, both of which can cause a fire. Improper installation, aging wiring or damage caused by rodents or insects can all contribute to faulty wiring.

Improper installation can occur when wiring is not installed according to the manufacturer's guidelines or local building codes. Let's assume too many wires were installed under one screw (mechanical connection). This can create a loose connection or a high resistance connection. A high resistance connection will result in heat damage to the wire and insulation or adjacent devices.

Here is a brief explanation of what happens during a high resistance electrical connection:

- Resistance is a measure of how much an object opposes the flow of electric current. Materials like metals have low resistance, while insulators like rubber have high resistance.
- In a circuit, the resistance of wires, connectors, and other components leads to some energy loss and heating as current flows through them. This is normal and expected. However, sometimes a faulty connection or damaged wire can cause an abnormally high resistance at one point in the circuit. This is called a high resistance connection.
- When current encounters the high resistance point, it has trouble flowing through easily. This causes extra heating at that spot as energy is lost trying to push through the resistance. The high resistance connection acts as a bottleneck for current flow. This means devices earlier in the circuit may not receive enough current to operate properly.
- The excessive heat at the high resistance point can damage insulation, melt plastics, or even start a fire. Common causes include loose wire connections, corroded connectors, frayed cords, or wires damaged from pinching or staples.

A high resistance connection therefore wastes energy, reduces current flow, and generates excessive heat that can damage the circuit. Finding and repairing these faulty connections is important for both safety and efficient operation.

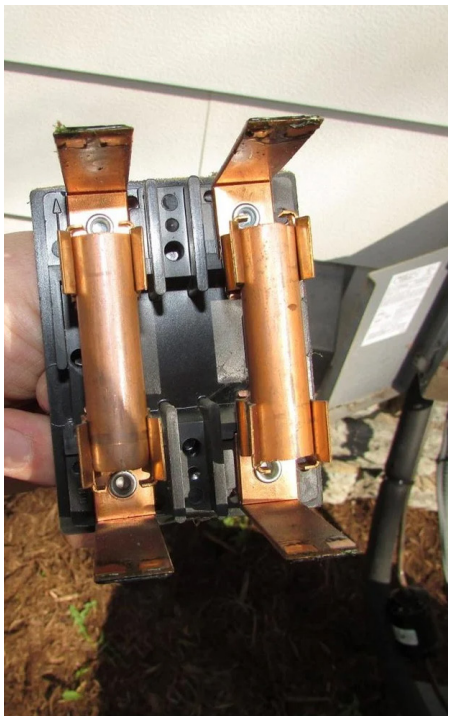
Discoloration of the conductors is an indication of a high resistance connection. Although aluminum conductors can be used in an electrical wiring system, certain installation procedures must be followed to avoid overheating. The device must be rated to accept both CU (copper)/AL (aluminum) wiring, and an antioxidant compound applied to the aluminum conductors that are terminated.

Aging wiring can also be a problem. Over time, the insulation on wires can become brittle, allowing the wires to touch each other and cause a short circuit. In addition, the insulation can crack or break, leading to exposed wires that can generate heat. Brittle insulation usually occurs when wires are installed in areas where the ambient air temperature exceeds the manufactures rating for the wire or device. This includes attics or ceilings, roof tops, wires adjacent to hot equipment or wires exposed to the elements. Conversely, cold areas can also cause wiring insulation to deteriorate. Electrical wiring and devices are rated for temperature resistance (hot and cold environments) and care should be taken when they are installed so the ambient air temperature will not exceed the rated values.

Animals and insects can also cause damage to electrical wiring or devices. An interesting trait among rodents, squirrels and rabbits is that their teeth continue to grow and they will chew on wires to help wear them down, which can result in exposed wires or fires. Insects can also cause damage to electrical wires or devices. They may chew the insulation; their waste can be corrosive or nest building actives can result in damage.

To prevent faulty wiring from causing electrical fires, any unusually flickering lights, buzzing or humming sounds, or receptacles or equipment that feel warm to the touch, should be investigated by a qualified contractor and repaired when necessary to prevent an electrical failure or fire.

Loose connection leads to overheating / glowing connection



Malfunctioning equipment

Malfunctioning electrical equipment can lead to a fire due to a range of factors. Electrical equipment that is overloaded or used improperly can also generate excessive heat, which can cause insulation and other adjacent materials to melt or start a fire. Flammable materials stored to close to electrical equipment may cause a fire either from excessive heat buildup or sparks emitted from an electrical failure. Lastly, electrical equipment that is not maintained properly can develop problems over time that increase the risk of fire, such as frayed wires or loose connections.

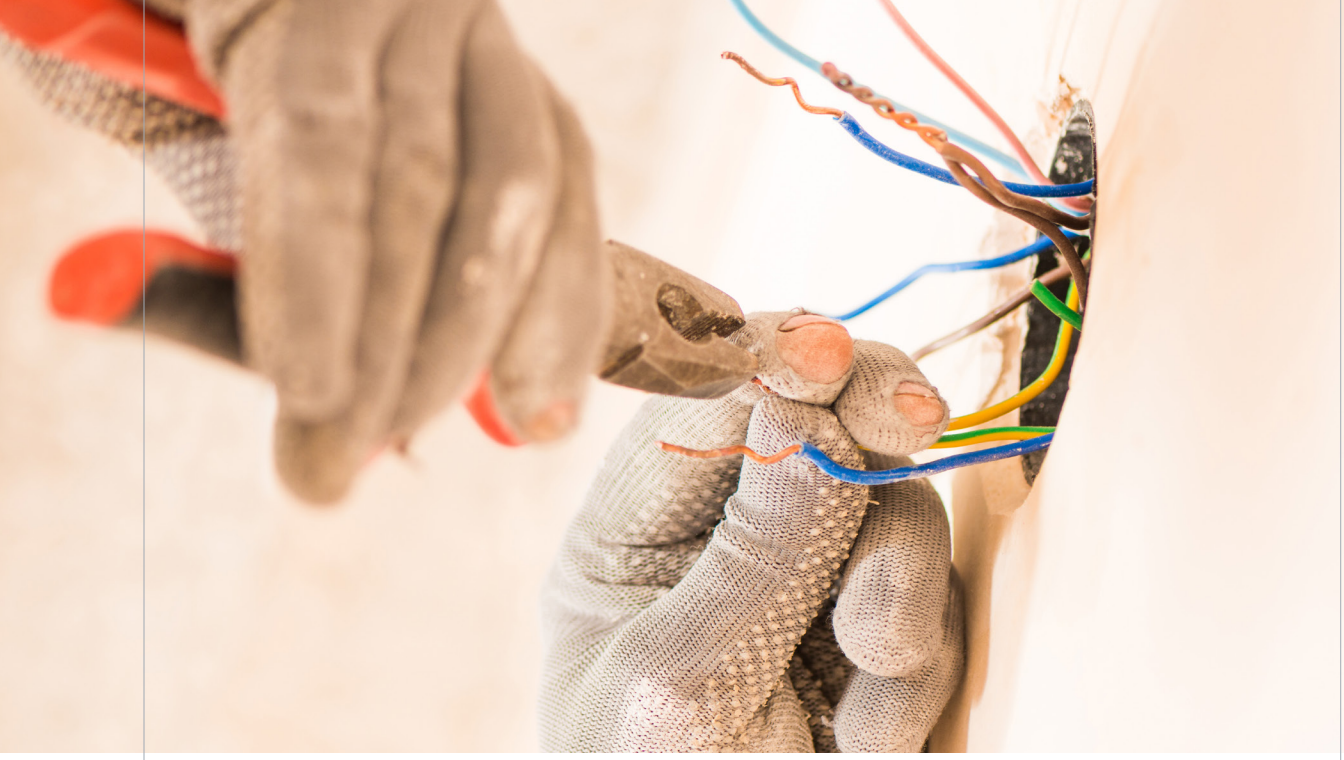
Do-it-yourself repairs – bypassing fuses that keep blowing

A heating, ventilation and air conditioning (HVAC) system consist of a condensing unit which is usually located on the ground outside but could also be in an attic or on a roof. The condensing unit contains a compressor motor which generally draws a significant amount of electrical power. The below example is a homeowner remedy to correct the continuing blowing of fuses. Copper pipes were installed in the service disconnect pullout in place of the fuses that protect the equipment from overloads and short circuits. Although not classified as an electrical fault, disconnecting or bypassing any electrical components intended to provided system shutdown can result in catastrophic failure.

There are several reasons why a condensing unit might cause fuses to blow, some of which are listed below:

- Overloaded circuit: If the condensing unit is pulling too much current, it can cause the fuses to blow. This could happen if there are issues with the compressor such as age-related deterioration of the compressor motor windings. The unit may have been undersized when it was installed and is continually running instead of cycling.
- Short circuit: A short circuit occurs when there is a low-resistance path that allows electric current to travel between two or more conductors. This can lead to a sudden spike in current and cause the fuses to below.
- Faulty wiring: Wiring issues, such as loose or damaged connections, can cause the system to draw excessive current and lead to blown fuses.
- Dirty or clogged condenser coil: A dirty or clogged condenser coil can cause the compressor to work harder than it should, leading to an overload on the circuit and subsequent blown fuses.
- Refrigerant leaks: If there is a refrigerant leak in the system, it can cause the compressor to work harder than it should, leading to an overload on the circuit and subsequent blow fuses.

The equipment owner attempted to minimize the number of blown fuses by inserting copper plumbing pipes in place of the fuses. What can go wrong? The copper pipes can potentially allow excessive current to the compressor, which can damage the equipment or cause a fire.



Do-it-yourself repairs – tapping into an incoming electrical conductor

Screwing wiring to the main electric service conductors is unsafe and against the National Electrical Code (NEC). In general, residential service conductors are supplied power from a transformer that also supplies multiple houses. Should the wire attached to the service cable fault, the current that is intended to supply the other residences will flow to the fault location until the fuses protecting the transform blow. It is possible the transformer fuses do not blow and the fault continues to arc until the utility company disconnects the transformer from power.

Power distribution unit failure

A power distribution unit (PDU) is a sizeable cabinet that distributes electricity from the building's primary power to multiple rack/devices within a data center. In one instance, the PDU was new and suspected of starting a fire as a result of a glowing connection. The National Fire Protection Association (NFPA) describes a glowing connection as follows: "When a circuit has a poor connection such as a loose screw at a terminal, increased resistance causes increased heating at the contact, which promotes the formation of an oxide interface. The oxide conducts current and keeps the circuit functional, but the resistance of the oxide at that point is significantly greater than in the metals. A spot of heating develops at that oxide interface which then becomes hot enough to glow. If combustible materials are close enough to the hot spot, they can be ignited". Two electrical busbars were joined by a bolt; however, the bolt was not tightened at all, according to a forensic examination of the PDU.

Determining the cause of failure

Determining the cause of the fire due to electrical faults can be challenging. Forensic engineers are trained experts who investigate the origin and cause of fires, as well as the specific reason a piece of equipment malfunctioned. They are able to examine mechanical fixtures, electrical assemblies, wiring and other components to determine if they contributed to the fire.

Forensic engineers must ensure that evidence is collected and handled properly to prevent spoliation, and to maintain the integrity of the investigation. Upon completion of the investigation, the engineer can provide expert testimony as it relates to the cause of a failure.

Summary

Electrical faults are a significant cause of fires that can cause damage to property. Insurance carriers can seek compensation from the responsible party in case of an electrical fire caused by faulty equipment or workmanship. However, determining the cause of the failure is not always a straightforward process. Forensic engineers have the necessary skills and knowledge to investigate the origin and cause of electrical fires, provide recommendations on how to prevent future incidents, and present credible evidence to support subrogation.

About EFI Global

EFI Global, part of Sedgwick, is a well-established brand with an excellent reputation in the Americas, Africa, Asia-Pacific and Europe as a market leader in environmental consulting, engineering failure analysis and origin-and-cause investigations. Each year, EFI Global completes more than 45,000 projects worldwide for a wide range of clients, such as commercial, industrial, institutional, insurance, government, risk managers, public and private entities. EFI Global is one of the world's most respected emergency response firms, capable of providing practical solutions to the most complex problems. Our multidisciplinary team of first responders, project managers, engineers, geologists and scientists are selected for their technical proficiency and in-depth industry knowledge to aid clients in resolving technical problems. For more, see efiglobal.com.

Get in touch with an expert

James Graf P.E., CFEI, CVFI – forensic engineer

James has over 22 years of engineering experience and 15 years of experience as an electrician prior to that with extensive knowledge and experience in residential, commercial, and heavy industrial design and installation of electrical systems. He is a subject matter expert in electrical building system design and installation, electrical project cost estimating, electrical system failures, troubleshooting electrical controls for building systems and machines, and other areas. His previous experiences include work in the following industries: commercial and industrial (steel mills) electrical system design and installation. His past forensic projects have included, product failure analysis, electrical fires, lightning strike damage, battery failures, water damage to electrical systems, and vehicle electrical systems. He has provided repair recommendations and estimates for building electrical systems. He has extensive expertise in the National Electrical Code (NEC), National Safety Code (NESC), and a working knowledge of the International Building Code (IBC). For more information, contact james.graf@efiglobal.com.

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