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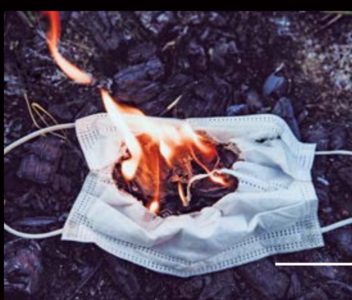
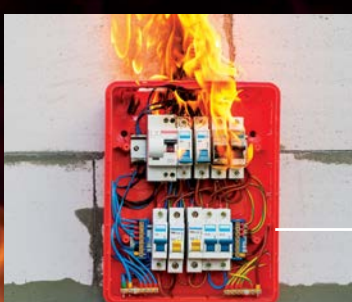
Electrical Fire Prevention via Automated Real-time Audits

As Fire kills many, the question: Who is Responsible?



Electrical Fire in Covid-19 Hospitals A Preventable Emergency

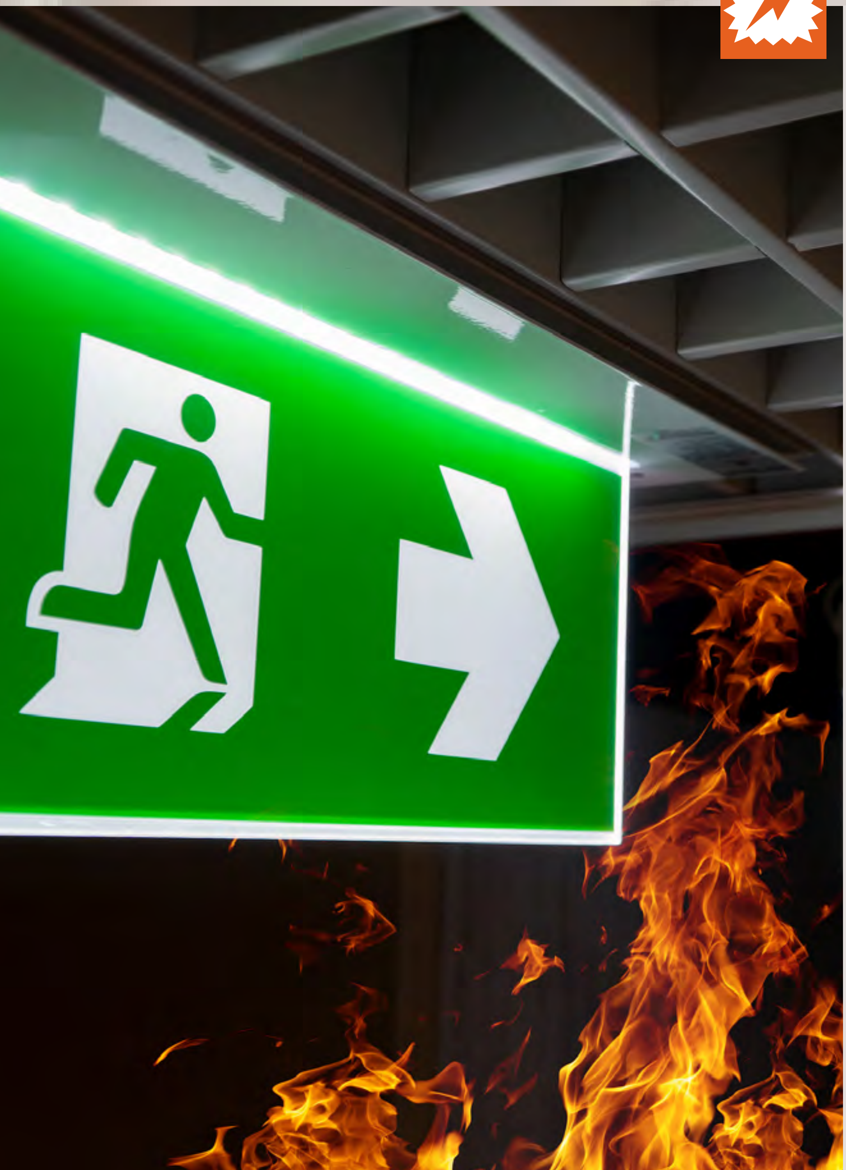


Codes for Fire Safety?

Electrical Fire Safety!

COVID-19 Stay Safe

Electrical Fire Prevention
via Automated Real-time Audits



We are all appalled and disgusted to read of the news of electrical fires. Fires that have had fatalities become sensational news for a few days, with eminent personalities providing their condolences. The government does it bit by offering compensation packages to the victims.

One of the most gut wrenching cases occurred in Bhandara (Nagpur) in the early morning hours of 9th January 2021. It's hard to write about the loss because we lost 10 newborn babies, and have learnt nothing! I am driven to this hard conclusion in the wake of several fires reported in hospitals across the country over the last 3 months. Many with fatal consequences.

I was optimistic to see this tweet on the very same day from the Maharashtra Chief Ministers Office (@CMOMaharashtra) response to the events in Bhandara. It was the first time there was recognition within the government that this event was more than just a short circuit; more than just an accident, rather an inability to act on an existing electrical condition. A condition that was identified and could be fixed, if an trained auditor got there at the right time.

This specific tweet raises a fundamental question:

In a system where audits are an expense that needs approvals to ensure checks and balances are maintained, how do we ensure that our facilities are operating safely?

Imagine, somebody having an heart attack right in front of you, and instead of getting that person the required medical help, you have to go get permission and budgetary approvals.

You are correct. I cannot compare humans to an electrical system in a building. The truths is, I am merely comparing risk to human life. If and when a heart attack occurs, we know the aftermath can be difficult to control and with unpleasant consequences. An electrical short circuit is similar in many ways, where, if there is an incident, the aftermath can be deadly.

Let us discuss what we must really do to protect ourselves and others. We all understand that monitoring the health of the heart is essential for maintaining a healthy body with the risks of a heart attack minimised. With the advances in medical science, we have learnt the importance of monitoring select phenomena and early diagnosis e.g. Cholesterol levels and Hypertension. Our best bet against short circuits is acting on events preceding it. A recently completed Ph.D. Dissertation by Jean-Mary Martels (2018) from University of Ilmenau (Germany) sheds some interesting light on the causes of electrical fires. 86% of all electrical fires were preceded by visibly identifiable electrical conditions such as light flickering/dimming, slow moving appliances, power interruptions, fuse blowing, breaker tripping or bulbs burning out. Many times, such electrical conditions are ignored. If we can read these signals in advance, then maybe we can be warned in advance.

Furthermore, there are other factors such as a brain stroke, kidney failure, etc that lead to fatalities. Electricity is no different. Inspired by the work performed by Martel, we at Jhaveri Power Labs, have studied and classified 20 electrical faults that lead to fire risk, electrocution, equipment loss or efficiency losses. A total of 12 of these issues can lead to electrical fires. Let us study them in detail.

	Electrical Fire Risk	Description of fault	Why does it occur
1	Short circuit	Extremely high current flowing between two live wires via an unintentional low resistance path. It generates excessive heat that becomes an ignition event for the fires.	Exposed wires Failure in devices
2	Arcing	The flow of electricity after the breakdown of a non-conductive material. Arcs generate up to 3750 C of heat and are a primary cause of electrical fires. There are two types of arc: **(a) Parallel arcing** is when the arc flows between two wires of different electric potential. These can be detected in over current conditions **(b) Series arcing** occurs when the arc flows between two wires of the same potential such as in the case of loose connection or a partially broken wire.	Loose connections Insulation damage Rodents
3	Over current (Overload)	Excessive currents flowing through wires and switchgear exceeding the rated currents. It generates excessive heat that becomes an ignition event for the fires. Overload conditions also increase the probability of arcing events	Damaged equipment Unplanned addition of electrical loads
4	Earth Leakage	High leakage current flowing into earth wire. Currents greater than 20mA can cause electrocution. Higher currents can also cause connections to the earthing systems to heat up and become ignition events.	Equipment degradation Improper wiring
5	Critical overvoltage	High voltages observed from the electric supply company. Voltage higher than 10% of nominal can cause excessive current for resistive loads that leads to overheating. Under certain conditions higher voltages will also lead to components such as capacitors exploding. Over voltages also increases the probability of arcing events.	Poor power quality from utility
6	Critical undervoltage	High voltages observed from the electric supply company. Voltage lower than 10% of nominal can cause excessive current for non-linear and motor loads such that it leads to overheating.	Poor power quality from utility Poor sizing of cables

7	Phase loss	Disconnection of at least 1 phase from a 3 phase supply. This condition leads to excessive currents for 3 phase equipment such as motors and power supplies that becomes a source of ignition for fires.	Disconnection from supply Damage to wiring or switchgear
8	Neutral loss	Disconnection of the neutral wire. This is one of the most critical conditions in facilities that have 3 phase supply. A neutral loss is very difficult to diagnose manually. A loss of neutral will appear as a normal operating condition but only under certain unbalanced loads will it trigger extremely high voltages that are greater than 50% of the nominal voltage. These voltages are sufficient to trigger explosions in capacitors in air conditions or power supplies.	Disconnection from supply Damage to wiring or switchgear Overload/ unbalanced loads
9	Surge	Sudden increase in voltage for a few microseconds. Typically observed during load changes or lighting conductions. If there is not adequate surge protection it can lead to equipment failures and components exploding.	Poor power quality from utility Sudden load changes
10	High Earth Voltage	Increased voltage measured between earth and neutral. This voltage is an indication of poort earth resistance, poor connection to neutral or faulty equipment. A poor connection, loose connection, oxidized busbar or carbon formation are all possible causes. High earth to neutral voltages is an early sign of exposed wires in some cases. Not correcting this fault early enough will lead to overheating of busbar contacts and in some cases arcing events.	Poor earthing Faulty neutral Leakage in devices Poor quality of busbar and contacts
11	Current Unbalance	Uneven current between 3 phases. Unbalanced currents lead to higher currents in the neutral wires. In facilities that have 3 ½ core wiring it can also lead to overheating of neutral and neutral loss conditions.	Poor electrical design unbalanced loading
12	Current Harmonics	Distortion in the shape of the current waveform. Current harmonics have become a much talked about topic when it comes to power quality issues. Although, triplen harmonics (3rd, 9th, 15th, etc harmonics) can lead to 3 times the current through the neutral wire The high neutral current can lead to neutral wire overheating and even a neutral loss condition. Current harmonics also lead to overheating of transformer windings which is another fire risk.	Poor equipment design Harmonic generating electronic loads Transformer saturation

How does one identify these faults, without having a PhD in electrical engineering? Automation can lead the way. Just like we monitor biological signals to prevent heart attacks, it is necessary that we develop methodologies to protect ourselves from electrical fires by careful monitoring of these electrical conditions.The key is to monitor these 12 conditions continually and in real time. With advances in electronic technologies, there are devices available for early detection, monitoring and reporting all of these 12 critical issues. But common practice only relies on protection for short circuit, overload and earth leakage. In effect, we are only protecting ourselves for 25% of the overall fire risks.

An obvious question to ask -- aren't these issues covered when we follow the standards for installation? Precisely! They ought to be. IS732 is the standard for electrical wiring prescribed to be followed by the National Build Code. Many of these 12 issues are required to be avoided by taking proper precautions during design. Unfortunately manual implementation and manual verification make it impossible to ensure compliance to the requirements stipulated by IS732. Furthermore, the only practise in place to verify compliance in continual operation are periodic manual audits (if budgets are approved). These manual audits, if and when performed, focus on identifying issues that are identifiable visually or by thermal scans at specific locations and during the limited time that an auditor is present at site. In our analogy it is like using a thermometer when an ECG is required. ■

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