IIT GANDHINAGAR

SAFETY MATTERS

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FROM THE EDITOR'S DESK

In April 2019, the world-famous Notre-Dame Cathedral of Paris went up in flames, causing serious damage to its roof structure. Closer to home in Surat, on 24th May 2019, we lost 22 young lives to a fire which was foreseeable and preventable. The two incidents and the many more which are occurring quite often around us indicate the carelessness and flaws in our fire safety policies. Unless we know the reasons for these events, we cannot prevent such accidents in future. In India, most of our fire investigations blame 'short circuit' to be root cause of fire and such conclusions are accepted without much scrutiny.

This edition of Safety Matters looks at the electrical causes of fires and discusses what we can do about them. Dr. Tejas Jhaveri explains the type of electrical faults that can occur and the consequences in the first part. On the same topic, a recently published report of NFPA [National Fire Protection Association, USA] further elaborates 'how to classify and study home electrical fires'. Road accidents are another major killer in India and many other parts of the world. In this regard, India occupies the top slot in the world ranking and account for about 10% of the road death in the world. The annual death due to road accident is more than 1.4 lakhs which is about the population of Shillong, the capital of Meghalaya. The reason behind this high fatality number is mainly due to the careless behavior of drivers, defective road design, poor enforcement of the traffic rule, bad condition of road etc. There is an interesting article that this edition carries on Road Safety and Speed Limits – making a case for the effective speed limit.

Hope you enjoy reading this edition. We are now three editions old and need to review and take stock. We need your suggestions and ideas. Please do write to me with your feedback and suggestions.

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ELECTRICAL SHORT CIRCUIT ….. CATCHING THE CULPRIT [PART 1]

Dr Tejas Jhaveri, Founder, Jhaveri Power Labs, INDIA

On Friday 24th May 2019, the country was shocked to see the graphic images of young boys and girls falling off a building in Surat. A fire had broken out in the building that housed their coaching classes. The source of the fire was attributed to electrical issues aka Short Circuits. Although, there has been a lot of resentment after the event, the fact is that the life of 22 young Indians will not come back. Unfortunately, this is not an isolated incident. More than 80% of the building fires in India are attributed to Electrical Short circuits – rightly or wrongly. Even if we had the best of firefighting equipment and manpower and other facilities, unless we address the electrical causes of fires, lives will be lost. We owe it to ourselves to address the elephant in the room, **Why are these short circuits occurring in the first place.**

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 Eg Cholesterol levels and Hypertension. 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 event, the aftermath can be deadly. 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 a times, such electrical conditions are ignored. If we can read these signals in advance, then maybe we can be warned in advance.

Inspired by the work performed by Martel, we at Jhaveri Power Labs, have studied and classified 20 unique electrical condition that lead to one of four risk, namely (a) Fires, (b) electrocution (c) damage to equipment (asset loss) or (d) efficiency loss. These studies have been done in Indian conditions. It must be highlighted that there are 12 unique electrical conditions that can lead to fires. The well-known condition of a short circuit is just one of 12 conditions. It is no wonder that after installing protection devices such as MCBs, MCCBs, ACBs, VCBs, we still experience electrical fires.

Type of Fault	RISKS			
	Fire Risk	Electro-cution	Equipment Damage	Efficiency loss
Short circuit	X			
Over current	X			
Earth leakage	X	X	X	
Critical Overvoltage	X		X	
Critical Undervoltage	X		X	
Arc faults	X		X	
Neutral loss	X		X	
Surge	X		X	
Earth voltage	X	X	X	
Phase/Line loss	X		X	
Phase Reversal			X	
Voltage harmonics			X	
Short term interruptions			X	
Voltage variation			X	X
Voltage unbalance			X	X
Current unbalance	X			X
Current harmonics	X		X	X
Power factor				X
Inrush current			X	
Reverse current		X		

We must mention that there are devices available to protect from all these electrical conditions [that could lead to fires] but common practices, standards and codes only rely on protection for short circuit, overload and earth leakage. In effect we are only protecting ourselves for 25% of the overall fire risks. 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.

[In Part 2 of this article, we will examine some of the means by which electrical faults like short-circuits can be detected in advance and acted upon].

WHAT IS A SHORT CIRCUIT?

Acknowledgement: *https://engineering.mit.edu/engage/ask-an-engineer/what-is-a-short-circuit*
Extracted from post by Meg Murphy dated 11th Nov 2017

…….. *"A short circuit is a connection between two parts of an electrical circuit that you don't want to be there," says Karl Berggren, professor of electrical engineering in the Department of Electrical Engineering and Computer Science. He also heads the Quantum Nanostructures and Nanofabrication Group in the Research Laboratory for Electronics.*

"When you build an electrical circuit, you try to make the current go through certain paths to perform certain functions," he explains. "In the case of a toaster, when you introduce a knife to the heating element, it provides the current with a short cut. This new path is easier than moving through the heating element, which has a lot of resistance to the flow."

*So what exactly happens when the electricity changes course. First of all, Berggren says, your toaster stops working. "Your device will not function as intended because the current is not going where it is supposed to go," he says. And then it gets worse, very, very quickly. "**Because the metal object causing a short in the circuit is more conductive, a lot of current can flow into it." Within milliseconds, the current can become thousands of times larger than normal. Boom……***

SAFE SPEED: WHY DO WE NEED IT?

Roshan Jose, Research Scholar, IIT Kharagpur

Imagine a car capable of moving at speeds in excess of 180 km/h, driven by a driver capable of driving the machine at 140km/h on a beautiful smooth road and with no speed limit signs. What speed should the car be driven at? If a really smart engineer was to put up some speed controls or a dedicated law-maker was to implement speed limit laws, how does s/he determine the requirement? Again, how should they vary across different geographies. These questions are a real challenge, in India just as they are in other countries.

In the 1960s, when the discussion on speed limits started, drivers were thought to be perfectly rational beings - self-aware and self-preserving. It was assumed that people drove at speeds, at which they felt safe and were perfectly capable of controlling the vehicle. It was thought that the speed limit should be 'that speed at which people drive on the road' in practice. Thus, the speeds at which people drove on roads were measured and the 85th percentile chosen after excluding the 'outliers' who over sped.

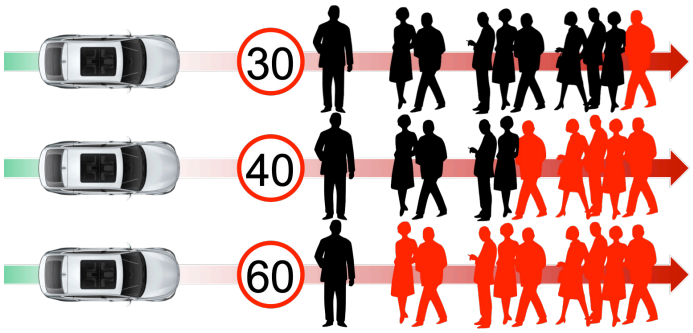
However, speed is only one of the variables impacting safety. It was found that drivers were unable to judge safe speeds, especially when the situation of the road changed suddenly Eg: sharp curve on a highway or a wet road. Here safety is impacted by the judgement of the driver as well as the design of the section of the road. A highway with a sharp curve and proper design will allow the driver to maintain his speed at the curve, but an improper design will send the car flying into the ditch nearby! Very soon, the engineering principles of highway design based on vehicle tolerance and capacity became variables in determining the speed limits.

It would be tempting to think that the number of crashes started reducing with these steps. But, by now, faster and faster cars were on the roads and the number of cars zoomed too. On the road infrastructure, economic trade-offs and cost-benefit analysis using 'value of time' were being used to justify investment in better roads which meant higher speeds – and more crashes.

Three to four decades later, in the '90s, a new thought was introduced - *it can never be ethically acceptable that people are killed or seriously injured when moving within the road transport system.* Simply put, the speed of the vehicle should be such that no one should die on the road even if a mistake were to be committed. This thought led to the Vision Zero, introduced by the Swedish Government in 1997. All of a sudden, speeds had to consider the possibility of human mistakes and errors and put the probability of the death of a road user into consideration while posting speed limits.

Although this would not be very popular, it makes a lot of sense. Vehicles should travel at speeds where, even if the driver makes a mistake, there is no death or injury. If the pedestrian crosses the road and forgets to look on either side, and there is a crash, no life should be lost. Since all citizens have equal right for use of the road, the safety of the weakest must be ensured.

The figure below shows the probability of being killed by a car going at a given speed. At 30 km/h there is a 9 out of 10 chance that the person survives, but at 60 km/h there is only 1 in 10 chance of surviving. Safe speed considers human tolerance to sudden impact, which means the speed of the car should be lower than the speed at which there is a fatality. Researchers have thus calculated that the safe speed on a highway can be 70 km/h and 30 km/h in residential/busy areas.



Safe-speed can be slow and boring for some, but consider this - the time saved in travelling a distance of 30 km through an urban area with a speed limit of 60 km/h instead of 30 km/h is approximately 15 minutes (considering all the signals and traffic jams)! That time saved is much lesser when the distance is less. The reduced speed can reduce the deaths on the road by a considerable margin as we can see. In India, with more than 1,50,000 people deaths due to road accidents every year, 'safe speed' needs to enforced effectively.

Let us get back to the question we started with. So what speed should a car be driven when it is capable of moving at speeds in excess of 180 km/h by a driver capable of driving the machine at 140km/h on a beautiful smooth road with no speed limit signs? 70 km/h of course! And now you know why - because that is the speed where the driver, passenger and innocent bystander / pedestrian can all be safe (mostly), even when there may be a crash.

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NFPA RESAERCH REPORT ON HOME ELECTRICAL FIRES - MARCH 2019

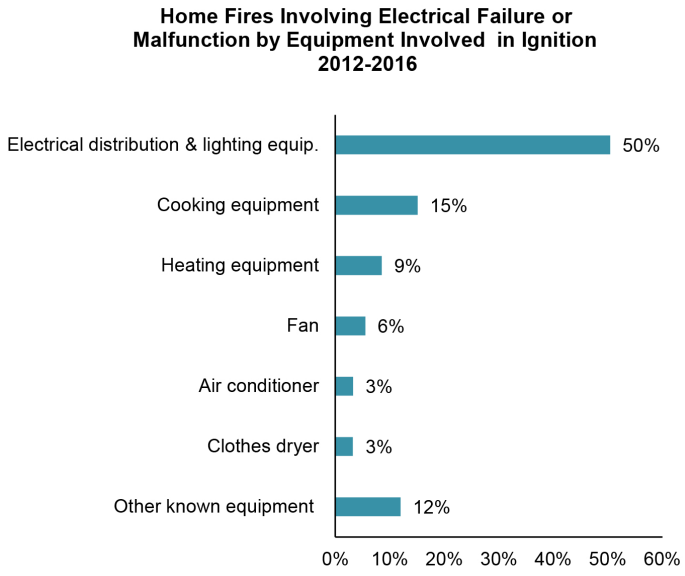
The National Fire Protection Association [NFPA] recently published a study on Fires involving Electrical Failure or Malfunction – a study of 44,880 fires over the period 2012 – 2016. The analysis was based on data provided by local fire departments and the National Fire Incident Reporting System [NFIRS] and covered largely home fires.

Home fires involving electrical failure or malfunction caused an estimated average of 440 civilian deaths and 1,250 civilian injuries in the US each year in 2012-2016, as well as an estimated $1.3 billion in direct property damage a year.

Electrical distribution, lighting, and power transfer equipment accounted for half (50%) of home fires involving electrical failure or malfunction, followed by cooking equipment (15%), heating equipment (9%), fans (6%), air conditioners (3%), and clothes dryers (3%).

Following are two charts that we felt were very relevant for us in India as we enhance our ability to determine the root causes of fires.

TYPES OF ELECTRICAL FAILURE OR MALFUNCTION CONTRIBUTING TO THE IGNITION OF HOME FIRES



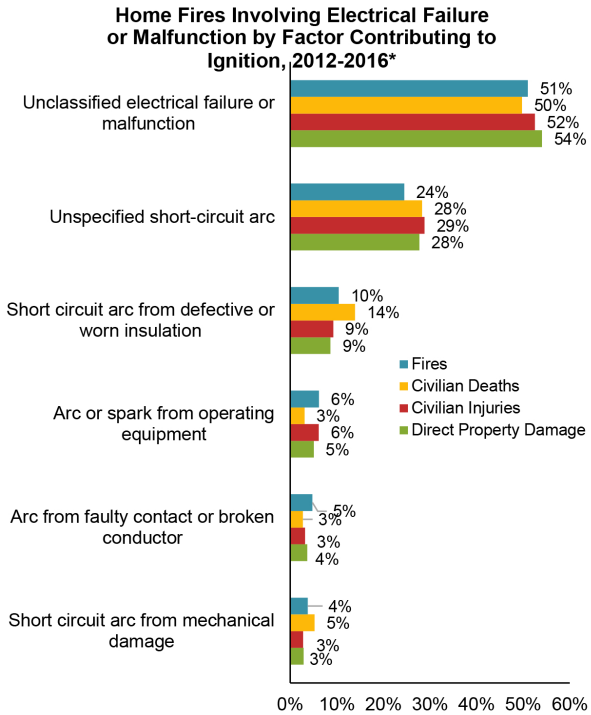


Figure 1 shows the types of equipment involved in home fires in which electrical failure or malfunction contributed to ignition. As indicated, electrical distribution and lighting equipment account for half of these fires.

As shown in Figure 2, home fires due to electrical failure or malfunction primarily involve some form of arcing, which results from an unintentional discharge of electrical current between conductors. Given sufficient time and level of current, arc faults can produce enough heat to ignite a fire. Arc faults are produced by damaged conductors and connectors and may involve damaged wiring, frayed appliance cords, loose connections in wall outlets or faulty switches and junction boxes. Arc faults may originate in different areas of the home or virtually any electrical fixture or equipment.

Short circuits from defective and worn insulation caused 14% of civilian home fire deaths as shown in Figure 2. This can be caused when cords are pinched by doors or furniture or through repetitive flexing of appliance cords. It can also be due to damaged wiring inside walls from nails, screws, or drill bits that puncture insulation during ordinary activities like hanging a picture. Even electrical cords running under carpets can generate enough heat to produce an arc fault.

Aging electrical systems in older homes can be a source of arc faults, either through normal wear and tear or because the systems cannot accommodate the greater demands of modern appliances. Circuits can also be overloaded by providing electricity to too many appliances, often through power cords.

[The full report can be accessed at NFPA Website : www.nfpa.org/research]

ELECTRICAL CAUSES OF FIRES IN INDIA

TOTAL NUMBERS

YEAR	INCIDENTS	INJURIES	DEATHS
2013	23,593	2,391	22,177
2014	20,377	1,889	19,513
2015	18,450	1,193	17,700

CAUSE : ACCIDENTAL / COOKING GAS FIRE

YEAR	INCIDENTS	INJURIES	DEATHS
2013	3,856	288	3,857
2014	3,738	310	3,691
2015	3,503	134	3,529

CAUSE : OTHERS

YEAR	INCIDENTS	INJURIES	DEATHS
2013	18,076	1,998	16,630
2014	14,875	1,405	14,043
2015	12,462	736	11,916

CAUSE : ELECTRICAL SHORT CIRCUIT RELATED

YEAR	INCIDENTS	INJURIES	DEATHS
2013	1,661	105	1,690
2014	1,764	174	1,779
2015	2,485	323	2,255

Electrical Short circuits and related factors are significant factors behind fire accidents in India. The need for identifying and understanding the triggering causes cannot be overstated. In India, the need to conduct fire investigations to establish the facts and to take corrective measures, cannot be overstated.

The tables to the left indicate that the causes for the vast majority of the fires are allocated to the heading 'OTHERS", pointing to the need for analysis and classification.

Source: Above numbers are extracted from the NCRB reports of respective years. The Reports have not been published in the regular format for the years from 2016.