Fire risks in electrical installations: the review

K.S. Santhosh Kumar[1*] and *Dr.K.* Balachander[1]

[1]Department of Electrical and Electronics Engineering,Karpagam Academy of Higher Education, Coimbatore, India

Abstract. In India, fire poses a significant risk to a variety of industries. Media outlets across the nation report on fires virtually every day. Not only these fires result in the loss of numerous lives and injury to a large number of people, but they also caused extensive property damage. During the past two decades, India's construction industry has flourished, notably for high-rise structures. As a result of their special character, fires in residential structures, particularly high-rise buildings, become more complicated and salvaging activities more difficult, sometimes resulting in a large number of fatalities and substantial property losses. The scenario has become more complex due to the fast modernization of Indian industry. A fire is a mishap may at times result in loss of life and property. We have strong regulatory measures, standards, good material specifications and national building construction codes. However, we are facing fire accidents on regular basis. After the investigation fire authorities are concluded that 80% of fire accidents happened due to electric short-circuits. Fire safety norms mandated by National Building code (Ref Indian National Building code 2016 part 4) is not given any significance of fire loads related to electrical installation and its components. More over National building code given lesser importance to the quality aspects of materials and components which can play a significance role of origination of fire accidents. The National building code considering only fire load related to cable and insulation failures. During my recent survey and analysis of few fire accidents pointing out that the failure in the electrical components and equipment's are related to the appliances are the major cause of fire. This review intends to understand the gap in the existing system and extend to further studies to find out a proper solution. **Keywords:** fire; risk, installations; malfunction; short circuit.

1 Introduction

While designing the electrical component and associated major equipment's are the part of electrical installation, we need to consider enough safety factor for absenting risks of fire due to unwanted and abnormal faulty malfunction..Power System design should consider enough safety factor to ensure electrical components in the system with more fire resilience. Also, the design slowed take course of sufficient cooling gradient or reducing intensity of ignition to limit the spread of fire to the constructed materials and vulnerable in the vicinity.

* Corresponding author: k_santhoshk@hotmail.com

So far products like cables and accessories are used for electrical installation to be analyzed for its preparation for fire spread. Equipment's and appliance in the system are also to be analyzed for fire risks in the operators, malfunction and influence of operational environment and climate conditions.

I. MALFUNCTIONING OF ELECTRICAL EQUIPMENTS

When an electrical equipment is under rated or its over loaded due to excessive connected loads leads to malfunctioning due to prolonged working hours. This malfunctioning leads to equipment failure and creates unforeseen incidents. Major reason for afore mentioned issue arrived from wrong choice of selection of equipment during electrical design as the electrical design engineer did not consider the quality of the power supply conditions, environment factors like ambient temperature, humidity and elevation of electrical equipment where it is going to be installed.

Above factors not only effect the efficiency of the equipment performance but also add excess load in the system. During the design, the designer should consider above factors and make additional provision on reserve capacity. Most of the equipment in India rated with 50deg ambient temperature which is considering an excess capacity of 50%. So ambient temperature rating of an electrical equipment at normal working condition is considered as per manufacturing standards in India as 33 deg . However due to global warming our ambient temperature is above 45 deg. But still, we are using the equipment which is rated with 33 deg ambient temperature.

So, this will reduce our reserved capacity and leads to effect the efficiency of equipment during a continuous functioning. When equipment draws excess current then it effects the entire electrical installation. So, calculating the load current, selection of the equipment and materials are to be factored with higher temperature rating. Otherwise, this will create an unsafe situation. So necessary revision is required in the existing manufacturing standards highly demanded.

This is the major gap in the latest national building construction code of India -2016-part8 section2. National building construction code of India is giving guidance on good installation practices and specification of materials as per statutory requirements. Control measures related to installation compliance is a definite gap.

Statutory requirements are addressed but no specific guidance on control of lapses in the compliance in the system. In recent years we are experiencing fire accidents in every alternate day and we are unable to control . Fire officials are pointing out that around 80% of them initiated through electrical short circuit.

So, we need to review electrical lapses causing electric short circuits. Before going to analyze electric short circuit, we need to understand about electric short circuit. When a phase conductor in contact with neutral conductor or with a ground portion of the circuit forming a low resistance unwanted current path leads to short circuit. So huge volume of current will draw form the circuit in a short span of time and generate excess heat. This will cause a burnout and damage entire system in a short span of time.

2 Literature Review - Major reason for electric short circuit

2.1 Loose connections

We can validate that loose connection create sag between conductors thus forming an arc and generate an unintentional discharge of electric current between conductors. However, this research manual is not giving any directions to control or mitigation process to eliminate loose connections and acceptable sags between the conductors without effecting the wire

insulations. Loose connections are formed due to nonstandard terminal connectors, damage of terminal threads and excess stress of wires at terminals. [1].

As per The SPRUCE Manual article written by Mr. Timothy Thiele, updated on 06/08.2021 on "6 common wire connection problems and their solution "is detailing about reasons for loose connections. The SPRUCE manual described that loose connection can be occurred due to bad workmanship of an electrician by improper fixing .This article is also pointing out that due to prolonged working conditions and effect of temperature expansion and contraction process also result into loose connection. Actually, we do not have any safeguard in our system to prevent arcing due to loose connections [2].

Reference to research article published in Journal of Physical Science and Environment Studies on march 2021 on the subject "Appraisal of electric wiring and installation status in ISOKO area of DELTA State Nigeria" by Mr. Obukoero John and Mr. Uguru. H.E., we can confirm that loose connections are causing electrical structure fires.

They have mentioned with the help of experiment that loose cable connection causes lot of serious damaging effects. Voltage fluctuation due to loosen connections are causing variations in power loading result into electrical system fires. If a loose cable or loose cable connection in a power circuit, then high possibility of ARC is produced and became a reason for large fire damage to entire surroundings. It is concluded on the basis of above research that most of the electrical installations in ISOKO area are not meeting the requirement of the Nigerian Industrial standards. This is a very quality gap and creating an unsafe situation. They have concluded with a recommendation to the government to form an inspection and regulatory body to control unhealthy electrical installation practices [3].

Another effect of the loose connection is a formation of glowing contact. So, Mr. JohnJ. Shea in his research article on "Glowing Contact Physics "published in research gate on 20, July2015, stating the significance of severity of glowing contact formation due to lose connections. Glowing connections are resulting into overheating condition in the surrounding. Glowing contact causing an arcing and affect the PVC insulated cables and turn into residential fires. Glowing contact formation is a lengthy phenomenon can raise a potential hazard in the vicinity. So, he is strongly substantiating the importance of his research on Glowing Contact Physics [4].

3 Power Quality Issues

Reference to IEEMA journal volume 12, issue no.9 of May 2021 describing about fire incidents reported in covid 19 hospitals in India. Most of the reasons are due to power Quality issues. Power fluctuations causing harmonics this will overheat equipment and cables and entire electrical system vulnerable to instant fire. Poor quality of hardwires and poor workmanship are effecting the life of the electrical system and major reason for short circuits. IEEMA Journal is also mentioning that very low attention given to safety of electrical installations. IEEMA Journal is pointing out set of facts causing fire accidents in a very important place like hospitals where doctors and supporting staff are struggling to give extra care to bring their patients to normal life.

We know that most of the medical equipment are working on electricity and we are giving less importance to electrical safety. We never give attention to ensure quality of installation as per national building code of practice. All electrical installations are required more personnel attention to ensure safer working environment. However, we did not pay much attention to this turning into big disaster finally.

Power quality issues in the industrial area very much affect the functional performance of precise instruments. One of the major issues is the voltage fluctuations in the incoming supply and this will develop high harmonics in the distribution network due to nonlinear loads. Harmonics current will affect the reliability and leading into safety issues. Causing

overheating in the neutral conductor in a 3-phase system. Due to overheating effect the insulation failure and resulted into short circuits[5].

Article on Power Quality Issues published on 26th May, 2022 by Electrical India Magazine written by Ankush N is al describing about the causes and consequences of power quality issues. This article is theoretically describing about the commercial impact of power quality issues and he is giving less importance to safety. He is also emphasizing the importance of power quality monitoring. He is also giving the directions regarding power quality monitoring parameters and also giving methods to improve power quality[6].

Article published in the International Journal of Scientific Technology, Research Volume 6, Issue5, May2017 written by Narasimha Pandit et al describing about the various power quality issues in the Indian Power distribution networks resulting into equipment failures and power interruptions to the consumers and their financial losses. Also, this article is demanding for a structural change in the ongoing regulatory policy for power quality improvement. They are also recommending a proportional incentive to consumer on the basis power interruptions affected by the power quality from the utilities.

Article is concluded with the importance of more investment by the Power Utilities for the equipment and manpower to modernize existing power system to improve quality and efficiency. This article is selectively pointing out the commercial impact effected by the consumers only. They are not describing anything about the effect of power quality issues and related equipment failure leads to safety and unwanted disaster[7].

Abdul-Jabber Fathal ali et al describing about various power quality issues related to voltage sag and harmonics and concluding with the introduction of power quality improvement devices like dynamic voltage restorer in the existing system to protect equipment from power quality issues. Dynamic Voltage Restorer is advisable for selective equipment and it is not advisable for entire sensitive loads. This will add additional cost into the system voltage sag is higher when incoming source of various industrial units fed through one transformer. In such cases harmonics distortions are very high due to nonlinear loads. This article is also not pointing out safety and unwanted disaster due to power quality issues[8].

A special article on fires in Indian Hospitals: root cause analysis and recommendation for their prevention written by Dr. Kanchan Chaudhari in 2014, is detailing about the intensity of fire and its aftermaths to affect a social, economic and human disaster. In this article air-conditioners are playing vital role in short-circuit and fire. Vibration of air conditioners are causing loose contact and causing short circuits. We came to know from our literature survey that defects associated with air conditioners are playing vital role in electric short circuits and fire accidents[9]. Afore mentioned information validated by NFPA fire research foundation article" Evaluation of the fire Hazard of Ashree Class A3 refrigerant in Commercial refrigeration "application by Mr. Scott-G Davis published in 2017.Article is stating about the effect of leakage of refrigerant which is causing fire and generating excess heat in the surrounding and thus creating an explosive atmosphere. There is an unfavorable thermal environment is created[10].

Reference to Mr. George J.Anders et al stating that a cable routed through thermally unfavorable environment result into the reduction of ampacity of cable. Reduction in the ampacity of cable adversely affected the current capacity of cable and result into over heating. Normally we are selecting the cable with respect to ambient temperature.So, this unfavorable thermal environment is unexpected and adversely affects the cable insulation and result into short circuits[11].

Refrigerant leaks create an unfavorable thermal and explosive atmosphere in the surrounding of air-conditioner split unit where compressor unit and fan unitare placed in the same outdoor unit. Excess heat leads to unfavorable thermal environment badly effect the insulation off an motor winding. Fan Motor insulation class calculated on the basis of

normal current carrying capacity of the motor with respect to ambient temperature. Where unexpected factors of unfavorable thermal environment are not being calculated during manufacturing. Unexpected temperature rise is effected the motor efficiency and insulation cannot accommodate the temperature rise which result into motor burn out.

4 Poor maintenance of electrical equipment

NFPA 70 E, 2015 which is the standard for electrical safety in work place and this standard demands for Arc flash risk assessment to identify if electrical equipment poses an arc flash hazard. Arc flash is caused by an arcing fault that crosses the air gap between conductors, including phase to phase, phase to neutral, and phase to ground. If electrical equipment is not properly maintained, arc faults will develop and leading to undesirable safety hazards.

As per OSHA CFR 1910.303 b (1)states that electrical equipment shall be free from hazard. NFPA 70E states that electrical equipment shall be maintained in accordance with manufacturer instruction or Industrial practices to reduce the risk and failure[12].

NFPA 70B, 2006 “Recommended Practice for Electrical Equipment maintenance”. This standard covers the installation of an electrical preventive maintenance programme, suggested maintenance intervals, testing and testing techniques, maintenance centered on dependability, and acceptance testing[13].

Indian National Electrical Code (SP-30) 2011, Reaffirmed in 2016, chapter 1, Section 19-Safety in electrical work is not detailing about the preventive maintenance of electrical equipment and providing information about permit to work safety system. National Electric code is introduced in 1985 for the rationalization of electrical safety practices as per Indian Electricity act 1910 and Indian Electricity rule 1956. Revised National Electric Code 2011 is introduced on the basis of latest India Electricity act 2003.

National Electric Code 2011 reaffirmed by 2016 is referring to Safety of General Guidelines on equipment, device and appliances to IS:5216(part 1) - re affirmed by 1985 is also giving information on work men safety and safety appliances required for electrical installation works. This code is not giving any direction or guide line on recommended practice for preventive maintenance of electrical equipment[14].

5 Usage of old electrical equipment and appliances and absence of safety load of electrical installation

Indian electricity rule 1956 and revised rule 2003 are not giving any guideline or instruction on usage of old electrical equipment and appliances. So, there is no restriction on fitness of equipment in service and this can be decided by the consumer. Inferior quality of equipment will adversely affect the safety of the electrical system and finally turn into an unsafe situation.

It is so important that we should keep the enough safety factor when calculating the total connected load to the circuit. As per the SPRUCE Manual article written by Timothy Thiele published on 26/05/2022, on how to calculate safe electrical load capacity, recommending a reserve capacity of 20%[15].

In India all electrical equipment are manufacturing with temperature rating of 50Deg. This is covered with safety factor of 50%. So ambient temperature rating of an electrical equipment at normal working condition is considered as per manufacturing standards in India as 33 deg. Due to global warming our average ambient temperature during summer season is reached around 45 Deg. So, this is apparently affecting the reserve capacity and substantial reduction in safety factor. So excess ambient temperature due to global warming affects the safety factor and also reserve capacity.No provision for adding new equipment in

the existing circuit will be remained. If incase any extra equipment added to the existing circuit is resulted into over load and the prolonged working condition gradually deteriorate insulations turn into an unsafe situation.

6 Conclusion

On the basis of above literature review, it is understood that there is a big gap in the implementation and compliance as per the regulatory requirements. All are concluded with a set of findings and recommendations. No directions are given towards the mandate and compliance. This study will ensure mandatory implementation and compliance of electrical safety regulations during installation and service to create an electrically safer access to all as at present no institution in the world is encage with this problem.

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