Recent Trends in Electrical Safety in Industries

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Abstract— Owing to increase in population the demand for electricity has also raised which has leads to several accidents in industries in large decades. Electrical accidents are not as rare as statistics imply as minor accidents remain unreported causes lack of information about existing electrical safety problems and hinders preventive actions The suggested measures in this paper will help in preventing several electrical hazards as well as in rising awareness among people to take safety measure at homes and industries. Exposure to electrical energy is the 6th leading cause of occupational fatality. This paper will highlight recent development impacting further improvement in preventing occupational electrical hazards using new protective devices and technologies.

Key words: Electrical Hazards, Electrical Safety, Electrical Safety Standards, Recent Development in Protective Device, Electrical Safety Assessment, Electrical Safety Audit

I. INTRODUCTION

Electrical accidents are proportionally severe and costly. The number of electrical accident has no longer decreased during the past decade. Current measure to increase electrical safety are not effective enough.in order to decrease the number of electrical accidents in residential, commercial & industrial sector, there is need for more information about electrical accidents risk at the operative level. According to the electrical accident statistics reports most electrical accident occur because of certain safety procedure are not carried out prior to work and there is little information about the protective device limitation and selection of proper device for particular electrical faults. According to recent trends in electrical safety in industries new protective devices such as GFCIs, GCDs, AFCIs, RCCBs, HFFR Cable, Linear heat sensing cable has been innovated which offered more features.

New technology such as Atomic fire detector and extinguisher system, infrared hotspot detector, thermography survey etc. Should be implemented in India to achieve electrical safety to greater extent.

II. ELECTRICAL HAZARD & IT'S EFFECT

An electrical hazard can be defined as a dangerous condition where worker could make electrical contact with energized equipment or a conductor, and from which the person may sustain an injury from shock. Overheating, ageing of the material and use of sub-standard quality of electrical gadgets have been the main factors contributing to the increasing fire accidents in industries.

The main hazards of working with electricity are electric shock and burns from contact with live parts. Injury from exposure to arcing, fire from faulty electrical equipment or installations. The following statics shows the electrical accidents in past decade: IN INDIA almost 12 people die due to electrocution every day (source-NCRB national crime records bureau).42% of total fires occur due to electrical sources (Source-OISD)8% deaths that occur in Indian factories due to electricity.IN US: 25% of all fires occur due to electricity(NFPA).411 deaths from job related electrical accidents per year(NIOSH0Electrocution is the cause of 12% of all workplace deaths among young workers.

III. TYPES OF ELECTRICAL HAZARDS

The voltage of the electricity and the available electrical current in regular businesses and homes has enough power to cause death by electrocution [2]. Even changing a light bulb without unplugging the lamp can be hazardous because coming in contact with the "hot", "energized" or "live" part of the socket could kill a person. There are four main types of electrical hazards: electrocution (fatal), electric shock, burns, and falls. These electrical hazards can happen in various ways: Direct contact with exposed energized conductors or circuit parts. When electrical current travels through our bodies, it can interfere with the normal electrical signals between the brain and our muscles (e.g., heart may stop beating properly, breathing may stop, or muscles may spasm).When the electricity arcs (jumps, or "arcs") from an exposed energized conductor or circuit part Thermal burns including burns from heat generated by an electric arc, and flame burns from materials that catch on fire from heating or ignition by electrical currents or an electric arc flash. Contact burns from being shocked can burn internal tissues while leaving only very small injuries on the outside of the skin. Thermal burns from the heat radiated from an electric arc flash.

Ultraviolet (UV) and infrared (IR) light emitted from the arc Flash can also cause damage to the eyes. An arc blast can include a potential pressure wave released from an arc flash. This wave can cause physical injuries, collapse your lungs, or create noise that can damage hearing. Muscle contractions, or a startle reaction, can cause a person to fall from a ladder, Scaffold or aerial bucket. The fall can cause serious injuries.

IV. EFFECT OF CURRENT ON HUMAN BODY

- Electrical Hazards Awareness

- Electrical Safety Improvement Project
- Current in mill amperes Effects
- 1 or less No sensation; probably not noticed
- 1 to 3 Mild sensation not painful
- 3 to 10 Painful shock.
- 10 to 30 Muscular control could be lost or muscle clamping
- 30 to 75 Respiratory paralysis
- 75mA to 4 amps Ventricular Fibrillation
- Over 4 amps Tissue begins to burns. Heart muscles clamp and heart stops beating

V. CAUSES FOR ELECTRICAL HAZARDS

Most electrical safety hazards can be prevented with common sense and plain, old good wiring. For most people, preventing an electrical accident means not plugging too many things into one feeble extension cord (which they do anyway) or not using a hair dryer while taking a bath (hopefully they don't do this). And while these are valid and important precautions, there are many other potential electrical safety hazards in any home [3]. Taking a look at some of the most common causes of electrical accidents can help you appreciate the considerable power (and danger) of electricity and how to use it safely.

A. Cords and Plugs

According to the National Fire Protection Association (www.nfpa.org), electrical cords and plugs are responsible for the most civilian deaths related to electrical accidents each year [2]. Yet these are among the easiest hazards to avoid: Never use a cord or plug with evidence of burning, melting or any other visible damage. If the insulation is damaged or missing, or the cord has come loose from the plug, replace the whole thing; never use a cord repaired with electrical Extension cords

Including power strips and surge protectors) are the biggest offenders in the cord category. Don't use extension cords for permanent hookups, conceal them in any way (especially under carpeting) or expose them to water or possible damage. Always use the right cord for the job, such as 3-prong grounded cords for all appliances and tools that require grounding. Also make sure the cord's capacity well exceeds the demand of what's plugged into it; heavier-gauge cords can handle more current than lighter-gauge cords. Avoid using 3-prong adapters to plug grounded cords into 2-prong outlets (while theoretically possible, the chances of a true ground existing here are extremely slight).

B. Fixtures and Appliances

Misuse of lamps and light fixtures is another top cause of electrical accidents [5]. As harmless as it seems, using a 100-watt bulb in a 60-watt fixture (for example), can melt the fixture wires, creating a shock and fire hazard. The same danger exists when plugging a cord into an adapter outlet that screws into a light bulb socket. As for appliances, don't use any device that sparks, smokes, and buzzes, emits a burning smell or shows any cord damage. Unplug appliances before cleaning them. Never operate an appliance or equipment while standing in water.

C. House Wiring/Wiring Systems

Fixed wiring is the second-leading cause of electrical-related house fires [5]. Potential problems with household wiring systems can range from overloaded circuits (and improperly rated or installed circuit breakers) to damaged wires to loose connections on switches, outlets and other devices [3]. Since most electrical wiring is behind the scenes-and beyond the realm of common knowledge-the best way to prevent a wiring-related electrical accident is to have your home inspected by a certified electrical inspector. This pro can look for all of the most common hazards and advise you about correcting problems and how much the solutions might cost.

VI. VARIOUS ELECTRICAL SAFETY STANDARDS

- NFPA - NEC (1897)
- NESC (1913), from IEEE
- NIOSH (Research example: development of voltage detector that will signal the person if he gets close to live power)-1970
- OSHA (1970)
- NFPA 70 E & B (1979) -approved by OSHA
- Electrical Trauma Centre, Chicago (1990)
- NESF (1994), by UL, NFPA, NEMA, CPSC

VII. CASE STUDY

Electrical faults seem to be the major reason for industrial disasters in the country as 56 per cent of incidents are reportedly caused by them. Overheating, ageing of the material and use of sub-standard quality of electrical gadgets have been the main factors contributing to the increasing fire accidents in industries in the past four years, said V. Srinivas, member of the Fire and Security Association of India (FSAI) National Executive Board. Quoting the National Crime Records Bureau statistics, Mr. Srinivas said that eight per cent of the deaths in industries due to electrical hazards. The fire in AMRI hospital in Kolkata

claimed 92 lives, while 32 persons were charred to death on board the Chennai-bound Tamil Nadu Express at Nellore district in Andhra Pradesh.

VIII. PRESENT ELECTRICAL SAFETY STATUS IN INDIA

- Use of HRCs /RCCBs is the rise, finer details are yet to be understood by many
- More ES workshops / seminars are conducted in India
- ES Awareness is slowly growing
- Statutory regulations are enforced strictly (Karnataka, Delhi - Use of RCCBs mandatory in residential buildings) Many industries are re-aligning their Electrical practices based on international standards (NFPA, IEEE, etc.)

IX. RECENT DEVELOPMENT IN PROTECTIVE DEVICES

To provide electrical safety in industries to greater extent following devices technology has to adopt which are as follows[10]:

A. RCCB:

A residual-current device (RCD), or residual-current circuit breaker (RCCB), is a device to quickly disconnect current to prevent serious harm from an ongoing electric shock [4]. Injury may still occur in some cases, for example if a person falls after receiving a shock. In the United States and Canada, the device is more commonly known as a ground fault circuit interrupter (GFCI), ground fault interrupter (GFI) or an appliance leakage current interrupter (ALCI). In the United Kingdom, these are better known by their initials RCD, and a combined RCD+MCB is known as a RCBO (residual-current circuit breaker with overcurrent protection). In Australia, they are sometimes known as safety switches or a RCD. An earth leakage circuit breaker (ELCB) may be a residual-current device, although an older type of voltage-operated earth leakage circuit breaker also exists. These electrical wiring devices disconnect a circuit when it detects that the electric is not balanced between the energized (line) conductor(s) and the return (neutral) conductor. In normal circumstances, these two wires are expected to carry matching currents, and any difference usually indicates that a short circuit or other electrical anomaly is present. Even a small leakage current can mean a risk of harm or death due to electric shock if the leaking electric current passes through a human; a current of around 30 mA (0.030 amperes) is potentially sufficient to cause cardiac arrest or serious harm if it persists for more than a small fraction of a second. RCCBs are designed to disconnect the conducting wires quickly enough to prevent serious injury from such shocks. (This is commonly described as the RCD being "tripped".)

B. AFCIs:

An Arc Fault Circuit Interrupter (AFCI) is a type of duplex receptacle or circuit that breaks the circuit when it detects a dangerous electrical arc, in order to prevent electrical fires[4]. An AFCI distinguishes between a harmless arc that occurs incidental to normal operation of switches, plugs and brushed motors and an undesirable arc that can occur, for example, in a lamp cord that has a broken conductor in the cord.AFCI breakers have been required for circuits feeding electrical outlets in bedrooms of homes by the electrical codes of Canada and the States since the beginning of the 21st century; since 2014, U.S. code has required them for outlets in most rooms in houses. Arc faults in a home are one of the leading causes for electrical wiring fires.[1]Each year in the United States, over 40,000 fires are attributed to home electrical wiring. These fires result in over 350 deaths and over 1,400 injuries each year.[2]Conventional circuit breakers only respond to overloads and short circuits; so they do not protect against arcing conditions that produce erratic, and often reduced current. An AFCI is selective so that normal arcs do not cause it to trip. The AFCI circuitry continuously monitors the current and discriminates Between normal and unwanted arcing conditions.

C. GCDs:

A Glowing Connection

- Can develop anywhere electrical connections are made
- Is currently difficult or impossible to detect until it's too late
- Is particularly likely in older buildings with aging wiring
- Can NOT be detected by a conventional circuit breaker
- Can NOT be detected by a Ground Fault Circuit Interrupter
- Can NOT be detected by an Arc Fault Circuit Interrupter

D. HFFR Cable:

Recent developments have produced a prototype detector, capable of detecting intermittent series arcing as well as a glowing connection. The device consists of a small electronics package that is carried room-to-room, and individually plugged into the outlets. A series of LEDs indicate if any series arcing, or a glowing connection, is found. An electrician can use the device to isolate the circuit, or sometimes even the outlet, which harbours the hazard. With this information, an electrician can make Repairs, or replace faulty equipment or wiring *before* a disaster occurs.

E. Linear Heat Sensing Cable:

- Linear Heat sensing (LHS) cable is a very commonly used method of fire detection.
- It can detect a fire anywhere along the length of the cable, and can be of lengths in excess of a kilometer

- Applications can range from building fire alarm systems to mobile plant machinery.
- Linear Heat Sensing (LHS) cable is essentially a two-core cable terminated by an end-of-line resistor (resistance varies with application).

F. Thermography surveys

- Thermography can help you see heat and potential Electrical equipment failures before they become issues, Helping you manage equipment costs, increase fire safety, and look for energy reduction opportunities.
- A single critical fault (defined as a temperature delta of >75F above norm) can mean additional energy costs of $550 annually and average repair or replacement costs of $3,000, including components and labor.
- On average, each thermography survey reveals five to eight faults, highlighting the relative affordability of this predictive service.

Thermography surveys offer a low-cost, predictive maintenance tool to find and correct heat-related issues before a more costly failure happens.

X. ELECTRICAL SAFETY AUDIT

The objectives of the assessment are accepted with detailed visual inspection of the installed electrical and automation equipment [6]. At first detailed description of type of data is required for panning of audit. After analyzing the information by the audit team members, a schedule is prepared, post discussions with the factory management. Site study will be undertaken on mutual convenience and during the audit an attempt will be made by the auditors to identify the activities that can lead to major fires, explosions and toxic releases which will have both onsite and offsite consequences. After the site study a report is prepared and submitted. The total methodology of electrical assessment represent in fig.1

XI. BENEFITS OF ELECTRICAL SAFETY ASSESSMENTS

A well-prepared and well-executed safety assessments program can make a substantial difference in helping companies prevent accidents and injuries. The main benefits of safety assessments are following below:

- Identify hidden failure modes and electrical safety risks - Loose connections, insulation breakdown, and excessive heat can all cause or be an indication of unexpected failures.
- Identify actions required to meet new performance targets or regulations.
- Provide documented evidence of inspection and maintenance for client confidence.
- Operational benefits that assist the management of industrial site improve the comfort, safety and productivity.

XII. AUDIT PLANNING

The audit requires careful planning and diligent preparation. An audit program must have proper guidelines and procedures that describe how the audit should be conducted and what corrective actions should be taken. These procedures should define audit activities, such as planning the audit, on-site activities and follow-up

XIII. AUDIT SCOPE

Defining scope of electrical safety audits based on specific requirement is the first step in the process of Electrical safety auditing. The audit scope presented completed with findings, defects report, analysis and recommendations [6]. Typically Electrical safety audits scope of work could include:

- Visual check of generators, motors, transformers, switchboards, LT & HT panel and cables.
- Collection of data covering various management and technical elements of Occupational Safety and Health.
- General review of the operational process and likely benefits and enhancements Review of hazardous area classification and selection of flameproof electrical equipment in the plant, including maintenance aspects.
- To identify areas of overloading by carrying out load current measurements and compared against cable current carrying capacity calculation
- Assessing the integrity of insulation of cables by carrying out insulation resistance tests on a sample basis
- Recording of the equipment nameplate data, breaker and protection settings
- To identify training needs of the plant employees from the point of view of electrical safety.
- Hotspot detection using infra-red hot spot detection equipment/ thermal imaging. Hotspot could indicate: (If necessary)
- High contact resistance
- Loose/tight connections
- Unequal loading
- Over loading

XIV. AUDIT FREQUENCY

Determine a nominal risk classification, based on the known operational risks of the organization [8]. Table 1 shows the classification of risk with take action necessary. The risk classification includes:

- High Risk: Observations RED- Immediate correction required.
- Medium Risk: Observations ORANGE - Monitor and take actions at earliest convenient.
- Low Risk: Observations YELLOW- Monitor and take action as necessary.

Risk Classification	Take Action Necessary
High risk	Immediate
Medium Risk	6 month
Low Risk	1 Year

Table 1: Classification

XV. DOCUMENT REVIEW

Electrical safety assessments must have considered comprehensive document reviews of safety and industrial health exposures in a given area or complete factory. Electrical safety audit involves document review of

- Detailed review of the drawings and documentation for the equipment
- Review of the importance given to electrical safety in the company safety policy, safety committee, continuous electrical risk identification, etc.
- Measurement of the insulation resistance for the generators, motors, transformers, switchboards, drives and cables.
- Review of the following test records, evaluating the test results and to suggest recommendations as per applicable standards
- Transformer oil tests.
- Insulation resistance tests
- Earth resistance tests

XVI. CONCLUSION

An electrical hazard is dangerous to human health and an Electrical fault seems to be major reason for Industrial Disaster in several countries. With using recent protective devices and technology we can improve the electrical safety to greater extent. Electrical safety Audit and Electrical Assessment is an effective tool in identifying and perusing a comprehensive safety. A properly designed, planned and executed safety audits can bring about many hazards that could save life and property of the organisations.

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