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Electrical Hazards, Safety and Regulations Global Concerns and Indian Perspective

Krishna Kant Gautam
Assistant Professor,Department of Electrical Engineering ,
Rustamji Institute of Technology ,B.S.F. Academy,Tekanpur,Gwalior
kkgautam11@yahoo.co.in

Abstract **– Electricity is inseparable part of our life but it is also life taking factor if not handled properly. Anyone can be exposed to electrical hazards at home or work. Electricity not only utilized in every industry it is also a major industry. Precaution, awareness, rules and regulations can make the proper path to flow the current in safe and usable manner. This paper represents the various electrical hazards with the various works worldwide to reduce these hazards and the solutions in term of rules and regulations also discuss the problem to implementation of these rules with the solution to prevent hazards by reinforce or amend the safety rules and its practice.**

Keywords **– Electrical Hazards, Hazard Analysis, Electrocution, OSHA and NFPA Regulations, IE Rules for Safety.**

I. Statistics of Electrical Hazards and Electrical Safety Organization

- According to OSHA 10% of job fatalities due to the electrocution.
- 97% of all electricians have been shocked or injured on the job.
- Approximately 30,000 workers receive electrical shocks yearly.
- Over 3600 disabling electrical contact injuries occur annually.
- Electrocutions are the 4th leading cause of traumatic occupational fatalities.
- Over 2000 workers are sent to burn centers each year with severe Arc-Flash burns.
- Estimates show that 10 Arc-Flash incidents occur every day in the US.
- 10% of workplace accident deaths are caused by burn injuries.
- Over 1000 electrical workers die each year from workplace accidents.
- Medical costs per person can exceed $4 million for severe electrical burns.
- Total costs per electrical incident can exceed $15 million.
- In the year 2002, work injuries cost Americans $14.6 billion
- According to NFPA 25% of all fires occurs due to electricity

About 12 people dead in India daily due to electrocution according to NCRB[1]-[2].

II. Some Safety Organizations

Several organizations working potentially on creating and amending standards and regulation with awareness to enforcing them to developing safe electrical work, laboratory work and other jobs. Some of them are given below:

- OSHA (Occupational Safety And Health Administration)
- NIOSH (National Institutes For Occupational Safety And Health)
- NFPA (National Fire Protection Association)
- NEMA(National Electrical Manufacturers Association)
- NECA(National Electrical Contractors Association)
- IEEE(Institute Of Electrical And Electronic Engineering)
- ASTM(American Society Of Testing And Materials)
- ANSI (American National Standards Institutes)
- Canadian Standards Association (CSA)
- UL(Underwriter laboratory)
- ERDA(Electrical Research And Development Association, India)
- ELCA (The Electrical Consultants' Association, India)
- BIS (Bureau of Indian standards)
- NABL(National Accreditation Board Of Testing And Calibration Laboratories, Govt. Of India)

Electrical rules of different country also govern and enforce some valuable rules and guidelines for consumers, supplier, contractors, owners and industries regarding to safety from electrical hazards and safe use of electricity. Some standard electrical safety codes are:

- National Electrical Code (NEC), or NFPA 70 ,US
- PSE law, Japan Electrical Safety Law
- Canadian electrical code
- Indian electrical rules,1956

III. Various Electrical Hazards and its Analysis

Electrical hazard is potential to cause harm due to exposure of situation when a person come in contact with energized part of apparatus or conductor and feel the shock, encountered with injuries, burn etc. it is also define as such accidental condition which lead the arc flash and arc blast with fire. Basically electrical hazards categorized as three main hazardous conditions [10].

1. Electrical Shock
2. Burn and Fire
3. Arc blast with pressure impact

1. Electrical shock: Electric shock occurs when the body becomes part of an electrical circuit. it is defined as sudden and accidental stimulation of body's nervous system when the body becomes the part of an electric circuit. A current of 3 mA or more start causing mild sensation and at slight variation gets converted into a painful shock and can be the potential cause of loss of life

2. Burns and fires: burns suffered in electrical accidents are of three basic types: electric burns, arc burns and thermal contact burns. In electrical burn tissue damage (whether skin deep or deeper) occurs because the body is unable to dissipate the heat from the current flow. Typically electrical burns are slow to heal.arc burns are cause by electrical arc and are similar to heat burn from high temperature. Temperature generated by the arc melted nearby material, vaporized material in close vicinity and burn flesh and ignite clothing at distance of several meters depending on the energy deposited on the arc. Thermal contact burns are those that occur when skin come into the contact of hot conductor which is overheated.

Generally we heard about the fire and explosion due to short circuit of current, the arc or spark lead the fire caught to nearby flammable material. Fire is most hazardous condition. It may be turn everything into ashes, so safety against fire and burns must be required

3. Electrical arc blast: electrical blast is most dangerous condition it is destructive in bulk, electrical blast involve three main step or effect:

a. Arc flashes: result in intense heat (causing burns), intense light (can cause blindness), or ignition of other materials.
b. Arc blasts: cause the same conditions as an arc flash, but are more intense and can also include a strong pressure wave. These pressure waves can damage machinery, throw a person, collapse a lung or rupture ear drums.
c. Releasing of toxic gases, pollutants [1]

IV. General Feature of Electrical Safety Rules Analysis

Electric hazard analysis is very important to control hazards. Last decade is devoted to hazard analysis and control by various safety organizations. OSHA did tremendous work in this field. Various researches concluded the main cause of hazards broadly classified as:

(1) Use of defaulted equipment and bad installation
(2) Fault by person due to careless attitude and accidental incident
(3) Hazardous working environment

So by avoiding these causes we can pledge the hazards in great manner, summery of these rules presented here which is also documented directly and indirectly in various organizations work and these general safety rule easily observe by any sensible person

- Consideration about de-energize of all equipment before inspection, lock-out &tag-out during maintenance, repair or inspections. Avoid the use of defective or not proper insulated tools.
- Adjust distance of working and elevation for on line work with use of proper personal protective equipment, verify always power status(not only on and off also static discharge status).
- Using 3-wire cord with a 2-wire plug. Removing the third prong (ground pin) to make a 3-prong plug fit a 2-prong outlet.
- Avoid overloading, loose connection, faulty insulation, defective equipment, bare terminal, extensions cords improper grounding
- Use of circuit protection device like Fuse, Circuit Breakers , M.C.B. , R.C.C.B. and proper grounding may save equipment and life
- The precaution consideration should also be take space of hazardous environment of working like explosive areas contains flammable gases, combustible dust etc. also water -electricity combination may dangerous.
- Last but not the least first aids and electrical emergency rescue technique very important safety consideration

As we mentioned these rules are easily observable by any sensible person even after this hazards can happen due to be careless attitude, lack of training and practicing these rules, legal enforcement of rules [5]

V. International Work on Safety Rules

The list of different organization work in this field also mentioned in previous section; most of countries are taking interest in this subject and modifying rules and regulations on electrical safety and working with some standard organization. OSHA, NFPA, IEEE are some big name.

OSHA regulation is very well structured around electrical safety. It is published by US federal register in which part 1910.301 to 1910.395 discussed about electrical safety. It cover four major topic related to safe work.

(1) Safety work practice
(2) Develops safety regarding standards
(3) Maintenance related requirement for safety
(4) Safety requirement for special equipment and working conditions.

OSHA section 5(a).1 act of 1970 indicate employees and work providers have to recognize hazards and hazardous environment which cause of death and serious injuries.

29, code of federal regulation (CFR) 1910.32 and 1910.335 empathize the use and requirement related to PPE (personal protective equipment like rubber shoes and gloves etc.). PPE is most important thing to diminish electrical shock harm. OSHA 29 part 1910.333 consolidate the electrical work practice. It also defines properly about energized and de energized part and working condition in live areas with proper selection and use of PPE [1].

NFPA is other major organization in this field; NFPA 70 E seems synonym of national electrical code NEC.NFPA 70 E standards for electrical safety workplace has been adopted by the ANSI. Important thing which is states in NFPA standards is analysis of various hazards in detail like arc flash analysis by various methods of calculation and observation, electrical shock analysis with PPE categorization, lock-out and tag-out procedure and so on.[9]

NFPA 70E established shock and arc flash approach boundaries around an energized part, also discuss about the selection of PPE.NFPA 70E article 110.8(B) and 130.2 (A) has contains well documents about shock analysis it forced to establishment of production boundary requirement. And according to it table 130.2 (C) listed PPE requirements to minimize the effect of shock. These boundaries are

(1) Limited approach boundary (unqualified person may be permit with qualified person and with PPE).
(2) Restricted approach boundary (qualified or trained person permitted)
(3) Prohibited approach boundary (only qualified or trained person with PPE permitted in special conditions.)

Shock protection boundaries are designed according to system voltage And NFPA 70E Table 130.2(C). Define these boundaries distance for nominal phase to phase system voltage from50 v to 800 KV.

Shock hazard analysis not only performs to reduce the potential from shock it also about the emergency technique to save life after shock. Both OSHA and NFPA 70E discuss about electrical emergency rescue technique.[9]

NFPA 70 E article 130.3 requires flash hazards analysis by designing of system, use of protection devices like C.B. And flash protection boundaries. Some calculation is required to designing flash hazard risk category and PPE level for example incident energy release during arc flash, short circuit or fault or arcing current data, one line diagram estimation, clearing time of all over-current protective device NFPA 70E article 110.6(D) state about employees training to meet the requirement qualified persons with the proper definition of qualified person which indicate difference between with the qualified person for some work and same unqualified for other works OSHA also define qualification and permit in solid words. Training is must to make them aware about hazards and emergency technique, use of PPE or other tools and testing equipments safely so they become habitual to do safe work practice [9]

OSHA and NFPA regulations kind guidelines clearly mention about safe circuit design and electrical maintenance, the summary of instructions are:-

(1) Design a safe working system and environment.
(2) Use of proper current limiting switch gears.
(3) Implementation of electrical safety training program.
(4) Observation of safe work practice.
(5) Use of PPE warning labels, lock out and tag out.
(6) Electrical work permit and proper inspection by authority
(7) Coordination and maintenance with use of proper selection of protective device. [5]

IEEE also published guidelines regarding electrical hazards and safety. A guide for performing arc flash hazards calculation 1584-2002(amended) published to ensure safety regarding to arc flash hazard IEEE also published various safety books for safe work practice [8]

NIOSH also established by the federal of occupational safety and health ACT 1970. It is an agency of the US department of human and health service which assure the safety requirements. It is worked by providing training programs, educational courses and researches.

ANSI also works in this field. ANSI represents U.S. in international standard organizations such as ISO (international organization for standards') and IEC. OSHA electrical safety regulations 1910 subpart S refers several ANSI standards. The ANSI standers involves electrical safety are ANSI C33.27-74 (safety standard for outlet boxes and fitting for use in hazardous location) and ANSI S82.02 provide important safety rules for electrical tests on instruments. ANSI C281 national electrical safety code deal with electrical installation for more than 1000volts [7]

VI. Indian Perspective Over Electrical Safety Rules

India has encountered many electrical accidents last decade. There are not much and such organizations like OSHA and NFPA. The government policies somewhat compensate this thing but it is only in documentation not in practice.

Indian electrical rules 1956 is such compensation in which from section 29 to 46 instructed about safety requirements in electrical work. IE Rules section 29 (1) highlight the need of sufficient ratings of the equipment and materials to be insured for safety of human life loss and injuries and also animal and property loss. The rating should be according to bureau of Indian standard (BIS) and NEC. Section 30 (1,2,3) highlight the duty of electricity supplier regarding supply lines, wire fittings, installations etc. installed on the premises of consumer in safe and tested manner. It also explains the role of consumer to take precaution of safe custody of equipment belonging to supplied. Section 31 (1) speaks about the existence of adequate enclosed fire proof cut out. It also mention about separate cut out at junction which reduce overloading effects and its damages.

Section 35 mention the use of danger notice in every medium, high and extra high voltage installation in Hindi, English and regional language with sign of skull and bone. Luminous tube sign indicate the high voltage supply, x-ray and similar high frequency installations, here also instruct about proper working environment so that reduce the ladder falls. Section 36 indicates about the handling of electrical supplier and apparatus which can also reduce many accidents [6].

Section 32 discuss about the use and identification of proper earthing system. Section 33 elaborates the requirement of earthing system on consumer's premises. Earting can reduce the shock so it is very important consideration in term of electrical safety. Section 34 ensure about inaccessibility of bare conductors under the responsibility of electrical inspector [2]

In the similar manner according to the Indian electricity act, 2003 a govt. body established which known as the Central Electrical Authority (CEA) makes regulation about the safety requirement. Regulation clearly defines contractors, owners, occupiers, employees and safety provisions for each. Owner should have certification for task. The safety management system and safety manuals set up by owner but there is also a procedure for internal and external audit of safety management system. Regulation also establishes process to hazards observation and its analysis which has potential to save life and injuries. Owner and contactor have the responsibility of providing safe working environment, medical facilities and other resources. Adequate training is must to make aware the worker and getting sufficient knowledge about safety and protection with proper analysis and documentation. Safety officer and safety committees appointed by the authorities design the safety training program at regular interval (ten hours training per year for each employee) [2].

VII. Conclusion

Different organizations in different countries are working on the safety rules and regulations. Developing countries are laying stress on need of rigorous electrical safety rules but lack for improper coordination between agencies responsible for framing out rules, enforcing rules and covering legal provisions related to electrical safety leads to loss of energy, life, efficiency and of course invites capital expenditure. If a single agency is entrusted with threefold task of framing, enforcing and legalizing (penalizing) them the electrical safety requirement challenge can be very well meet out in developing countries

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Author's Profile

K.K.Gautam received his B.E. AND M.E. degrees in Electrical Engineering from Pt. Ravishankar University Raipur and Madhav Institute of Technology and Sciences Gwalior respectively.
He has worked as Assistant manager [E&M] with India Tourism Development Corporation [A Govt. of India Enterprise] and as Assistant Professor [Electrical Engineering] with ITM Group of Institutions and ITM University Gwalior. Presently he is working as Assistant Professor [Electrical Engineering] at Rustamji Institute of Technology BSF Tekanpur, Gwalior.
His Areas of Interest include Power systems, Application of AI to Power systems, Energy Efficiency and Electrical safety. He is life member of I.S.T.E and UACEE