

Effectiveness of Conventional LOTO v/s IOT based LOTO in Industrial Safety.

Sameer Kumar¹, S.M.Tauseef²

^{1,2}*Department of Health, Safety and Environment,*

University of Petroleum & Engineering Studies, (India)

ABSTRACT

Safety has always been important part of the Industries. Many processes which use hazardous energies have been identified worldwide. Control of these hazardous energies ensures and enhances Safety. A very important Hazardous energy Control Program known as Lockout Tagout (LOTO) where hazardous energies like electrical, chemical, gravity, thermal, hydraulics etc. are handled with utmost precaution .As example- a physical lock is put on the electrical switch and key is kept with the service person so that no one can make the Switch ON while service person is working on electrical panel. Factories Act-India, OSHA (Occupational Safety and Health Administration, USA) & others has defined a very detailed LOTO procedure.

These detailed LOTO procedures are not able to result in zero accidents. Many Accidents has happened due to non-adherence of LOTO procedure. The LOTO procedure has many manual man dependent activities. With emergence of IoT (Internet of Things) these manual (man dependent) activities can be combined with automated activities without any compromise with safety.

The study aims to study the conventional LOTO procedure and IoT based LOTO procedure and find out the gaps between these two. The study has been divided in to understanding of conventional LOTO procedure, Analysis of accidents data, present IoT devices and possibilities of developing IoT based LOTO device.

Combining conventional LOTO procedure with IoT based LOTO device can be very efficient in safety enhancement and reduction in safety related incidents.

Keywords- Hazardous Energy, Internet of Things(IoT), Lock Out Tag Out(LOTO), Safety & Accident.

I. INTRODUCTION

We use energy in almost everywhere and everything. Industries also have many equipment and processes which uses energy and some of the energy can be harmful [1]. We use different type of hazardous energy[2] like electrical, pneumatics, hydraulics, chemical, potential etc. in our machines in Industries[3]. The person working with or near to the machine must use hazardous energy control procedure or LOTO(Lockout Tagout) procedure[4] to safeguard himself/herself from the risk, As per NCRB (National Crime Records Bureau, India) Accident and Death Data in 2015, Accidents due to electrocution and other unnatural causes has increased[5].

II. BACKGROUND AND SIGNIFICANCE OF THE STUDY

OSHA (Occupational Safety and Health Association, USA)[6] and various other Safety organizations[7],[8] in the world have well defined LOTO procedures. The person going to operate, repair or service of the equipment which has hazardous energy must follow these procedures.

The person may meet with an accident if the procedure is not followed[9].

III. REVIEW OF LITERATURE

An exhaustive literature review was done to understand the theoretical significance of the concept and a detailed review to understand the theoretical significance of the concept. Present and Conventional LOTO devices[10] and IoT based device for a modified lock out tag out (LOTO) ie Hazardous Energy Control Program.

3.1 OSHA specified LOTO procedure and The Factory Act 1948

OSHA (Occupational Safety and Health Association, USA) have well defined Control of Hazardous Energy Program (Lock Out Tag Out or LOTO) procedures[11]. As shown in Fig-1 The person going to operate, repair or service of the equipment which has hazardous energy must follow these steps defined in OSHA Standard Number 1910.147.App.A The Red star mark steps like notify employees,Attach Lockout Tagout Device and Verify Lockout are the steps where the employees has the possibilities of not adhering or bypassing the procedure.

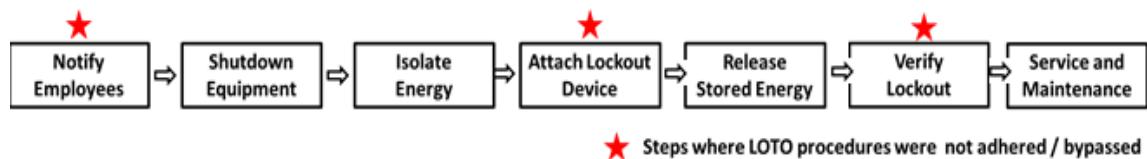


Figure 1- OSHA defined LOTO Procedure, OSHA Standard Number 1910.147.App.A: Typical Minimal Lockout Procedure

IV. SCOPE, STUDY, EXPERIMENT AND TRIALS

We have defined the scope limited to study and compare both conventional[12] and IoT based LOTO Processes. We have studied a process flow where in an Electrician working in a substation notices line fault and follows conventional Lockout Tagout Procedure (LOTO) and uses his padlock with key in his possession.

4.1 Process Flow Study of LOTO implementation with Conventional LOTO Device and Padlock

Power is ON, Circuit Breaker is ON and Everything working all right

- a. Fault Occurs, Circuit Breaker Trips and goes to OFF Position
 - b. Electrician present in the room, sees the circuit breaker in OFF Position
 - c. Electrician calls his immediate supervisor and explain him about the fault and circuit breaker tripping and takes his approval for putting LOTO device and Padlock on the Circuit Breaker
 - d. Supervisor calls his manager and explain him about the fault and circuit breaker tripping and takes his approval for putting LOTO device and Padlock on the Circuit Breaker
 - e. Manager Approves and now immediate supervisor calls electrician and allows him to follow LOTO procedure and gives his approval for putting LOTO device and Padlock on the Circuit Breaker
 - f. Electrician fills the LOTO register and follows defined and approved LOTO procedure.
 - g. Conventional LOTO Device with Pad Lock
 - h. Electrician put LOTO device and Physical Pad Lock and ensures that there is no residual energy. Electrician follows defined and approved LOTO procedure.
 - i. Electrician perform the actual trouble shooting work and repair the fault..
 - j. Electrician calls his immediate supervisor and explain him about the fault work completion and take his approval for removing LOTO device and Padlock on the Circuit Breaker

- k. Supervisor calls his manager and explain him about the fault and work completed and takes his approval for removing LOTO device and Padlock on the Circuit Breaker
- l. Manager Approves and now immediate supervisor calls electrician and allows him to follow LOTO procedure and gives his approval for removing LOTO device and Padlock from the Circuit Breaker
- m. Electrician fills the LOTO register and follows defined and approved LOTO procedure
- n. Electrician follows the LOTO procedure and removes the Padlock.
- o. Electrician follows the LOTO procedure and switch ON the Circuit Breaker

Figure 2- Process Flow Study of LOTO implementation with Padlock

We have also studied and analyzed accident data from DGFASLI (Director General Factory Advisory Services and Labor Institutes, Govt. of India).[13] While analyzing the data from 2011-2012, Total 45 incidents were analyzed, There were 29 Non-fatal incidents out of 45 incidents. 22 cases were related to electrical energy and 20 cases out of 22 were related to LOTO procedure and applying padlock. 19 cases of non-fatal electrical accident were recorded where padlocks were applied as LOTO procedure even then the accident took place.



Figure 3- Analysis of Various Accident related to LOTO

The study shows many limitations and challenges in conventional LOTO procedure using Padlock.

4.2 Limitations and Challenges of Conventional LOTO Procedure

- Electrician has sole responsibility and decision making of Putting LOTO device and physical pad lock, Electrician can bypass and lock or unlock the LOTO device and padlock.
- Any other unauthorized person can lock/unlock the device or break the lock and only personal vigil can avoid these mischiefs..
- Supervisor and Manager Needs to visit, see and verify physical condition of actual Padlock at circuit breaker.
- LOTO procedure takes time and delays the actual trouble shooting, fault finding process.
- Record Keeping is manual.
- Mode of communication is phone call or physical discussion.

4.3 IOT (Internet of Things)

Many physical and smart devices (other than computers, phones and tablets) are being connected to the Internet. This concept of connecting various things to the internet is being known as Internet of Things(IoT). In simple words (Fig.4) we can connect any device with an ON and OFF switch to the internet and control them. We get many data through many sensors and It becomes a very huge network of connected things[15]. The IoT can work between things-things, people-people and people-things[16].

For LOTO, We need to have an IoT enabled device[14] which can communicate to different devices, actuate different switches, which further makes the actuator work. We can lock/unlock the IoT enabled LOTO device

from remote/any location and have the SMS/text message(digital) about the condition of LOTO (Lock/Unlock/Tempered/Broken) and can take any pre-defined action[17].

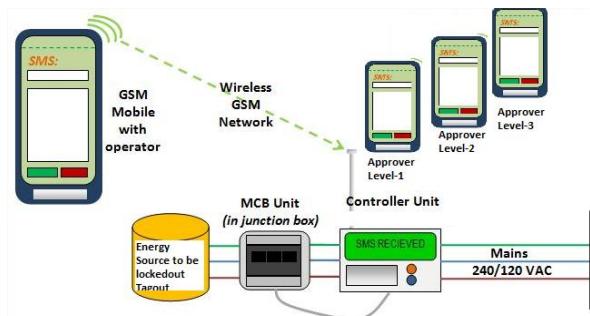


Figure 4-Pictorial Illustration of IOT enabled Communication System

4.4 Trial of different IOT (Internet of Things) enabled kits

Different experiment kit (Fig.5) is being developed for experimenting different LOTO conditions. Some of the trial kit developed for trial and experimentation are as below.



**(A)Programmable Logic Controller Kit (B)Pneumatic Kit (C)Electro pneumatics and Automation Kit
(D) Arduino Board (E)GSM Module**

Figure 5- IOT based IOTQ device Experimentation Kits

Figure 5- IOT based LOTO device Experimentation Kits

- (A) Programmable Logic Controller Kit[18] is being used in developing different logics of switching on/off the switch. PLC has features to test various logics like it will give command if and if all the three approvers has approved the locking/unlocking of the device and/or It will switch on/off as per pre-programmed and/or it can display the message and/or it can do any programmed and defined operation.
 - (B) Pneumatic Kit is being used in experimenting different pneumatic actuator which provides mechanical motions.
 - (C) Electro pneumatics and Automation Kit is being used for experimenting actuation with electrical and pneumatic mediums.
 - (D) Arduino [19] Board is being used for experimenting different programmes and logics for switching on/off with the help of phone or text message or through PC/Laptop.
 - (E) GSM module [20] is being used for experimenting different communication condition [21] with actuator, controller and Kits [22].

4.5 IOT based LOTO device implementation(proposed illustration)

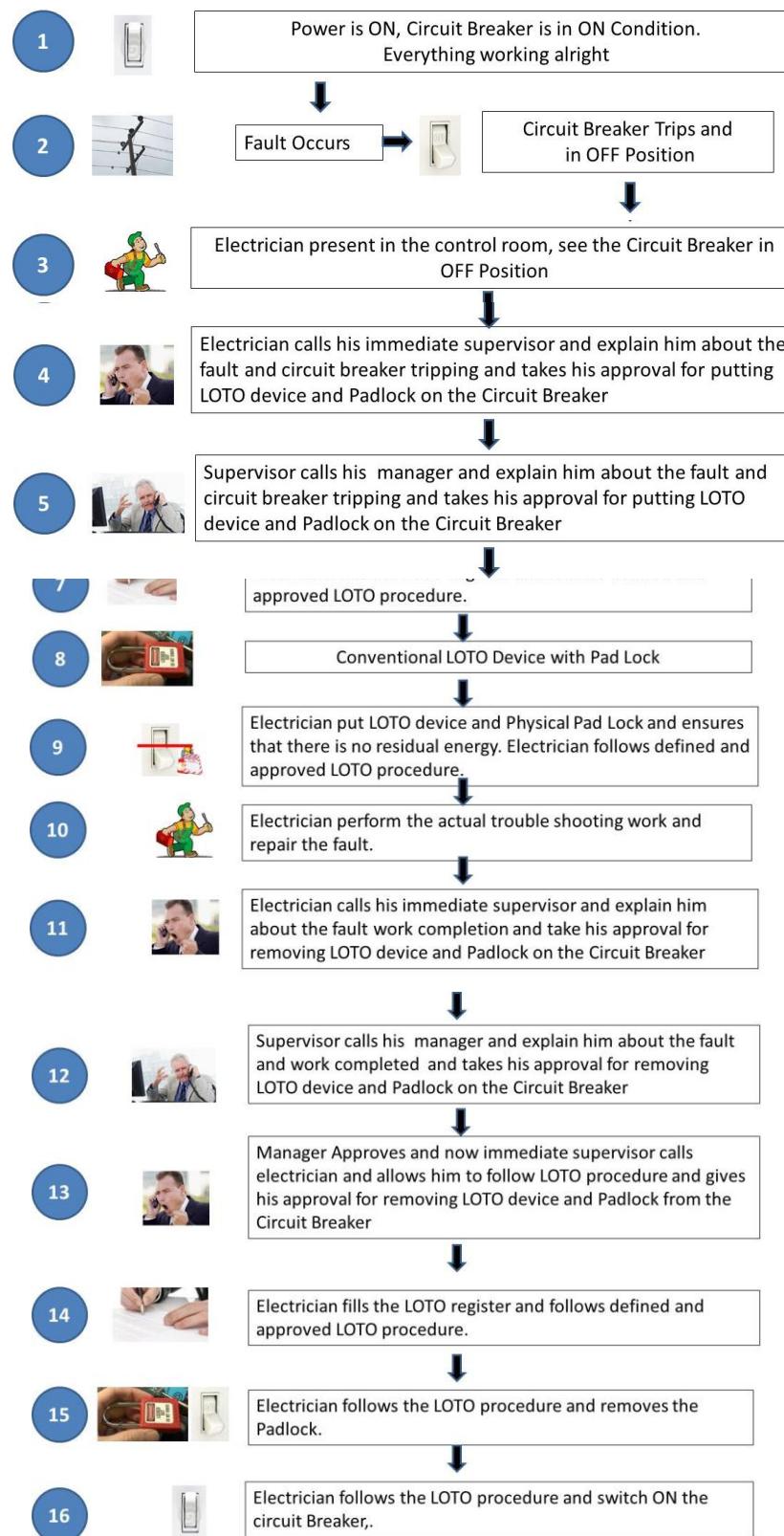


Figure 6- Flow Diagram IOT based LOTO Program

4.6 Proposed benefits and advantages of IOT based LOTO Procedure

- IOT based LOTO device gets locked it's own (based on the pre-programmed flow) and send text messages to defined person (based on the pre-programmed approval authority) for example- LOTO device gets locked and electrician, supervisor and manager gets text message.
- Electrician can not bypass the LOTO procedure as any action by him will send an automatic text message to his supervisor and manager.
- Any other unauthorized person can not lock/unlock the device or break the IOT based LOTO device, as any action by him/her will send an automatic text message to concerned electrician, supervisor and manager.
- IOT based LOTO procedure in fast/instant and does not take much time and this fastens the actual trouble shooting, fault finding process.
- Record Keeping is digital/electronic.
- Mode of communication is phone call, sms, system based and physical discussion.

V. CONCLUSION AND FUTURE SCOPE

An IoT based Lockout Tagout device can be developed. Trial to be taken and validated. This device can be used in adherence of the LOTO procedure which will result in to reduction in accident cases.

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