Effectiveness of Energy Source Documents on Safety at Steel & Power Industries

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Abstract— The aim of study is to examine the strategic issues pertaining to employee safety and health. Some organizations replace the revoked safety programs with more innovative ones. Some safety programs also have rewards for employees who avoid accidents. The study helps to maintain proper safety standards using Energy Source Identification Document (ESID). It would also help the manufacturing sectors to ensure that employees take protection against unsafe practices. Every organization should formulate and implement the principles explained in this paper. The procedure to be adopted naturally depends upon the size of the company, the number of plants it operates, the nature of the industry in which it is engaged, the production technology it uses, and the attitude of the top management. After it has spelt out its ESID program, a manufacturing institution should establish a ESID oriented safety program, the primary goals of which should be to reduce the number of hazardous factors that are likely to cause accidents, and to develop safe working habits among its employees. Hence a realistic & positive view has to be inculcated to ensure the safety & health of workforce in an organization.

Keywords: Occupational health, Accidents, Employee safety & health, Rewards, Hazardous factors, Energy Source Identification Document (ESID), Job Safety Analysis, Frequency Rate, Severity Rate, Lock Out Tag Out

I. INTRODUCTION

Past many years Steel & Power industries have grown dramatically due to high economic development but if we look into safety aspects followed in the manufacturing sector, they are very pathetic, and it becomes threat to the employee's life. So, safety aspects in manufacturing requires huge amount of improvement. Many companies have the policy to reduce the accident rates, but still statistics shows a high rate of accidents and injuries happening in manufacturing sector. Safety management system has various indicator to minimize the accident rates. Organizational safety culture, Behaviour safety, Safety performance are indicators of a safe workplace.

In past twenty years number of industrial accident took place in the manufacturing industries due to lack of environmental safety, unaware of industrial accidents and importance of safety. Most of small and medium level manufacturing industries do not focus on safety because of one-time investment but they don't know about the indirect loss that occur due to accident. Management must focus on their safety improvement. According to Heinrich theory, 88% of industrial accidents were caused by human unsafe behaviour, 10% accidents were caused by the industrial unsafe environment and 2% accidents were attributed to other factors. Nowadays more number of industrial accidents occurs due to the human error.There are some methods to prevent such an industrial accident and the most effective method is to develop the human behaviour by giving particular training for the work, conducting behavioural based study to reduce the accident rates and to improve the safe environment in industry. From the various studies, we can clearly say that, one of the causes for initiation of industrial accident is poor management system such as policy, safety systems etc. For improving the safety culture and behaviour of the employee, industry needs to provide training, education, meeting, review etc.

For this purpose, the industry is in the position to spend money for the following aspects: Training, Education Meeting. Communication also plays a major role in accident because the performance of communication from top level to low level management is very poor. This paper deals with causes of accident and from these causes, we may to find out solutions and it tends to increase the performance of safety culture, safety performance and behaviour of the employee. Safety management system is an approach to reduce the accident rates and improve safety. Some of the key elements of safety management system are safety policy, safety assurance, safety risk management, safety promotion. This paper suggests some systematic approach of safety management system.

II. ORGANIZATIONAL SAFETY CULTURE

Safety culture plays a key function in determining an organization's success or failure and it's a part of organizational culture.

Organization with poor safety culture which are widespread, routine procedural violations, failure to comply with the company's own safety management system. Various steps have been used to improve the safety culture which are communicating the company values, demonstrate leadership, personalize safety outcomes, develop positive safety attitudes, engage and own safety responsibilities and accountabilities, increase the hazard awareness and preventive behaviors. Various factors in the safety climate terms have been used to measure safety culture: procedure, management commitment, visible management, safety attitudes, workmate's influences, employee's involvement, safety knowledge, management takes the initial work of identifying the hazard at the workplace by using various methods, HIRA (Hazard Identification Risk Assessment), JSA (Job Safety Analysis), work permit system etc. The aim of the management is to eliminate the hazard and minimize their risk at the workplace. Periodic evaluation, review of work at their workplace survey is a must.

The main objective of safety culture is to focus on the working environment, welfare facilities and legal requirements. According to the factories Act 1948, Sec.11 suggests cleanliness of work environment, Sec.12 disposal of

waste and effluents, Sec.13 ventilation and temperature, Sec.42 washing facilities, Sec.45 first- aid appliances, Sec.46 canteens, Sec.47 shelters, restrooms and lunch rooms, Sec.48 creches and Sec.49 welfare officers, the relationship between the management and workers must be smooth. It improves safety culture in the industries.

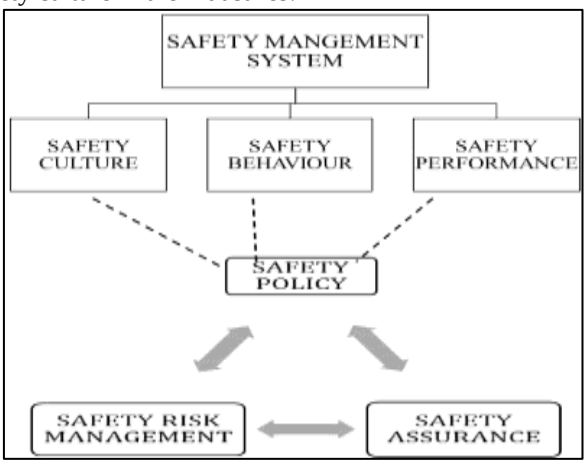

Fig. 1.1: Safety Management System (SMS)

III. OBJECTIVE

- To provide a generic guideline for Safety practices through Energy Isolation practices to be observed in Steel & Power Industries.
- To implement a document ,which provides details of Energy Source as a standard practice for carrying out maintenance work
- To study how this document helps in countering the safety issues in the Steel & Power Industries, their status of implementation and effectiveness.

IV. PROBLEM IDENTIFICATION

Steel & Power Industrial safety is an important global issue, and in particular, the Steel industry is over represented in workplace injury and death statistics. Despite modernization, this industry is exposed to dynamic & high risk environments.

In India, there were around 190 injuries recorded in the preliminary data for 2013, which was the second highest number of fatalities of all industries. This corresponds to a injury rate of 7.35 injury per 1,00,000 workers, which accounts for 16% of injuries for all industries. In addition, for the last six years, the steel industry accounted for about 135 deaths per year on an average in the country. This figure is one of the highest compared to other countries.

Safety culture is a concept that is gaining traction within this sector as a useful concept to further reduce fatalities, injuries and incidents. It has been used by organizations seeking to improve industrial safety. Even after taking proper permits & use of PPEs, accidents do happen as a result of false energization of the same equipment, on which the maintenance work is being carried out. This also happens due to employee unawareness/lack of knowledge of all the possible sources of energy, which in turn can prove fatal to the persons carrying out maintenance.

A. Examples of industrial accidents:

During this research, several incident reports were analyzed for determining the major factors causing accidents. Some of the examples of incident reports, which we came across, are as follows:

Sl. No	Year & Date	Details of Accident	Cause of Accident	Man days lost
1)	9/10/19	Mr XXXX, Age: 40 Yrs, Male, ElectricalChargeman Gr-1. 33KV switchboard shutdown was scheduled for maintenance. Permits were taken & the incomer breaker for the switchboard was made OFF. Before starting the maintenance work, the bus was discharged using discharge rod. The moment discharge rod was connected to 33KV bus, heavy flashover occurred. Thedischarge rod cable melted completely. Luckily Mr XXXX was not fatally injured& suffered minor burns as he was holdingthe insulated part of the discharge rod from a distance. The reason for the flashover is that the breaker OPEN condition was not confirmed. The breakerwas not racked out from service position. Isolation of Power Source was not confirmed before starting the maintenancejob.	Unsafe condition	2
2)	11/03/20	Mr YYYY, Age: 32 Yrs, Male, Straightening Machine Operator. He went inside the Block Maintenance Room to carry out the task of pin cutting assigned to him. During cutting of the pinin the Pipe Cutter the sparkles from cutting operation fell on the oil container located near him and caught fire. His cloths caught fire and he received burn injury as he escaped from the room through the Window and shouted for	Unsafe act & unsafe condition	6000 days
		help. The Plant Ambulance and the Plant Fire Tender were informed. He was taken to the Factory Medical Center by the Ambulance. He was shifted to the Burn Center OF hospital after preliminary treatment by the Factory Medical Officer , for further medical treatment, where he breathed his last on 27.03.2020 at 7.10 PM.		

Table 1: Examples of Industrial accidents

These are a few of many examples of accidents, which occurs at Steel & Power Industries. Unsafe work conditions & unsafe acts by employees plays a major role in these accidents.

V. FACTORS AFFECTING SAFETY PRACTICES IN STEEL & POWER INDUSTRIES

Some other factors which greatly affects Safety in Steel & Power Industries are:-

A. Poor Maintenance Operations

When heavy machinery and equipment are not maintained periodically, they can become very dangerous for operators, engineers, assemblers, electricians and compounders. Even a fail-safe mechanism may malfunction if operational issues go unchecked and are not fixed in time. To minimize the risk it is important to have vital infrastructure equipment inspected and serviced by in-house or on contract technicians on a periodic basis. However, at times even spaced out inspections may fail to address certain issues with the equipment. So, it is important that employees who work on specific equipment are trained to identify abnormalities like strange sounds or smell, exposed wires, vibrations, leaks, smoke, abnormal wobbling, irregular grinding or other potentially hazardous signs which indicate the need for an immediate shutdown.

B. Inability to Follow Risk Management Procedures

Machine guards protect employees from improperly installed machines. Signs and tapes help identify restricted areas or areas with limited access. Strict enforcement of safety codes and properly labelled chemicals that pose fire hazards help employees understand the risks and avert the hazards. Proper risk management procedures with hands-on teaching and demos are the best defence against manufacturing hazards. Accurate weighing with industrial floor scales is another great but often overlooked way to ensure that vehicles are filled to optimum safe capacity, ensuring compliance with safety regulations.

C. Not Wearing Personal Protective Equipment

Combustible liquids, open wires, spray booths; conveyor belts and automated vehicles make manufacturing facilities a high-risk environment. Fatigue, complacency, and carelessness further increase the risk and can lead to serious injuries in the absence of the right personal protective equipment. A clear, uncluttered facility that keeps safety top-of-mind and emphasizes the importance of wearing PPE can considerably reduce the risks involved in working around moving machines and heavy equipment.

D. Inadequate Safety Training:

Manufacturing facility is only as safe as the employees working for you and employees often work alone. So, when an unexpected event occurs, managing the most rapid response possible becomes challenging. This is why most manufacturing units have an appropriate safety training program in place to ensure employee safety against electrical hazards, chemicals burns, machines, moving parts and equipment.

E. Absence of Safeguards:

When Lockout/Tagout procedures are not in place, many energy sources can prove to be hazardous to workers who are servicing or maintaining electrical, mechanical or chemical equipment. Absence of safeguards can lead to an expected release of energy or start an equipment while it is being repaired, leading to a serious injury or even death.

F. Cause of Accidents

During the years 2019-2020, there were 33 accidents leading to fatalities in industrial maintenance. Among these, four of the cases involved two victims, thus making a total of 37 victims. During the reporting years, the number of severe non-fatal accidents was 90. In the case of fatal accidents, the maintenance operation was usually mentioned, whereas among severe nonfatal accidents the operation type was mostly not stated. According to the findings, the fatalities had mostly occurred during planned disturbance- and failure preventive operations. The most common accident scenes for the fatal accidents were indoors at a process (46%). Of the total number, 19% of the accidents occurred while executing maintenance operations outdoors (e.g. at a process pipeline) and 15% occurred indoors in maintenance workshops.

Maintenance operation	%
Planned disturbance- and failure-preventive operations	48
Unscheduled repairs	24
Changes (e.g. to processes and machinery)	18
Calibrations, testing, and inspections	9
Other/unknown	1

The fatal & non-fatal accidents were analyzed on the basis of the prime Organizational factors & were tabulated. It was found that DEFECTIVE WORK INSTRUCTIONS were causing the most number of accidents.

According to the findings, the most significant organizational factors were defective work instructions, whereas dangerous working methods were the most common unsafe acts. Victim's insufficient experience of task was identified among 20% of fatalities. Among unsafe acts, it is notable that working at a running machine or process is a cause in 15%–30% of accidents. The dangerous working methods refer to conscious risk-taking where the task is

executed in an unsafe way or without sufficient safety measures. Within both accident groups, defects in machine equipment are the most significant local workplace factors.

VI. ESID (ENERGY SOURCE IDENTIFICATION DOCUMENT)

Due to the specific characteristics of maintenance, such as varied tasks and working in close contact with machinery, a tailored tool was developed to properly clarify Work instructions & proper isolation of equipment, on which the maintenance work is to be carried out.

ESID (Energy Source Identification Document) provides proper isolation protocols as well as clarify the Work instructions in far better way. Its implementation in Industrial maintenance procedures/activities can surely eliminates the risk of accidents.

A. How to Isolate Power Source/ Energy Source

There are four methods of Energy Isolation -

1) Individual Isolator Isolation;
2) Isolation for working alone;
3) Group Isolation;
4) Control Stop Isolation

1) Individual Isolator Isolation:

This procedure is to be used preferably: -

1) when Isolation is to be done at a single place and
2) The agencies involved are not more than two.
3) The agencies asking for Isolation may be allowed to enter the area for applying the Personal Locks, without any risk to the plant, machinery, safety of person as well as Equipment and mal-operation. If any one of the above conditions are not met then Group Isolation method is to be adopted.

2) Isolation for working alone:

This procedure shall be used only where an Isolating Person wishes to isolate and be the only person (Maximum one more person is allowed) under the isolation. This procedure is permitted only when a single isolator need to be put off for taking the maintenance job. The person who is taking self Isolation must be Authorised Isolating Person for that particular job and the owner of the Energy source. This isolation procedure should be adopted in those location where the isolating person is the owner of energy source so in no case doing the isolation should not affect plant process flow.

3) Group Isolation:

This is used when number of isolators are to be locked. When only one Group isolation box is used: This is adopted when numbers of Isolators are to be locked. The Isolating Person ensures all steps of the Isolation procedure are carried out and all Isolators are locked in the safe position with an Equipment Lock. The keys for these locks are then secured in a compartment on a Group Isolation Box/Portable Group Isolation Box and locked by the Group Lock and the Personal Lock of every Protected Person covered under Isolation. Where the Isolating Person also wants to work as Protected Person, all the rules for the Protected Person shall apply.

B. Control Stop Isolation:

Control Stop is a method of stopping Equipment (where full isolation of energy is impractical to implement) for the performance of short duration, low risk routine tasks. A separate Control Stop procedure is to be developed. Where Control Stop can be used: It should meet all of the following criteria:

1) Routine Task
2) Short duration task i.e. < or = 30 Minutes
3) Low level of Consequences i.e. Even if isolation fails it should be restricted to minor injury.
4) Control Stop Procedure should be approved by Chief / Head of Operation and Head/ Sr Manager Safety
5) The Operator and working agency should be trained on Control Stop procedure

Where Control Stop can NOT be used: Control Stop System shall not be applied to, nor exemptions granted for the following job which are:

1) Non Routine job
2) Involve Electrical work on equipment or near bare conductorsc
3) Involve specialist isolation like High voltage or Combustion

C. Accreditation/Authorization:

Each Department shall identify the Accredited/Authorised Persons for every type of job. Only these persons shall be Authorised to do energy isolation for doing the job. These persons shall be defined as Isolating Persons.

1) TRAINING for conducting the isolation process:

Training in specific Isolation tasks is the responsibility of the department. Records of person trained shall be kept by the department. Isolation Planners, must complete Isolation Training Level-2. Protected Persons must complete Isolation Training Level-1. Isolating Persons must complete Isolation Training Level-1A. It is the department's responsibility to ensure that contractors working in the department are trained Level#1.

2) Energy Source identification(ESI)

ESI is a document which shall have the following details about Isolation for each particular type of maintenance jobs

1) List of Isolation points,
2) Method of Isolation,
3) The locking points.

3) The purpose of this document is:-

1) To have an established and approved procedure for all energy Isolation so no deviation occurs in the method of Isolation and locking points by different persons.
2) This document can be referred to by any external agency which is asking for energy Isolation and can be confirmed by them while placing the locks that the correct source has been isolated.

The ESI document should have a proper document number as per Quality Management System of the department and should be reviewed minimum once in a year for any revision.

D. Energy Identification

Energy comes in many forms. The key to energy source identification is understanding the equipment and machinery that you are working with and the types of energy that may be associated with the equipment or machinery. The following are types of energy to which an employee may be exposed.:- Electrical (E), Hydraulic Pressure (H), Pneumatic

Pressure (A), Potential Energy (PE), Thermal Energy (TE)
,Kinetic Energy (KE), Chemical Energy (CE)

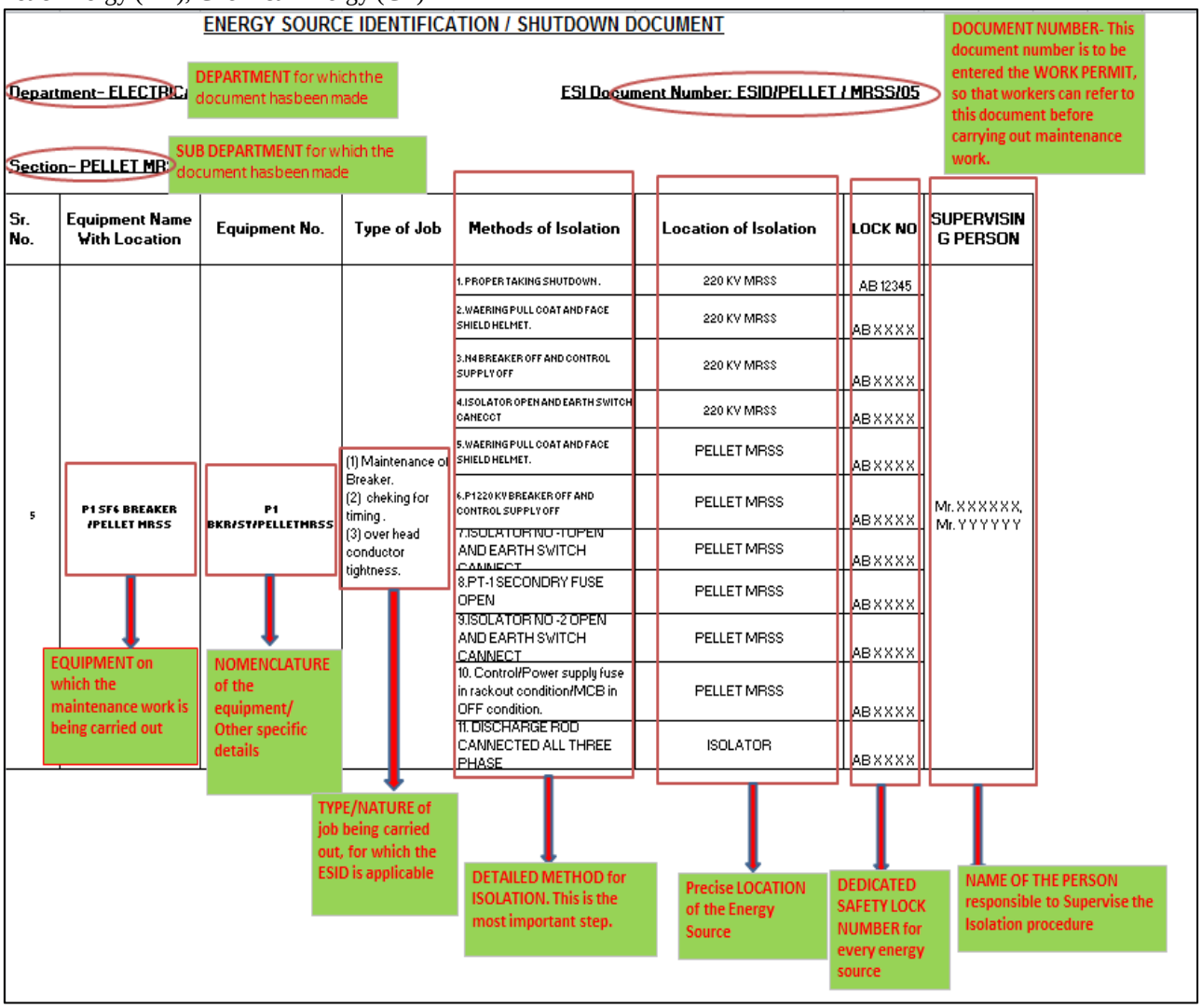

Fig. 1: ESID format

Fig. 2: Examples of LOCKOUT

Fig. 3: Example of Valve LOCKOUT

E. Display Boards at Maintenance site

A display board is to be made available on maintenance sites, at which all the essential documents regarding the maintenance job being carried out, is displayed. The information being displayed at the board should be presented in an easiest possible way, so that everyone involved in the job (be it a contractor person or job supervisor) can understand everything about the job. It should contain all the necessary information about the job, such as

1) WORK AREA: The equipment or area, on which the job is being carried out. This gives an important information about the work zone.
2) DETAILED DIAGRAM OF ENERGY SOURCE: A diagram is to be made (or a map) in which the WORK ZONE & THE ENERGY SOURCES are clearly marked. It should also show which energy sources have been isolated & which Energy sources are still active
3) WORK PERMIT: Work permit should be displayed on the board, containing the names of the persons & supervisors involved in the maintenance job being carried out.
4) ESID: An actual ESID (for the equipment/area on which maintenance is to carried out) is to be pasted on the board, or atleast a print out or carbon copy of the ESID (if actual document is in soft format). This is necessary as now every person can check whether the source isolation is being followed or not (before starting the job)
5) NAMES: Names of the all the persons who are designated to carry out the maintenance job. This ensures that
6) DESCRIPTION OF JOB: This consists of a list of all the jobs which has been decided/planned to carry out within the WORK ZONE.

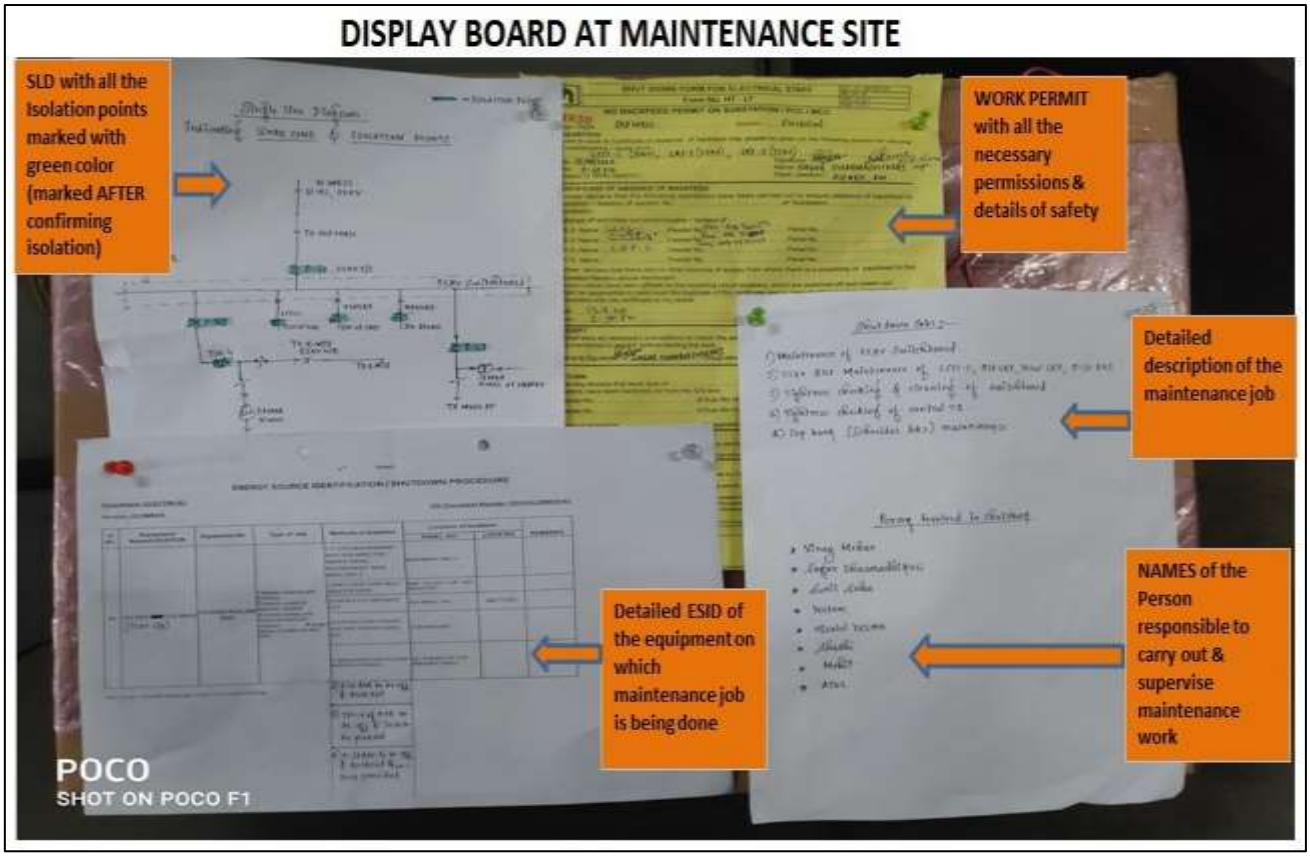

Fig. 4: Display board at Maintenance sites.

VII. RESULTS

The Safety data for Rolling Mill Maintenance operations for the period of January-2020 to December-2020 was analysed. Field observations were also conducted. Multiple discussions were conducted with the employees. A number of respondents' age lies between 30 and 40 years. These means the employees working in this companies are in productive age and if they face accidents, they are costly to the economy of the citizen. They have recommendable job experience so that we can consider them enough matured to give reliable data. Reduction of problems cannot be achieved without the involvement of employees and the company owners/managers.

The findings of the observations & discussions are tabulated, indicating percentages of several factors responsible for the accidents.

Sl. No	Fatal/Non-Fatal Accident causingfactors	No. of employees in favour	% (percent)
1)	Insufficient experience of the job inhand	10	5%
2)	Insufficient Safety equipment	14	7%
3)	Improper Work instructions	70	35%
4)	Risk taking by employees (dangerous working methods)	30	15%
5)	Defective/Temporary Working surface	32	16%
6)	Non utilization of PPE	10	5%
7)	Lack of Knowledge about safety	20	10%
8)	Improper hazard identification	14	7%
	TOTAL	200	

Table 1: The Findings

Out of 200 employees, 70 (35%) blames improper work instruction to be the major cause of accidents in Industrial areas. Another 30 (15%) says that "Risk taking" has been a major cause. Our analysis of the Incident Reports also reflects the same thing.

Both these factors are inter-related to each other. Lack of proper Work Instructions causes confusions related to the compliance procedure of the job & when the deadline comes close then in order to complete the job on an urgent basis, employees tend to take more risk. This in turn can causes a lot of unfavorable situations, leading to accidents.

KNOWING WHAT TO DO & HOW TO DO IT is one of the basic pillars on which the whole concept of ESID is based. By implementation of ESID at equipment evel, it is possible to completely eliminate some of the major accident causing factors,

This study tells us that INNOVATIVE IDEAS (such as ESID) support improvement of workplace environment through continuous improvement tools so that the working environment becomes comfortable. Occupational safety and health improvement or accident causes related factors such as Personal protective equipment, job systems, personal characteristics, occupational accidents/injuries, occupational injuries cost, occupational environment (external- internal), society, government, stakeholders/employers, employee participation, work culture, management culture/system, and family/individual are correlated with workplace innovation and sustainable development.

A. Implementation of ESID

It was decided by the management to implement the concept of ESID to reduce the rising number of accidents. The concept of ESID was implemented up to equipment level. Employees were made aware of the isolation practices & the ESID documents were controlled & standardized.

After the completion of training sessions of ESID, it was decided to implement ESID from immediate effect on the Preventive Maintenance 'of equipment, as Preventive maintenance were performed on a daily basis, sometimes even when the mill is in running condition. From March 2021 to June 2021, all the preventive maintenance & Scheduled Maintenance activities were carried out by keeping ESID as standard documents. The results were recorded & analysed at the end of each month.

Also, amendment sessions were organized at the end of each month, for the review of ESID documents. And some changes were made in the document for the SOP (Sequence of Operation) part & even on authorization level too, if needed. Some challenges were met in the first month of implementation, but as the ESID document became a regular process document, it was found that it enhanced the safety factor of the employees.

Below is a table for no. of Preventive maintenance jobs (PM) & Scheduled maintenance jobs (SM) carried out in each week for every month, after implementation of ESID & results in terms of NEAR MISS & Accidents.

Sl.no	Month	Week ofmonth	No of PM jobscarried out	No. of SM jobscarried out	No of NEARMISS	No. of Accidents
1)	MARCH-21	First Week	28	10	2	0
		SecondWeek	28	12	2	0
		ThirdWeek	28	7	1	0
		FourthWeek	28	9	0	0
2)	APRIL-21	First Week	28	12	1	0
		SecondWeek	28	8	0	0
		ThirdWeek	28	14	0	0
		FourthWeek	28	6	0	0
3)	JUNE-21	First Week	28	11	1	0
		SecondWeek	28	12	0	0
		ThirdWeek	28	8	0	0
		FourthWeek	28	9	0	0
4)	JULY-21	First Week	28	9	0	0
		SecondWeek	28	8	0	0
		ThirdWeek	28	11	0	0
		FourthWeek	28	11	0	0

Table 2: Results after implementation of ESID (MAY-21 not included as work hampered due to Covid-19 restrictions)

As it is evident from the above table that during the First week, some Near Miss were recorded. These caused some amendments in the SOPs of the maintenance. But once the system was perfected, we can see that the

Near Miss too were reduced to zero. And no fatal/non-fatal accidents occurred in the whole duration of study.

This shows that by following Energy isolation procedures according to a standardized, checked, revaluated & controlled document (ESID), it is possible to entirely remove unsafe conditions from the workplace. This also makes maintenance jobs easier as WHAT TO DO & HOW TO DO IT is now in documented form. Employees can now refer to it & can carry out maintenance job themselves as now they have a guide with them, which describes every step of the job.

Even in-experienced employees can learn the job quickly & safely. It develops a work culture which is more safety-oriented. This work culture gets reflected in other forms of jobs too, enhancing the overall level of safety being followed by the employees. It also pushes management for a more safety pro mind set, by purchasing more PPEs for employees, building better work spaces, following the guidelines of OSHA etc. This study has also attempted to see the industrial occupational safety innovation effect on the sustainable development. This research targeted and focused on the impact of ESID on the Industrial Safety by providing a guideline, which is applicable up to the equipment level.

VIII. Conclusion & Future Scope

The standard for the control of hazardous energy sources covers servicing and maintenance of machines and equipment in which the unexpected energization or startup of the machines or equipment or release of stored energy could cause injury to employees.

The rule generally requires that energy sources for equipment be turned off or disconnected and that the switch either be locked or labeled with a warning tag. Following ESID greatly reduces the risk of accidents due to un-planned or sudden energization of equipments. These sudden energization of equipments is one the major cause of accidents in Steel & Power Industries.

About three million workers actually servicing equipment face the greatest risk. These include craft workers, machine operators, and labourers. OSHA data show that packaging and wrapping equipment, printing presses, and conveyors account for a high proportion of the accidents associated with lockout/tagout failures. Typical injuries include fractures, lacerations, contusions, amputations, and puncture wounds with the average lost time for injuries running 24 days.

Due to the time limitations & restrictions due to the ongoing COVID- 19 crisis, the result of the study was concluded based on the 4-month data. But as approach to a safe & healthy work environment is an everlasting & ever improving process, the data collection will be continued in the near future as well. And feedbacks from the employees, employers, contractor person to be taken so as to further improve the ESID model. The challenges/ problems, which will come in the future, regarding the following of ESID will also be studied, analysed & rectified.

Once this study at Steel & Power Industry concludes, then the same model is to be applied to other industries as well. And to see, how other industries react to this form of safety procedures, what challenges arise from their side & how to compensate for them.

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