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# Risk Analysis & Risk Theories implementation in Hazard Identification & Risk Assessment of Aluminum Industry

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***Abstract : Risk Analysis is being done to identify and manage the major / potential problems in the industry . Risk Analysis some times may be more complicated .For doing the risk assessment , risk analysis has to be done . Risk assessment is the technique to analyse the actual level of risk and its consequences associated with a particular activity. In this method one activity is to be taken and that to be discussed with competent risk assessment team and historical data of same is to be analysed to find out the actual consequences of a particular hazardous activity. All the findings should be recorded separately for different activities. Risk Analysis & Risk assessment of a particular unit of the aluminium refinery will be taken in to consideration for the implementation of this technique . By using this technique many hazards can be controlled and the risk of accidents can be reduced in the industries by the proper implementation of Risk Analysis and risk theories. It will be helpful for the Safety professionals to identify the hazards and risks associated with those hazards and successful elimination of the hazard's or the reduction of the risks by proper implementation of Risk Analysis and Risk Theories .***

***Keywords : Risk Analysis , Risk Theories , Risk Assessment , Aluminium Industry Risk Assessment , Qualitative Risk assessment , Quantitative Risk Assessment .***

## I. INTRODUCTION

In current scenario of Industrialization world new types of hazards are arising very faster manner. As industrial demand and supply have a limited time period, so it is difficult to control. So within this limited time schedule worker have to work and production is must for all organizations. To control all type of industrial hazards most of the companies in India are following ISO 45001:2018 Occupational Health & Safety Management System (Previously OHSAS 18001), Factories act 1948 and other act & rules as per the industry category, where it is mentioned that all the potential hazards should be identified rectification is not possible. through HIRA technique & safe system of work and Risk assessment sheet must be provided.

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This is a legal requirement for all organizations otherwise enforcement action may take by authorities. So to achieve zero accident in industry HIRA technique must be followed where risk assessment is carried out for all potential hazards.

## II. RISK THEORIES

Risk assessment, control and communication are parts of the broad risk management system of a firm. These three approaches contribute differently but perspectives for overlapping on the assessment, control of risk and communication , the, psychological, technical/engineering and social-cultural approaches. The details of these approaches are discussed in this following sections.

## III. ENGINEERING OR TECHNICAL RISK APPROACH

Engineering approach towards risk involves the technological & scientific approach to manage risk at construction site. In this thinking, risk can be quantified to a number by a mathematical relation and the real accidents and injury record available at a work site. The level of risk can be estimated ,as the probability of the occurrence of an incident (in the given period) and the magnitude (seriousness) of consequences associated with these occurances (Marhavilas and Koulouriotis, 2011).

RISK = PROBABILITY (P) * SEVERITY (S)

As per this method risk is assessed in quantitative terms which relies on the probability information available at site such as accident and injury records and accident statistics. Many statistical & probabilistic risk assessment methods are available from the engineering approach such as Effect Analysis & FMEA (Failure Modes), actuarial approaches and The Probabilistic Risk Assessment (PRA).These methods often are not possible in many cases as they allow the incorporation of vague terms & subjective and heavily rely on statistical data that might not be available at work site.

### A. Phychological Risk Approach

In psychological risk approach, an individual's cognitive perception to a particular risk comes into action. This approach focuses on the individual's perceptions of investigating, attitudes, perspective, beliefs and the values. Selvic et al, 1987 explained the difference between knowledge and risk judgment by pointing out the concept that The risk is considered as multidimensional and complex than the statistical concept of the engineering /technical approach. The focal point in this approach of risk is that the manner risk is judged , assessed,

and communicated depends largely on an individual's cognitive perception of risk.

The problem is that different persons perceive risks differently depending upon their experience, education level, religion, nationality, social influence etc. Hence the responses recorded in this approach are not fully reliable for risk judgment.

### B. The Socio Cultural Risk Approach

The socio cultural approach based on the risk perception of persons as influenced by their society and region. They are being a part of an evolving social debate about knowledge, feelings, past experiences &, power relations , and a culture of the society (Douglas and Wildavsky, 1982). In this present study the risk assessment and communication has been based on the concept of probability of engineering, as well as the socio-cultural & psychological perspectives.

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### C. Abbreviations and Acronyms

ISO – International Organization Standard
HIRA-Hazard Identification & Risk Assessment
PRA - Probabilistic Risk Assessment
FMEA- Failure Mode Effective Analysis
SSOW- Safe System of Work
PPE- Personal Protective Equipment

### D. Equations

RISK = PROBABILITY (P) * SEVERITY (S)

### E. Figures and Tables

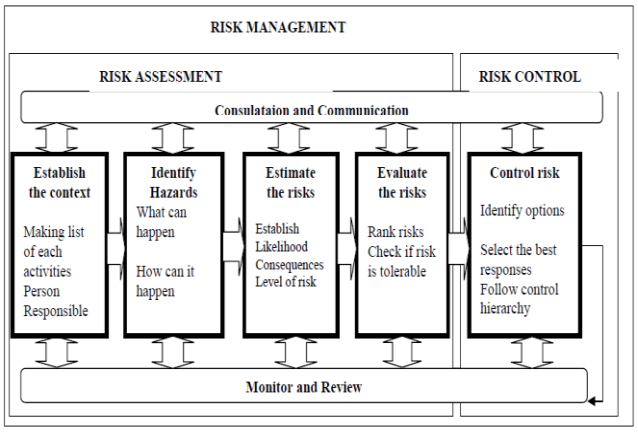


**Figure 1 Risk assessment of health & safety, control and communication lay out.**

| Severity of consequences ratings | Hazard probability ratings 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 6 |
| 2 | 2 | 4 | 6 | 8 | 10 | 12 |
| 3 | 3 | 6 | 9 | 12 | 15 | 18 |
| 4 | 4 | 8 | 12 | 16 | 20 | 24 |
| 5 | 5 | 10 | 15 | 20 | 25 | 30 |
| 6 | 6 | 12 | 18 | 24 | 30 | 36 |

| | | |
|---|---|---|
| | Unacceptable | 18-36 |
| | Undesirable | 10-16 |
| | Acceptable with controls | 5-9 |
| | Acceptable | 1-4 |

**Table 1 Risk matrix table for qualitative approach and risk rating** (Source: Selvic. P, 1987)

| Severity of consequences ratings | Hazard probability ratings 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 | 6 |
| 2 | 2 | 4 | 6 | 8 | 10 | 12 |
| 3 | 3 | 6 | 9 | 12 | 15 | 18 |
| 4 | 4 | 8 | 12 | 16 | 20 | 24 |
| 5 | 5 | 10 | 15 | 20 | 25 | 30 |
| 6 | 6 | 12 | 18 | 24 | 30 | 36 |

| | | |
|---|---|---|
| | Unacceptable | 18-36 |
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**Table 2 The Matrix for quantitative approach for estimating & rating the risk**

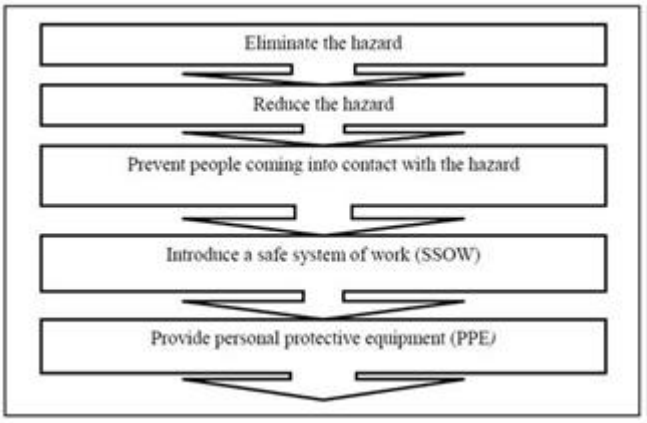


**Figure 2: Risk control hierarchy: Source (Lingard and Rowlinson, 2005)**

## IV. RISK MANAGEMENT SYSYEM

Many researchers (HSE: 2004; Rowlinson & Lingard , 2005; Ferret & Huges, 2011) have developed the risk assessment methodologies to suit their requirements. Though there are no restriction on methodology to be adopted for risk assessment but, there are some of the general principles that needs to be followed.

However, all the methods of risk assessment are different in terms approach but similar in terms on the basic principles and contains the key components as shown below in the figure 1 .

**Establish the context:**

It is the first stage of the risk assessment process as it analyses the work activities to be carried out. This includes making a list of people to be involved, responsibility to be assigned, detailed work procedure in chronological order, materials required, loading and unloading location, equipment's to be used etc. For this various information's are required such as the organizational charts, interviews,the records and the 'walk-through' survey of the work site. Walk through survey is considered to be the most effective way of listing out all the activities and possible failures at site (Huges and Ferret, 2011).

Figure1 represents the a typical risk management system which consist of four stages. Risk assessment is a step wise process consisting of distinct and interrelated phases such as the context establishment , risk identification, risk estimation , risk evaluation and controlling to the risk. Prior to identifying a hazard, the context must be established.

Figure 1 also indicates that risk assessment, risk communication and risk control in a cyclic process rather than a linear process which is undertaken once. The cyclic nature of the risk assessment is important in the view of constantly changing . It is cyclic in nature where at the each stage there is a communication, monitories if the construction site where new hazards and risks emerges periodically.

**Risk Estimation and Characterization:**

After identifying the risks it is estimated by considering number of people are exposed to each hazard and exposure time. So the probability and the severity of harm that can be caused by a hazard can be estimated. Meanwhile in order to find out the probability and severity of harm, it is required to know about ,The flow of the typical workday activities at the construction site. knowledge of the regulations and safety standards under which the facility operates is also important, as some of the regulations provide the guidelines about risk assessment procedure. Furthermore, experience of the estimator is also a requisite as it will be required to estimate risk ( Rowlinson and Lingard 2005).

There are three techniques / methods which can be used to determine or estimate the probability and the severity of a hazard.

I. qualitative method,
II. quantitative Method and
III. semi-quantitative

**Qualitative Risk Assessment:**

Here the probability and consequences of risk are estimated in descriptive terms. It relies completely on an individual's experience, education level as well as social and regional belonging. Risk identification terms of low, medium or high risk (selvic 1987) . To rank various risks in order of importance, a risk matrix (Table No 1) has been used. It is also noted that greater the magnitude of risk, the greater the urgency to control the risk and take action.

Table 1 shows a typical example of the , Ranking mechanism of the matrix, by indicating different risk levels. Risk is defined and categorized in five different groups such as [level] 1negligible injury as, [leve2] minor injury ,

[level 3]moderate injury , [level 4] major injury and [level 5] as fatality. In the same way, likelihoods can be determined as:[ level A] very likely, [level B]likely , [level C] possible, [level D ]unlikely, or [level E] rare.

Table 1 indicates that there are 25 potential risk's combinations and the outcomes of the risks have been divided into four risk levels (ratings) as, Extreme, High, Moderate and low. This matrix indicates that high rating fatal consequences should be dealt first while low rating indicates negligible injury which requires the primary treatments such as first aid.

**Quantitative risk estimation :**

The Quantitative risk estimation uses many numerical values to explain both the likelihood and consequences of an incident that is likely to occur. It also involves an intensive mathematical equations and a modelling to rank risk; such as high, medium and low. It describes that , risk is the frequency of injury or death. The risk can be calculated by considering the potential consequences of an accident, the probability factor and the exposure factor. Meanwhile, a risk matrix can also be also used for quantifying the risk as in the case of the qualitative approach. However, only numbers are used to take the decision on both the probability and the the consequences. Table 2 , shows the matrix for estimating the quantitative risk. Table 2 shows the quantitative risk assessment matrix which has risk categorization of six levels. It is clear from the matrix that as severity and probability increase, the risk also increases. This technique is very useful for offsite risk assessment activities. Some example where quantitative risk matrix technique is extensively used are transportation of construction material and industrial production materials (Ferrett and Hughes, 2011).

In the other hand, The semi-quantitative method / approach is the intermediate level in between the quantitative and qualitative method. The Semi-quantitative method is used for estimating the risks than the quantitative Method (Rowlinson and Lingard , 2005).

**Risk Evaluation**

The main purpose of risk evaluation is to determine the people's acceptability level of risk in the organization (Lingard and Rowlinson, 2005). Some risks cannot be reduced due to some unavoidable reasons, in that case to controlling the risk is the better option than reducing it. If risk is not acceptable, then the risk reduction pyramid is used. The risk reduction pyramid is hierarchical in nature which different levels according to priority (Barnard, 2005).

**Risk Control**

The control measure is the part of a facility, including any procedure, system, device or process that is intended to eliminate the hazards & reduce the severity of the consequences of any incident that does occur (Rowlinson & Lingard, 2005). According to (Huges and Ferret, 2011) Control measures may be proactive or reactive. In proactive approach includes elimination, prevention or reduction of the likelihood of incidents whereas in reactive approach, it tends to reduce the consequences of incidents.

In the occupational health and safety context, risk control is done by using the "risk control hierarchy". This hierarchy helps to decide on which risk control to implement. The preference of selecting the risk control option is arranged in a hierarchical manner from top to bottom. Figure 2 represents the risk control hierarchy.

Figure 2: Risk control hierarchy: Source (Lingard and Rowlinson, 2005)

The first stage of the risk control hierarchy is elimination which means control measures are taken to completely eliminate the hazard from arising. It is difficult to eliminate all the unsafe conditions, and therefore elimination is not always possible (Marhavilas and Koulouriotis, 2008).

The second stage is reducing the hazard or substituting the hazard with something that is less hazardous than the previous one, for example carrying a lighter load when handling manually or using less toxic paint. The third stage is preventing people coming into contact with the hazard which is also known as "Isolation". It means if risks are there at source and the above two risk control strategies fails to be applicable, in that case the hazard can be isolated from the people around by simply blocking their access to the hazard. Some of examples are machinery guarding, installing fences and barriers, circuit breakers, installing toe-guards to open edges on landings, fixed platforms and stairways.

The fourth stage is the introduction of a safe system of work (SSOW). The main objective of this is to identify the major hazards present in an activity and to ensure that appropriate control measures are in place before commencement of work. This uses information such as correct procedures and safe systems of work, supervision, instruction and training. The use of personal protective equipment (PPE) is the last stage in the Risk control hierarchy. Huges and Ferret, 2011 stated that PPE should be opted only as the last alternative and only after all other controls have been implemented.

## V. RESULT AND DISCUSSION

By using this techniques at Aluminium Warehouse / Bagging Plant of NALCO , many hazards were being found on the site and reported . Risk Analysis and Risk Theories were being studied for the implementation on site for the reduction of risk .Risk assessment has been done for every hazards individually and reported to the EHS Department . These techniques are found satisfactory in the Aluminium Industry . By using these techniques risk ratings were given for all hazards according to its probability and severity . HIRA was prepared for the site by using this technique and alternatives solutions were being found for the elimination of the hazard's from the site and risk has been reduced after using this technique .

## VI. CONCLUSION

We have applied this technique to the warehouse unit (Aluminium Bagging Plant) of National Aluminium Company Ltd ( Asia's Largest Aluminium Refinery, A Govt PSU ), This unit of NALCO was considered as a very hazardous unit inside the plant as per the past history .Warehouse plays a crucial role in every industry . The hazard's can be eliminated if we follow proper techniques to identify the hazard's and also the risk of accident/incident can be reduced. Hazard's are the agents which are having the potential to cause harm those who are exposed to it . There were so many hazards found on the warehouse unit of Aluminium refinery during the site inspection. The hazard's found on the site has been recorded and informed to the company . Due to the hazard's who are coming under risk( person/property/business) has been reported to the company and risk matrix and hierarchy of control techniques are being studied to eliminate the hazard and control the risks associated with the hazard's . Risk Analysis and Risk theories were being studied and implemented in this hazardous unit of NALCO whose results were found satisfactory and the recommendations were also accepted by the EHS Department for further implementation at various other sites to maintain a good safety culture in the plant .

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