EFFECTIVENESS OF SAFETY MANAGEMENT IN CONTROLLING OCCUPATIONAL ACCIDENTS IN TRANSFORMER MANUFACTURING INDUSTRY IN SRI LANKA: MANAGEMENT PERSPECTIVE

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Declaration

I hereby declare that I compiled this thesis and it is a record of the work I completed. I have read all references cited here and that it has not been earlier accepted by a degree or diploma in any other university or institute of higher learning. To the best of my knowledge and my belief, this research document does not contain any material previously published or written by another person except where acknowledgement has been made in the text.

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The candidate mentioned above has conducted the research for the dissertation for the Degree of Masters under my supervision.

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Prof .(Mrs.) Nayanthara De Silva Date

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Abstract

Effectiveness of Safety Management in Controlling Occupational Accidents in Transformer Manufacturing Industry in Sri Lanka: Management Perspective

Effective management of occupational health and safety (OSH) is vital in every industry. It enhances the favorable motives for the accomplishment of goals in a particular industry. The effectiveness of safety management procedures for controlling occupational accidents in manufacturing industry has been acquired increased attention over the recent times. It can be understood that it is crucial to avoid occupational accidents caused by poor management and awareness related to OSH practices in Sri Lankan context. As a result of mitigating accidents, desired productivity can be achieved. Therefore, the study aimed to assess the effectiveness of occupational safety and health management systems in accident prevention at Transformer Manufacturing Industry (TMI) in Sri Lanka. In the literature synthesis of the study, possible hazards and injuries have been discussed with their risk and security levels. Questionnaire survey was used to collect primary data and further company accident data were referred in data collection process.

The most common accident identified are slips and trips, cut and laceration, being caught in or stuck by moving machinery, and overexertion injuries. Since the implementation of the occupational safety and health management system in the work environment became safer and there was a decline in the number of lost time accidents recorded each year thereafter according to TMC accident primary data. High risk accident has been identified as an eye injuries and electrocution injuries. The existing occupational health and safety management system at transformer manufacturing company met the majority of the requirements comprehensive safety management systems. Furthermore, is implementation of accident control actions and the occupational safety and health management system are align with international standards always improved the occupational safety and health performance generated positive results in health and safety sector. With the proper involvement of management practices in monitoring and controlling occupational accidents, higher productivity can be assured with lesser negative consequences in transformer manufacturing industry.

Moreover it is understood that, mitigating occupational accidents assures the availability of potential skilled workers in the manufacturing industry which benefits the country's economy as well as social wellbeing.

Key Words: Occupational safety and health, Occupational accidents, Effective management, Transformer manufacturing industry

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LIST OF ABBREVIATIONS

Abbreviation	Description
TMC	Transformer Manufacturing Company
HIRA	Hazards Identification and Risk Assessment
LTA	Lost Time Accident
LTI	Lost Time Injury
OSH	Occupational Safety and Health
PPE	Personal Protective Equipment
SOPs	Safe Operation Procedures
SPSS	Statistical Package for the Social Sciences
SMCA/MCA	Safety Management Control Action/ Management Control Action
WREI	Work-Related Eye Injuries
OHSP	Occupational Safety and Health Practices
TMI	Transformer Manufacturing Industry

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CHAPTER 01

INTRODUCTION

1.1 Background

The transformer manufacturing industry is complex, challenging and difficult. In this modern era of advanced technological development, the manufacture of the largest standard converter and industrial power transformers goes back in history to 1831, when Michael Faraday made his observation of electromagnetic induction. Since developing transformer technology to match the specifications of different distribution and transmission as well as industrial applications through the decades, Grid Solutions has been in the lead of the transformer evolution (Transformers Magazine, 2020).

Mainly Sri Lankan transformer manufacturing industry (TMI) is an export oriented business therefore it caters for the local market for minor scale (EDB, 2018). In Sri Lanka, there are two main transformer manufacturing companies. The workforce of the biggest company is more than 1000 employees and it its 100% production is for the export market. The second company has more 300 employees and is the sole manufacturer of power distribution transformers for the Ceylon electricity board in Sri Lanka. There few other TMCs, but they only manufacture the assemble products for the main equipment according to information of export development board. Therefore, these companies are listed under the category of electrical and electronic component manufacturing companies.

Within the last decade, quite a number of workplace accidents has been reported in related to transformer manufacturing industry. For instance, in 2017, five electrical industry employees, together with a manager, died in a single working accident in Florida, USA (Bedi, Capriel, Dawson, & McGrory, 2017). According to an article in the Sunday Times newspaper on 2016-07-24 under the heading of “Industrial Accidents on the Rise”, more than 30 people are admitted to the Colombo National Hospital on a daily basis due to an increase in industrial accidents. More than 12,000 persons were wounded in workplace accidents in 2015, out of a total of 121,032 patients hospitalized at the General Hospital in Sri Lanka.

Accidents in the transformer testing and commissioning procedure have a high impact and are harmful, notwithstanding its scarcity. Despite the fact that the electric power business places a high priority on workplace safety and devotes significant resources to it, worker injuries and fatalities continue to occur. (Fordyce, 2007; Volberg, 2017). There are three main types of hazards such as physical, mechanical, and chemical, that lead to workplace accidents in Transformer Manufacturing Industry (Steven Jerie and Naison Mandebere (2019). Examples for physical hazards that occur are slipping, falling, fire, noise, and vibration, and also electricity. Mechanical hazards found in all manufacturing divisions include floor openings, falling items, unguided moving parts like fork lifters, and poor housekeeping such as insufficient ventilation and many more. Chemical hazards are directly linked to the varnish and finishing in the plant section. The chemical risks are fire, explosions, leaks, spills and fumes (Steven Jerie and Naison Mandebere, 2019). Melis Tabak (2011) states that most of the accidents referring to transformer manufacturing companies are cut injuries, slipping and trappings, being seized in or struck by moving machinery, electrocution, eye injuries and falling from heights and exposure to hazardous materials.

Most of these accidents can be avoided through the use of safety gear and education. Basically, electric utility personnel should be well aware of the risks associated with electrical work on and testing electrical systems and working arrangements and conditions (Fordyce, 2016). Further, trainers could be able to better prepare workers to run down the risks of electrical work and to mitigate hazards if they had a better understanding of the preventive methodologies (Fordyce, 2007; 2016). Organizational procedures, equipment, manuals, manufacturer's instructions, on site exercises, and publications can all help employees obtain explicit knowledge. Management involvement and management strategies are very vital to prevent accidents and injuries for employees of that industry Diaz RT, Cabrera DD (1997). Thus, analyzing the required management practices for the managerial staff to guide their subordinates to prevent these significant injuries, is a vital requirement.

The main focus of this research is on reducing accidents in the transformer manufacturing industry and preventing serious injuries and fatalities among employees. Furthermore, it is needed to identify the probability and severity of accident occurring and the effectiveness of accident controlling actions.

1.2 Research Problem

TMI has been recognized as vulnerable to accidents due to exposure to a wide variety of hazards at work Steven Jerie and Naison Mandebere (2019). However, the findings of research papers on the occurrence of accidents in the transformer manufacturing sector are very few.

As described in the background study, prevention of accidents have been played a major role in the successfulness of the manufacturing industry. If the number of accidents and their severity were increased, the loss of the productivity and additional overhead costs which affect the net profit of the production process can occur Hamid, H. A. (2015). Sometimes, it may lead giant manufacturing companies to loss their market value or sometimes their market reputation too Hamid, H. A. (2015). Additionally, transformer manufacturing process can be considered as highly technical and the expertise workmanship due to its complex nature. As the product is used in high voltages the poor workmanship may result in severe disasters in their operational time, transformer manufacturing companies are tend to absorb the higher qualified workmanship at any cost. But, as described in the background, severe damages and accidents cause to decreasing the available skilled workers for the industry.

Hence proper monitoring and management of avoiding occupational accidents is crucial Gyekye SA, Salminen S (2007). The main issue related to occupational accidents is poor accident controlling strategies by the management Diaz RT, Cabrera DD (1997). The standard guideline or comprehensive framework cannot be observed in effective management of avoiding accidents in manufacturing industry. Research papers are very few on this industry, especially on safety and health related areas in manufacturing industry compared to construction industry. It observed that there are few OSH related research studies for the manufacturing industry “Safety and Health Practices and Injury Management in Manufacturing Industry Taufek, F. H. (2016)” but they are also restricted to specific industries. Hence the study focused on accidents related to TMI and effectiveness of safety management in controlling occupational accidents by fulfilling the gap.

1.3 Significance of the Study

This study can be described as the first research related to identify the effectiveness safety management in controlling actions in occupational accidents specialized in the transformer manufacturing industry. Therefore, this research would be able to fill a vacuum in the literature caused by a lack of similar studies in Sri Lanka. The results of this study will assist occupational safety management in developing employee health and safety strategies. The research would also add to the existing literature on occupational accidents in the TMI, as well as training and competency requirements, and provide insight into the current condition of employee health and safety standards in the industry and across the country. The findings of research would aid testing whether the theoretical part can be applied practically and expand the areas of research.

1.4 Aim of the Study

To test the effectiveness of safety management in controlling occupational accidents in transformer manufacturing industry in Sri Lanka.

1.5 Objectives

Following objectives are set to;

I. Identify accidents and injuries in the transformer manufacturing companies in Sri Lanka.

II. Analyze the risk levels and severity levels of accidents and injuries.

III. Analyze the level of practice of safety management practices and assess the effectiveness of present safety management practices for managerial staff to guide their subordinates to prevent accidents and injuries in TMI.

1.6 Research Methodology

Research methodology is a way of attending the research study and obtain the desired aims and objectives. It can be supposed as a science that studies how scientific research is carried out. In this examination, the many processes can be discussed that a researcher takes when logically studying applicable research questions. The researcher must be knowledgeable about the research methods and procedures, with the appropriate approach.

The initial step in study methodology is to select the area. The second step is to decide the study population and study samples. The next step is to adopt a study design with study tools and the method of data collection. In Chapter 03 Research Methodology will be discussed in detail.

In the first stage, injuries and accidents will be identified in the selected organizations. The second stage is identifying the risk levels of these accidents. The final stage, level of practice of safety management practices were analyzed and assessed the effectiveness of present safety management practices for managerial staff to guide their subordinates to prevent injuries.

1.7 Scope and Limitations

This study results proved to be useful in the transformer manufacturing industry due to the uniqueness in this industry. For this research, two main transformer manufacturing companies were selected in Sri Lanka. Other industries are not directly involved in transformer manufacturing. To identify the background of the research problems, TMI and also electrical power industry literature were used because the basic product is transformers in the electrical power industry.

TMI industry in Sri Lanka runs by two large scale manufacturing companies which are subsidiary companies of world renowned transformer manufacturing companies. Although both companies were selected for data collection, due to the Covid 19 pandemic situation last year, data collection had to be stopped in one transformer manufacturing company but relevant information and published data was used to proceed with the research.

CHAPTER 02

LITERATURE REVIEW

2.1 Introduction

This chapter contains literature for the present study and comprehensively explains in focus areas of the study. The first part of the chapter reviews existing literature related to the study area in the transformer manufacturing industry. The next part reviews the literature explaining hazard identification and risk assessment of the transformer manufacturing industry. The third part of the literature review elaborates on the importance of management involvement in controlling accidents. The last section of the chapter explains the management practices used to control accidents in the transformer manufacturing industry.

2.2 Overview of Transformer Manufacturing Industry

According to Transformer-Global-Market-Report-2021, the global transformer market is expected to grow from $184.21 billion in 2020 to $202.08 billion in 2021. The market is expected to reach $266.73 billion in 2025 at a compound annual growth rate (CAGR) of 7% Global Transformer Market (2021 - 2026). The global electricity demand can predict around 38,700 terawatt-hours by 2050, around 30% higher than the consumption in 2006, which is reinforced by the enlargement of the transmission and distribution (T&D) network. This led to significant demand for T&D equipment, such as a transformers. The distribution transformers are expected to dominate the market, owing to the increasing number of load centers across the world. Now the cost of renewable-based power generation has come down consequently, power distribution and transmission requirements are expected to increase, which will increase the market share for manufacturing and supplying the transformers (Transformer Magazine 2020).

According to information, lead market share is for the Asia-Pacific region, increasing infrastructure development investments in power distribution and transmission sector. Moreover,

Sri Lankan renewable energy strategies over the next 10 years and the predicted power requirement of the next couple of years have been key concerns to forecast the growth of the transformer manufacturing industry. Hence the skilled workmanship should also have to be inadequate level to satisfy the market needs in transformer manufacturing. Therefore, it is crucial to assess the importance of management contribution in mitigating occupational accident in transformer manufacturing industry.

2.3 Occupational Health and Safety Accidents in Workplace

Workplace accidents can have a highly negative effect and a major impact on daily production, depending on the type of work. Dangerous situations can arise when high risk machines are handled Ali, H. Abdullah, NA Subramaniam, (2009). There can be several other ways that can result in accidents at the workplace. As the first step in preventing accidents, it is needed to understand the reasons or root causes for their occurrence.

The concept of 'accidents' has been considered as normally random incidents, conveying a combination of ideas such as injuries, unexpected situations, property loss and unexpected results (Loimer & Guarniri,1906). One person's actions or reactions can be planned, or unplanned, substance or an article resulting in an injury or the probability of happening incident is considered as accident (Heinrich et al., 1980). In the issue, there is the possibility of the contribution of the human factor. Some are linked to the organization, such as the management system and the training methodologies, while others are linked to the nature of the job profile: for example, the design of work place. The goal of any organization is zero accidents and is difficult to maintain need to do lot of work to achieve the goal. The social and human costs of workplace hazards would be reduced by introducing proper health and safety strategies (Gyekye, 2010).The Domino theory was developed by Heinrich, who was a leading industrial engineer (Heinrich, 1980), which explains these accidents. In his view, he divided all accidents into five categories, including ancestry and social environment, the fault of the person, unsafe acts or physical or mechanical hazards, the actual occurrence of accidents and finally, the resulting injuries.

According to Gyekye (2010), occupational accidents are mostly caused by two fundamental causes: internal causative factors, which are the characteristics of the worker, and external causal factors, which are the features of the work environment.

2.4 Occupational Health and Safety Accidents in the Transformer Manufacturing Industry

Table 2.1: Occupational health and safety hazards associated with the transformer manufacturing sector.

Types of Hazards	Hazard	Impact
Physical Hazards	Electricity	Death, general injuries to the body, electrocution
	Noise; Slips; Trips; Falls	Damage to the ear; Cause accidents due to communication brake down and injuries.
Mechanical hazards	Opening of the floor; Falling objects; Unguided moving parts eg shock lifts bad house-keeping like poor ventilation and dirty toilets poor materials of PPE	Sickness leading to spread of diseases.
	Welding, Soldering	Eye damage; Skin injuries, burns
Chemical Hazards	Liquid fluids; Solvent used to dissolve grease; Oil paints Glue; Fire; Explosions; Spill; Fumes and vapor.	Damage to the skin especial acid, Damage to property.
Biological Hazards	Bacterial ;Viruses; Fungi	Sickness.
Ergonomic	Poor work station; Physically heavy work; Poor working postures; Wrong working methods.	Sickness.
Psychosocial	Stress	Fatigue, Social and domestic instability; Violence and sickness.

Source: International Journal of Research and Innovation in Social Science (IJRISS) |Volume III, Issue VI, June 2019

Table 2.1 shows hazards to worker's health and safety linked with the transformer manufacture industry. The proper implementation of a safety management system can help to prevent accidents by lowering risk levels (Maruta, 2005). Physical hazards affect the majority of employees, according to table 2.1. Physical hazards include things like noise, fire, vibration, slippage, falling, and electricity. Mechanical hazards affect all sections of the company. Mechanical hazards include

floor openings, falling objects from above, moving parts without monitoring, and bad housekeeping, such as insufficient ventilation and inadequate PPE. Workers who contact with chemicals experience accidents and incidents. Chemical hazards in the transformer manufacturing trade include sudden fires, huge blasting and explosions, hazardous chemical leaks, and workers' exposure to fumes and vapors (Steven Jerie and Naison Mandebere 2019).

As identified by Steven Jerie and Naison Mandebere (2019), mainly physical hazards occur in the TMI. As indicated, electricity falls, noise, fire, vibration, falling objects, openings in the floor, improper housekeeping are common examples of physical hazards in the Transformer Manufacturing Company. Those hazards will lead to the occurrence of accidents and finally will cause injuries.

In addition, the discussed ergonomics hazards such as poor working postures, poor work stations and wrong working methods are associated situations. These are mainly recognized throughout the plant involve the lifting of transformers and cores, and henceforth muscular-skeletal issues result from repetitive activities such as lifting of transformers and carrying etc.

According to Melis Tabak (2011) most of the accidents referring to transformer manufacturing companies are cut injuries, slips and trappings, being seized in or struck by moving machinery, electrocution, eye injuries and falling from height and hazard material exposure. Eye injuries triggered by not wearing goggles or wearing improper goggles, and also hand-cuts injuries reported during the manufacturing process Melis Tabak (2011). In addition, various other types of hazards, such as chemical and psychological, are discussed.

2.5 Types of Accidents and Injuries Transformer Manufacturing Industry

2.5.1Overexertion Injuries

Overexertion injuries are lifting, pulling and carrying activities. Injuries to arms, legs, joints, repetitive strain and musculoskeletal disorders result from these accidents (Coreland, 2013). The repetitive movements of legs or arms, awkward postures and heavy manual labour and previous prevailing injuries can increase the risk of injury (Coreland, 2013). Overexertion can be caused by ergonomic hazards such as a poor workstation, heavy work, wrong working postures and methods (Steven Jerie and Naison Mandebere 2019).

2.5.2 Electric Shock

Electrical hazards in the workplace are electrocution and shock. Mittman (2016) stated that common cases of serious or fatal injuries or accidents are from fire, resulting from faulty electrical equipment, electric shock and those are extremely dangerous. The employees with the highest risk for this kind of injury are frequently involved with electricity. The hazard of electrical shock may lead to further accidents such as falling from scaffolds and ladders (Melis Tabak, 2011).

2.5.3 Hazards Material Exposure

The explosions, burns and serious injuries can happen due to exposure to hazardous materials. This could lead to workplace accidents. To prevent workplace exposure to hazardous materials, employers should carry out mock drills and maintain them up to date (Mittman, 2016). The employer needs to define exposure to hazardous materials control methodologies and design a program to educate the worker to prevent workplace hazards (Melis Tabak 2011).

2.5.4 Slipping and Tripping

Debris, damage, or wetness on the floor cause slipping, tripping, and falling at work. Slipping and, tripping incidents can create injuries such as broken bone injuries, head and back injuries (Mittman, 2016).

2.5.5 Injuries Caused by Falling from Heights

Falls can be classified as falls from the same level or falls from great heights. The most common types of falls are same level falls, which occur on level surfaces. They are triggered when a person's usual and expected walking gait is disrupted as a result of a rapid loss of balance. When it comes to falls from great heights, consequences can be expected such as shattered bones, internal injuries, lasting disability, and even death (Cax, 2015).

2.5.6 Being Seized in or Struck by Moving Machinery

Employees can be struck and injured by moving parts of machinery or thrown out materials. Parts of the body can also be strained in or trapped between rollers, belts and pulley drives, according to views of Etherton JR (2007). Cuts injuries can be caused by sharp edges of materials or machines. Sharp-pointed parts can cause wounding or puncturing the skin, and rough surface parts can cause friction or abrasion. People can be twisted between two parts moving together or towards a fixed part of the machine; two parts moving past one another can cause abrasions.

Injuries could be occur due to unreliable and faulty machines or when people with inexperience or lack of training use the machines or when machines are used incorrectly.

2.5.7 Work-Related Eye Injuries

Work-related eye injuries (WREI) are a leading cause of vision loss and account for a major portion of occupational injuries. WREI has an influence on employees and their families while also having a significant impact on manpower and social expenditures SY Chen (2009). Eye injuries can have serious repercussions and cost a lot of money. Employees in every industry are at risk for eye damage. When compared to industrialized countries, developing countries have a higher incidence and severity of WREI. This could be attributed to a reduced focus paid to occupational health and job safety, according to Chen SY (2009). WREI is typically prevalent among younger workers, according to reports. Moreover, referred to the researches, over 90% of all WREI can be avoided (Vats S, Murthy GV, Chandra M, Gupta SK, Vashist P, Gogoi M 2008). In the Transformer Manufacturing Industry, eye injuries occur due to contact with copper wires when workers use wires in winding work without wearing safety glass or shields.

2.6 Hazard Identification and Risk Assessment (HIRA) of Manufacturing Industries

The HIRA approach is a planned and systematic screening process for identifying and evaluating a problem in order to decrease accidents (Gokul, Raj S., Shivasankaran N, 2014). The HIRA method has been used to identify and control hazards in workstations (Kumar, M. Saravana., Kumar, Dr. P. Senthil 2014). A knowledge of probability of accident occurring and their consequences is needed for risk analysis. The consequences are the effects, damage, or level of injury caused by a series of events. The process of risk assessment is used to identify how to manage the risks that have been identified as a result of the analysis (Legget, David J, 2012). The easiest way to limit the risk is to remove anything that could cause an accident in the working environment. Anonim (2008) states that HIRA identification process is governed by hazard identification and risk assessment and risk control.

Carter & Smith, (2006) states that the purpose of hazard identification is to control the risks which are associated with the work involved by the employees. Consequently, it involves identifying the workplace and processes which are combined with the risks, as well as the risk to the employees and other relevant parties. Hazard identification is the most important factor in the risk assessment process Rejda (1992).

Identification of risks in context to the work activities is the first step of the risk assessment process Carter and Smith (2006). Risk assessment should include all the events that the employees are involved in and the use of equipment, as stated by Carter and Smith. Huges and Ferret (2011) state that the best way is to ensure that all the activities are listed to walk around the workplace and observe all the activities in each step of the hazard identification process.

Hazards should be identified during the initial stage, and then the risk assessment process could be performed in the workplace in a comprehensive manner.

Kartam (2001) states that risk is defined as the probability of uncertain, unforeseeable and even unpredictable events.

Risk Rating = Severity of Accident *Probability of Accident Occurring

There is no fixed methodology to carry out occupational health and safety risk assessments (Huges & Ferret, 2011). In general there are basic principles available to be followed. Risk assessment techniques were developed in some studies by researchers to suit their anticipated requirements (Lingard & Rowlinson, 2005).The risk evaluation criterion is based on three types of measures: qualitative terms, quantitative terms and semi- quantitative terms. According to this approach the possibility and severity can be determined and evaluated. (Lingard & Rowlinson, 2005).According to Petrovic (2017) the figure 2.1 below, shows the matrix for estimating quantitative risks. Whether the risk is tolerable or not tolerable should be decided, for the purpose of risk evaluations (Lingard & Rowlinson, 2005).

As shown in figure 2.1, if the risk is regarded as acceptable, controlling the risk only might be sufficient, instead of reducing the risk. Nevertheless, solutions for different types of risk reduction methods should be analyzed and compared. Assessing the decisions taken by the team take place in the evaluation stage of the risk-assessment process, in order to reach a decision on the suitable risk control strategies (Huges & Ferret, 2011).

Risk control measures are used to control hazards, prevent dangerous situations or reduce the severity of the consequences of any situation within any system, procedure, process or from an equipment (Lingard & Rowlinson, 2005). To eliminate, prevent, or to reduce the probability of such an occurrence, control measures should be taken in advance as well as reducing the consequences of any of these occurrences. (Huges & Ferret, 2011)

		Probability of Accident Occurring →				
		1.Unlikely	2.Seldom	3.Occasional	4.Likely	5.Most Likely
Severity of Accident ↑	5.Total permanent Disable/Fatal	5	10	15	20	25
	4. LTA and more than 3 days	4	8	12	16	20
	3. LTA but not more than 3 days	3	6	9	12	15
	2. Beyond first Aid bur not LTA	2	4	6	8	10
	1.First Aid only	1	2	3	4	5

Figure 2.1: Risk Rating Matrix

Source: International Journal on HIRA in Manufacturing Industry, 2018)

Type of Risk Level of Accidents

Risk Rating = Severity of Accident *Probability of Accident Occurring

- 1-3-Low Risk Accident
- 4-6=Moderate Risk Accident
- 8-12=High Risk Accident
- 15-25=Extreme Risk Accident

2.7 Effective Involvement of Safety Management in Controlling Occupational Accidents

The transformer manufacturing industry has high rate of injuries every year according to literature review. As explained above there are critical operations involved with work involving severe heat (annealing), risky electrical testing, and handling of heavy products, heavy steel slitting process and hazardous chemicals. As a high-risk industry, it's important to look into the factors that influence the prevalence of these injuries in order to protect workers (Kiani F, Samavatyan H, Pourabdian S, Jafari E, 2011). The employer and firm management play a crucial role in aiding professional standards, market and company expectations, and essential requirements that are favorable to a more helpful occupational situation, as well as giving essential organizational support. When the management and supervisors of an organization are concerned for worker safety by giving suggestions on worker safety awareness, then the workers in turn would develop positive attitudes towards the management, because the management is concerned about their safety and wellbeing. Then the employees will be keen on their own safety (Hofmann DA, Morgeson FP, 1999).

Employees believe that the satisfactory or unsatisfactory concern about their safety depends upon the humane qualities of the management of an organization Eisenberger R, Huntington R, Hutchison S and Sowa D (1986). Levinson (1965) stated that employees tend to look upon the organization as a living entity, since the management has responsibility for its actions. According to study of Clarke (1998), the workers voice their need, which is management sincerity regarding the implementation of proper health and safety measures. If the management does not take any notice or actions regarding safety issues, the employees would not report any issues or incidents

regarding safety. Furthermore, Mullen (2005) stated that when the employees are confident that the management is ready to listen to the worker's safety proposals and opinions, then the employees were more likely to invest time and effort into raising safety issues. The main signal that the organization extends support for safety measures is, when the management is ready to listen to safety suggestions. Managers and supervisors must also show their commitment to safety by responding to issues that are brought to their attention. According to researchers, strong levels of assistance in the workplace may help people avoid occupational diseases and injuries (Dickinson NS, Perry RE, 2007). Perception of safety by the management is crucial to motivate the employees to be keen on their own safety. According to research if the employees get the overall support from the management and supervisors, it decreases work stress and the application to work by the employees would be greater. Gyekye, (2007) stated that employees understand that the managers are supportive, give attention and are highly concerned about their safety and well-being, then the employees are more likely to be aware that the organization really place value on their safety.

If the employees think that the management is more concerned about the worker's health and safety than their production, the employees will do their work carefully and well. Since they do not have the job pressure to do their work fast, there will be less stress and fewer injuries at work. According to Diaz RT, Cabrera DD (1997) if the organizational policy is more concerned on safety rather than on production, then this will be the most important factor in performance while ensuring safety.

2.8 Safety Management Controls

In the manufacturing industry, workplace accidents are difficult to avoid fully and it can cost a huge amount of financial losses annually (Noor Aina Amirah, 2013). To avoid workplace accidents, more and more companies should be exposed to Occupational Safety and Health Practices (OSHP). This is because workplace accidents can have a negative impact on corporate operations in Sri Lanka and around the world. Occupational Safety and Health Practices (OSHP) are policies, strategies, activities, and procedures that employers can use to ensure the safety of their employees. (Vinod Kumar, 2010).

Safety and health practices in the workplace can help to reduce the chances of an accident (Hamid, 2015). Employee awareness can help to reduce the number of accidents that occur. An organization that provides a good OSHP can have a great impact on the employee to enhance their safety performance in the workplace. Furthermore Yueng-Hsiang Huang, (2006) elaborated that an organization with a good OSHP will mitigate the accident rate and also lead to a lot of benefits for the organization.

Based on Vinod Kumar (2010), Occupational Safety and Health Practices (OSHP) are policies, strategies, actions, and procedures that an organization can put in place to ensure the safety of its workers. OSHP is made up of a number of safety-related constituents. Those are accident investigation and take control actions, management leadership and personal commitment for safety, implementation of hazard control methods, risk management and control actions, use of personal protective equipment provided, comply with legal and other obligations, implementation of operational controls and procedures, readiness of emergency preparedness, safety training and competence programs and employee involvements on safety programs.

2.8.1 Safety Training and Competence programs

Safety training will equip employees with the knowledge they need to execute their jobs safely in the workplace. All levels of staff should receive safety training in the workplace. Employees can increase their knowledge, performance, and competence with comprehensive training. Occupational accidents and injuries will increase as a result of inadequate and inefficient safety training (H. Ali, N. Abdullah, and C. Subramaniam, 2009).

Management can be defined as the collaboration of the components such as objectives, functions, tasks, roles, plans, process, characters, beginnings, middles, and endings to make a process (Carroll, 2001). Caring and safety training of employees should be under the responsibilities of an organization (Barling, 2005).

Additionally, Mearns (1991), Milton and Ashley (1998) and Moore (1991) stated that the nature of the employees reflects the nature of safety management, which is dependent on one's own talents. Employees in the organization should be given clear instructions on how to manage safety measures and, as a result, prevent injuries.

Zohar (1980), states that beliefs and attitudes have a significant positive relationship towards safety and health practices in a company and to develop these attitudes, safety training is very important.

Advancement of safety, accident prevention, safety performance and compliance, personal protective equipment, accident and emergency response, workplace risks, and worker engagement should all be covered in safety training programs (Hamid, 2015)

Accidents, injuries, legal concerns, worker reimbursement claims, manufacturing property damage, and work time lost due to injuries can all be reduced with effective training programs (Othman, 2012)

2.8.2 Employee Involvements on Safety Programs

Safety and health programs need a representation or a team of representatives and workers have much to gain from a successful program. Employees also know the most about potential hazards connected with their jobs and with their participation, the management can tap into this knowledge base. Employees should be encouraged to participate in the health and safety programs, so that the management is able to value their contribution into safety and health decisions making. Employees

in an organization are the most suitable personnel to make proposals for improvement and they can also review safety and health issues that may affect the company's employees on a regular basis (Othman, 2012). Employees should also be encouraged to make safety-related suggestions and recommendations, as well as suggestions to improve work activities and processes where safety could be improved (Taufek, 2016). Workers can always spot workplace hazards, unsafe situations, near misses, and actual incidents, as well as program flaws, such as detecting workplace hazards, unsafe conditions, near misses, and actual occurrences..

2.8.3 Implementation of Safe Work Procedures

Employees must ensure that their work environments are in a safer environment by applying safety and health procedures to control risks and hazards.

To minimize accidents and injuries employers of an organization must implement and comply with all the safety and health guidelines. According to Gordon, Flin, and Mearns (2005), if appropriate techniques are established for corporate employees, workplace accidents can be reduced or avoided, and workers can control human errors properly. Management and employees should work together with positive safety attitudes, proper knowledge of safety and maintaining safe working methodologies.

All level of employees should adhere to safe work procedures in an organization, which will reduce work place accidents. According to Hagan (2001) when top management commitment is less and their safe work procedures are less effective, the employees may use safe work procedures by their own, which is a bad practice. According to expressions of Hagan (2001) that employee must consider about their work force regarding safety management programs as well as the management should make sure to provide a safe work environment for the organization. The management should always take their actions towards their employees fairly, especially in safety management programs. Similarly, employees should try to maintain a safe work place and follow the harmless work processes (Yule, Flin & Murdy 2007). Moreover, the cooperation of the management and workers is highly important to establish a safety management program as stated by Alli (2008).

As stated by Griffin & Neal (2000) and Hagan (2001) damages and accidents would happen due to not following safe work methodologies by employees. Therefore it is very important for the

employees to responsibly participate in safety programs. According to Vredenburgh (2002) the wrong practice and operation of machines is one of the key reasons of occurring accidents in the manufacturing industry and the injuries will affect the productivity of the company.

2.8.4 Management Commitment

Generally, management commitment means that the employers are dedicated to all their employees' well-being and health requirements. The employer has a significant part in reducing the accidents or injuries to their employees in the workplace while the workers should also be committed to support the health and safety practices. Hsu (2007), pointed out that management dedication is defined as to maintain a positive and loyal safety and health attitude for the employees, regarding health, safety and protection in the work environment. Moreover, Brown (2000) advises that the insights of employees and employers are identical and they should recognize about organizational health and safety. According to Cooper (2006), management commitment can be known as the participation and involvement of the top management alongside with their employees in activities to achieve an objective.

Zohar (1980) points out that to make an organizational safety program a success, the effectiveness of the management commitment regarding safety and health programs is needed to be increased and the participation of employees in safety programs is also needed in addition to the objectives of the organization. The major factor for a successful health and safety program, according to Zohar (1980), Arboleda (2003), and Choudhry, Fang, and Ahmed (2008), is the management's dedication to health and safety activities.

Furthermore, if management is committed to ensuring the health and safety of their employees, it will aid in the reduction of hazardous working circumstances. Management commitment can have an impact on safety culture. As a result, establishing a safety culture within the firm is enhanced. According to Marsh (1995), management commitment is crucial in all types of safety. There is a supportive idea mentioned by Hsu (2007) and he says employers should act with positive and supportive safety attitudes regarding their employees.

2.8.5 Accident and Incident Analysis

The importance of accident and incident analysis is to identify the causes of accidents and incidents, as well as the specific elements that contribute to them. The study identifies the errors that result in hazards and injuries, as well as the corrective actions that may be taken to prevent them from happening again. During the accident investigation process, data is gathered on the specific work area, the performed work activity, the work procedure, and the work technology involved. Different definitions of accidents and incidents can be found in the literature (Blacket, 2005; Johnson, 2003). However, most people believe that an accident is "an unintended occurrence or series of events that results in injury, ill-health, or property damage or loss," whereas an incident is "an unplanned, unintended event that delays the completion of a work and may result in injury or other damage."

Operator injuries resulting from a brief absence from work, minor damages to small components of the system, or component failure are all examples of events. However, these occurrences do not cause a systemic disruption (Blacket, 2005).

According to Stellman (1998), there are five different types of accident analyses. The location and types of accidents that occur are identified and investigated. Second examinations of accident monitoring and trends in the occurrence of accidents. The third analysis is to align activities that ask for high risk assessment values, which entails estimating the frequency and severity of accidents. The fourth analysis is to determine the reasons for the occurrence of accidents, including both direct and indirect underlying causes. Final analysis for clarity of specific areas that need to be prioritized.

2.8.6 Use of Personal Protective Equipment

Sutton (2017) stated that Personal Protective Equipment (PPE) that are worn by the workers can protect them from physical harm, chemicals and fire. To minimize the exposure to different hazards, protective gloves, safety glasses, fall protection equipment, hearing protection, respirators masks are the major PPE that are used by workers in manufacturing industries. Nevertheless, use of PPE does not ensure total protection of employees and does not decrease the hazard itself, but it is known as a means of protecting health and safety.

In addition to the type of work, physical requirements of the work, and the time required, the PPE wears out. The goal should always be to focus on worker or user comfort. Unsuitable use or improper use of equipment may cause discomfort. If all the workers accept the equipment, the utilization rate will be high. There is a lot of specification for PPE and it will highly depend on the requirement. Providing appropriate PPE should be done with great care. Otherwise, it may not fit the requirements.

2.8.7 Work Place Hazards

A hazard, according to the World Health Organization (WHO), is any source of potential damage, harm, or ill health effects on a person or object under specific conditions. When a hazard becomes "active," however, it produces an urgent or emergency situation where it occurs. Hazards can arise from natural processes, from man-made activities, or from deadly forces or retaliation (Oludele & Mayowa , 2014).

A work-related hazard, according to Bello (2010), is a risk to a person's health at their place of employment. Organizational hazards are brought about by “work conditions which are not safe” and “work behaviors which are not safe” (Oludele & Mayowa, 2014). Nevertheless, with the implementation of the appropriate occupational health and safety measures, workplace hazards and injuries can be prevented (Oludele & Mayowa 2014).

Evans, Head, and Speller (1994) classified workplace dangers into the following categories. Mechanical risks include accidents, falls from great heights, and being struck by moving objects owing to the effect of particular forces.

Other hazards are slipping and tripping, and falling on pointed objects. Types of Injuries are being crushed, cuts, frictions and abrasions, grazes and punctures.

Noise, vibration, illumination, electricity, cold stress (hypothermia), heat stress (hyperthermia), and dehydration are all can be identified as physical risks. Acids, bases, heavy metals, lead, solvents, petroleum, particulates, and asbestos are all chemical risks.

2.9 Transformer Manufacturing Process

In the manufacturing process, heavy machines are used to slit steel reels into required dimensions. As a next process, transformer core is prepared by using mechanical machines and next high temperature application is used for core annealing process.

The next process is transformer winding process. Here mechanical machines are used to wind copper wire around the core. Then transformer insulation process is done in the same area. In this section there are manual operations are taking place such as copper enamel wire is fixed to basic input or output wire through soldering process. Some kind of hot work is involved with this process. In addition intermediate electrical tests are being done in the transformer winding process.

The next operation is transformer testing process. A lot of high voltage, high current, and high frequency applications is used for transformer testing process. Next operation is transformer assembling process according to customer requirements. Here lot of crimping tool, different type of tools and equipment used in this section. Transformer varnishing process is a process where hazarder's chemicals are highly involved. Transformer potting operation is one of the finishing operation again where machines and chemicals are been used. Visual testing and transformer packing operation is done as a final stage of transformer manufacturing operation.

There are hazard situation or thing that has the potential to harm a person. Hazards at work includes noisy machinery, a moving forklift, chemicals, electricity, working at heights, a repetitive job, hot works can be observed in the transformer manufacturing process.

There are different type of employees categories involve with this transformer manufacturing process. They are winding machine operators, electrical testing operators, core winding operators, assembling operators, chemical process handling operators, potting operators, supervisors, technicians, cleaning workers, quality controllers, executives, stores operators, work study officers are involving in transformer manufacturing process

CHAPTER03
RESEARCH METHODOLOGY

3.1Introduction

Designing the Research Methodology is one of the key steps in research. First two chapters discuss the research problem and literature survey in detail. This chapter discusses the research methodology adopted in detail. The research was designed to collect data from both transformer manufacturing companies in Sri Lanka to achieve its objectives. However, due to Covid 19 pandemic situation, it has been limit to one transformer manufacturing company. Since this research project was focused on one particular industrial site, an intrinsic case study was taken as the research structure (Stake, 1995).

3.2 Research Process

The chain of actions and steps taken to carry out a study in an actual way is considered as a research process. Figure 3.1 shows the step-by-step approach that was implemented in this research. As it indicated, the process is started with problem identification, and then aim and objectives were formulated. A literature review was carried out to gather knowledge on the research area.

Subsequently, appropriate data collection tools were selected to gather primary and secondary data and the following section discusses details.

Research Process

Figure 3.1: Research Process

3.3 Method of Data Collection

The primary data was collected using a questionnaire survey in order to identify from the management staff that includes supervisors. The convenient sampling technique (non-probabilistic sapling criteria) was utilized to select sections of the company. The respondents for the survey were randomly chosen from particular departments and sections. The views of the respondents were obtained by distributing the questionnaire. The questionnaire was distributed among the sample of respondents to collect their views and questions were simple and self-explanatory. A self-administrative questionnaire is always economical, quick and easy to handle (Frederick & Sierles, 2003). Secondary LTA data was available on TMC which was used to analysis data. From this secondary data accident reduction % was calculated compared to year 2010 LTA data. Those data was used to find out accidents in transformer manufacturing companies and to find effectiveness of safety management controls implemented to reduce accident.

3.4 Study Population

First managerial level and upper managerial levels in the relevant company that means supervisory level and upper areas will be sample population. Then study population is around 120 sample population was selected as 46 numbers. According to Uma Sekaran, (2016) 25% sample, which is statistically significant and representative and efficient and sample population has been selected by accordingly.

3.5 Research Questionnaire

To collect the views of respondents, a structured questionnaire was prepared to collect data. The questionnaire which was used in this research was self-administered and it contains five questions areas which are based on the required information from the respondents. The Five-point Lickert scale measure was used and printed copies of the questionnaires were distributed among the randomly selected group of respondent.

The structure of the questionnaire is as given below. In the questionnaire there were 39 number of which included the demographic profile related questions as well.

3.6 Conducting the Survey

It was decided that a pilot survey should be done in order to test the feasibility of the questionnaire. Number 8 sets of questionnaires were distributed initially among the respondents who were selected primarily, before launching the actual survey. Participants responds was positive to conduct the survey there further more.

3.7 Data Analysis

The opinions of the respondents were collected by distributing a designed questionnaire. The questionnaires were distributed among the respondents by meeting them personally and Managers, Engineers and the Supervisors were in the team. The respondent spend around twenty minutes to fill the questionnaire and they did it during the working time at their respective work places. Since the questionnaire was simple and direct and was self-managed, it was convenient to collect the necessary data from the respondents.

The respondents profile data was presented in tabular form using percentages. The risk levels of different types of accidents were calculated using the following formula and the risk matrix table (Appendices – A)

Risk Rating = Severity of Accident *Probability of Accident Occurring (Equation3.1)

The views were converted into numerical values using the particular scale and then data was entered in to the computer data sheet. The SPSS software package was (IBM SPSS version 23rd) used to develop the spread sheet and spread sheet includes all the data collected through the questionnaires. The mean values and the standard deviation values were computed. One-Sample t-test conducted to analysis practicing level of safety management strategies. Then one-sample t-test conducted to analysis effectiveness of safety management strategies through SPSS. The data was presented in both descriptive and graphical forms. The data of the assessment for the need in were analyzed using statistical techniques. Student t - test, 0.05 significance level (one sample) was employed for testing the statistical significance of data.

CHAPTER 04

RESEARCH FINDINGS AND ANALYSIS

4.1 Introduction

This chapter deals with data presentation and data analysis and it contains of five sections. The first section analyses the demographic profile of the respondent's company information. The second section analyses the various types of accidents, the frequency of occurrence and severity of workplace accidents of the TMC. The next section analyses the various types of accidents and their risk levels. The fourth analysis of practicing level of management Strategies to reduce accident in TMC. The fifth section attempts to determine the Effectiveness of following management Strategies to reduce accident in the TMC Company. Finally in the sixth section accident reduction % data was calculated by using the available LTA data at TMC. Base year

4.2 Demographic Profile of the Respondents

There were 46 members was selected for the survey. The respondent's participation rate of the survey was 91% that means 42 members responded. Two members did not attend to all questions and other two members did not respondent. Descriptive statistical analysis was used to analyze the respondents' profile data. Percentage values and pie charts were used in this analysis first five questions. The figures 4.1 and 4.2 shows designation and department of working. The details of their working experience in TMC is shown in Figure 4.3.

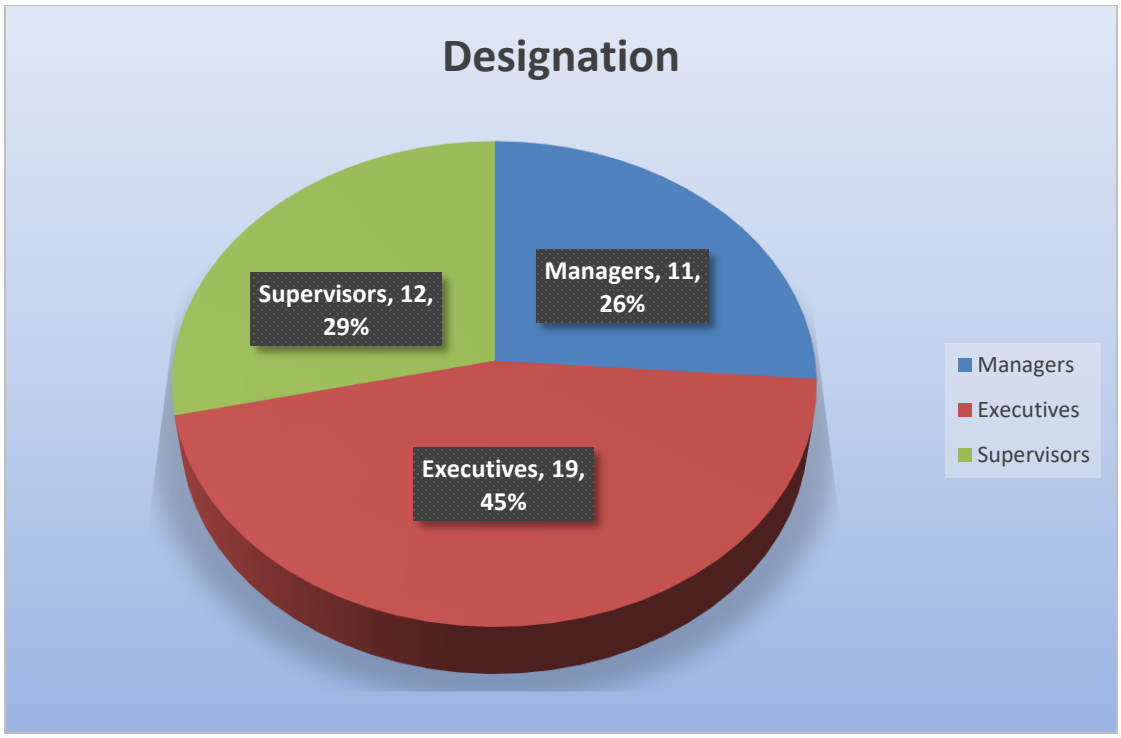


Figure 4.1: Designation of the Respondents.

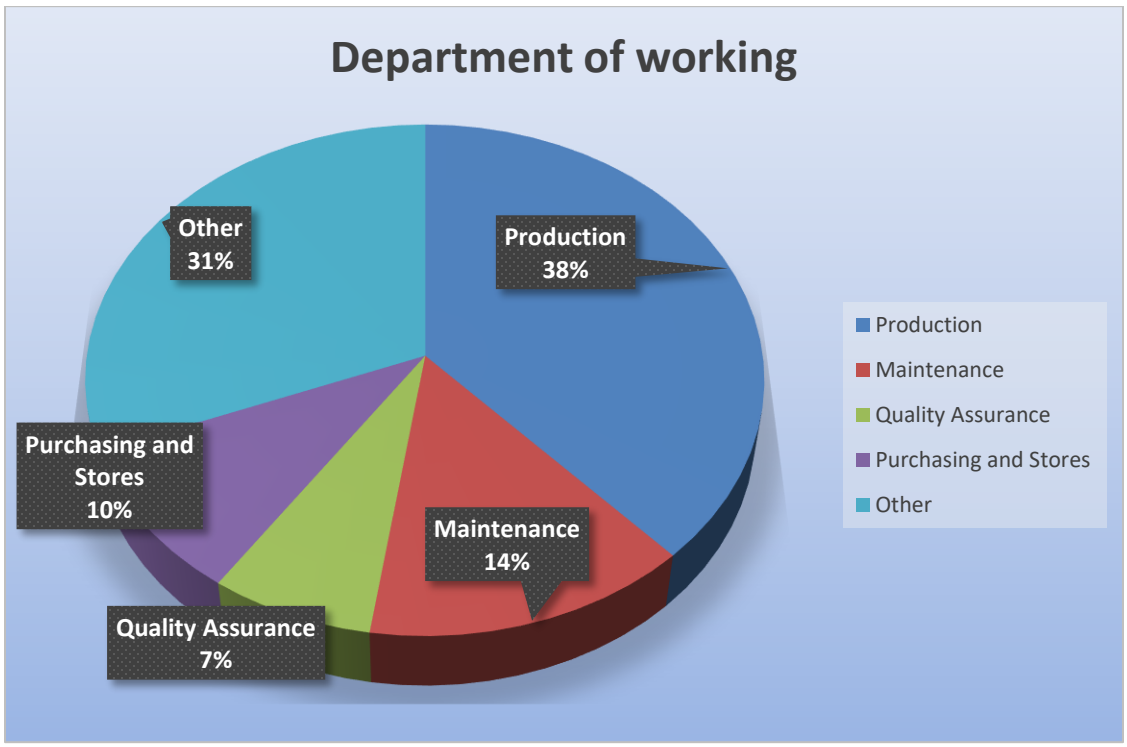


Figure 4.2: Department of Working on Respondents.

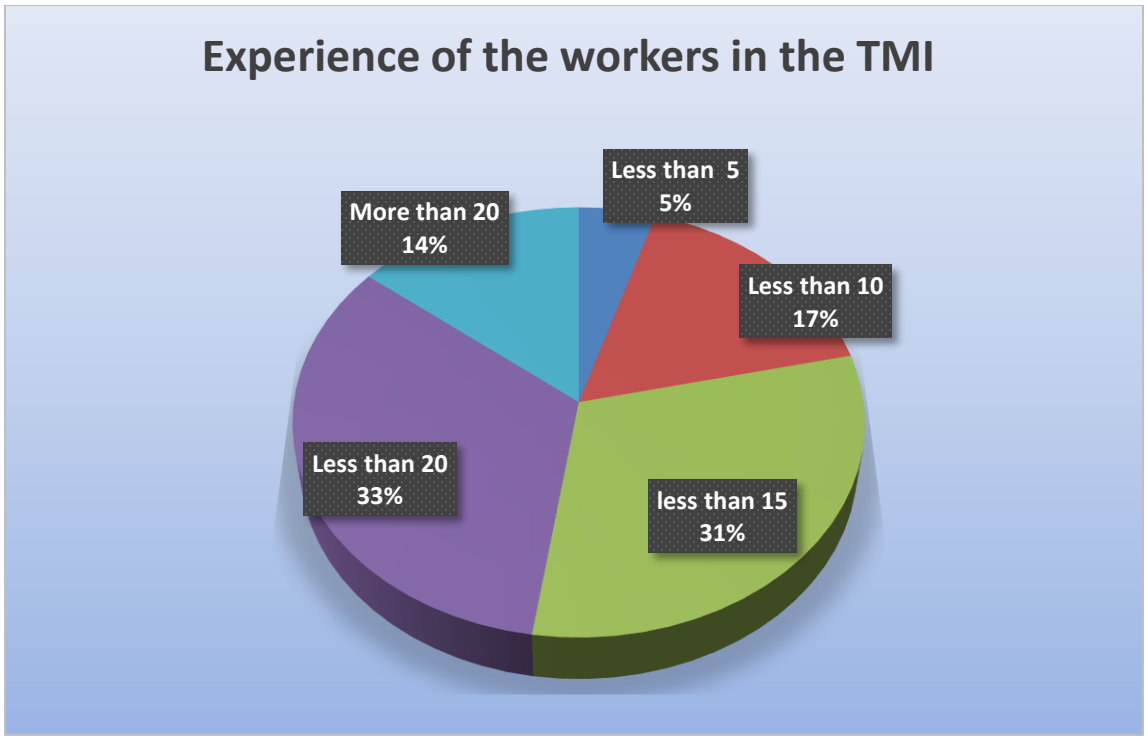


Figure 4.3: Working Experience Respondents within TMC

4.3 Analysis of Workplace Injuries in the TMC

The opinions was obtained from the selected managerial level employees of transformer manufacturing company regarding the severity and the frequency of accidents and injuries according to distributing the questionnaire. The severity and frequency of accident occurrence tabulated in the following Table 4.1 according to experience of respondents.

Table 4.1: Severity and Frequency of Work Place Injuries in TMC

No	Severity of occurrence of accident according to LTA*	Severity	Frequency of accident occurrence – mean average				
			1	2	3	4	5
			Unlikely	Seldom	Occasional	Likely	Most likely
6.1	First Aid only	1	4.8	9.5	21.4	52.4	11.9
6.2	Beyond first Aid but not LTA	2	7.1	26.2	33.3	28.6	4.8
6.3	LTA but not more than 3 days	3	16.7	33.3	28.6	19	4.8
6.4	LTA and more than 3 days (Reportable accident)	4	26.2	42.9	21	9.5	2.4
6.5	Total permanent Disable/ Fatal	5	98	2	0	0	0

*- LTA – Lost Time Accident.

According to table 4.1, 11.9% of respondents has indicated that first aid accidents happen always and 52.4% respondents says first aid accident are likely to be happen. 21.4% of accidents is happening occasionally and 9.5% accidents happen seldom according respondents. Only 4.8% indicated that first aid accidents are unlikely to be happen. 7.1 % of respondents says beyond first but not LTA unlikely happen but 33.3% respondent says this type accidents happening occasionaly.28.6 % respondents believe that accidents beyond first but not LTA likely to be happen in addition 4.8 % of employees says this type of accidents happening most frequently.

Lost time injuries less than three days happen seldom its percentage is 33.3% as well as 16.7% respondents think that this type of accidents rarely happen. 28.6% of respondent think lost time injuries less than three days happen occasionally happen and 19% of respondent stated that this type of may be happen.

Lost time injuries more than three days happen seldom and its percentage is 49.2% as well as 26.2% respondents think that this type of accidents very rarely happen. 21% of respondent think lost time injuries more than three days happen occasionally happen and 9.5% of respondent stated that this type of may be happen.

98% of respondent indicated that total permanent disable or fatal accidents all most could not be happen. 2% of respondent indicated that this type of accidents very rarely happen with reference to TMC.

4.4 Risk Levels of Accidents in TMI

Equation 3.1 was used to calculate the risk severity and probability of each accident shown in Table 4.2 mean average severity and probability of accidents were then used to assess the risk levels of accidents and illustrated using accident rating risk matrix Figure 4.4

Table 4.2: Severity and Probability of Different Accidents

No.	Type of accidents	Mean average of severity	Mean average of probability	Risk Level = Mean average of severity *Mean average of probability
7.1	Slips and Trips	2	2	4
7.2	Falling from Height	3	2	6
7.3	Being caught in or Stuck by Moving Machinery	3	3	8
7.4	Hazard Material Exposure	3	3	9
7.5	Cut and laceration	2	3	6
7.6	Eye Accident	4	4	16
7.7	Overexertion injuries	2	3	6
7.8	Electrocution	4	4	16

		Mean Average of Probability Accidents Occurring				
		1	2	3	4	5
Mean Average of Severity of Accidents	5	5/Moderate Risk Accident	10/High Risk Accident	15/Extreme risk accident	20/Extreme risk accident	25/Extreme risk accident
	4	**4** /Moderate Risk Accident	8/High Risk Accident	12/High Risk Accident	16/Extreme risk accident **Eye Accident, Electrocution**	20/Extreme risk accident
	3	3/Low Risk Accident	**6**/Moderate Risk Accident **Falling from Height**	9 /High Risk Accident **Being caught in or Stuck by Moving Machinery , Hazard Material Exposure**	12/High Risk Accident	15/Extreme risk accident
	2	2/Low Risk Accident	**4**/Moderate Risk Accident **Slips and Trips**	**6** /Moderate Risk Accident **Cut and laceration, Overexertion injuries**	8/High Risk Accident	10/High Risk Accident
	1	1/Low Risk Accident	2/Low Risk Accident	3/Low Risk Accident	**4**/Moderate Risk Accident	**5** /Moderate Risk Accident

Figure 4.4: Risk Rating Matrix of Accident at Transformer Manufacturing Industry

4.5 Analysis of Practising Level of Management Controls.

Significance of practising level of following management controls shown in Table 4.3 were analysed using t-test. All the t-values are statistically significant except last two management controls (p value is less than 0.05) as the p-value is varies between 0.000 and 0.898. The t - test was done at 0.05 significance level (at a 95% Confidence level).

Table 4.3 One-Sample t-test to Analysis Practicing Level of Safety Management Strategies.

Safety Management Strategies	Test Value =3			
	t- value	Mean	Sig. (2-tailed)	Rank
Safety Training and Competence programs	4.773	3.71	0	1
Risk Management and control actions	4.528	3.67	0	2
Use of Personal provided Protective equipment	4.411	3.67	0	3
Accident Investigation and take control actions	4.067	3.62	0	4
Management Leadership and Personal Commitment for safety	3.832	3.57	0	5
Reediness of Emergency Preparedness	3.485	3.57	0.001	6
Implementation of Hazard control method	3.201	3.55	0.003	7
Comply with Legal and Other Obligations	2.644	3.45	0.012	8
Employee Involvements on safety programs	0.682	3.12	0.499	9
Implementation of Safe Work Procedures	0.129	3.02	0.898	10

According to the table 4.3 Shown above t value of Safety Training and Competence programs is found to as 4.773 and mean is 3.71. The second highest practicing management controls is Risk Management and control actions and t-value found to be 4.528 and mean value was found to be

3.67 according to views of management staff. The third highest practicing management strategy is Use of Personal Protective equipment as the t-value found to be 4.411 and mean value was found to be 3.67. The fourth highest practicing management strategy is Post Incident Investigation and take control actions as t-value was found to be 4.067, the mean value was found to be 3.62. The fifth highest practicing management strategy is Management Leadership and Personal Commitment and t-value was found to be 3.832 and the mean value was found to be 3.57. The sixth highest practicing management strategy is Reediness of Emergency Preparedness and its t-value was found to be 3.485 and the mean value was found to be 3.57.

Implementation of Hazard control method and Comply with Legal and Other Obligations comes as seven and eight practicing management strategies according to view of respondents where t value comes as 3.201 and 2.644 as respectively. Employee Involvements on safety programs and Implementation of Operational Controls and Procedures comes as ninth and tenth practicing management strategies according to view of respondents where t value comes as 0.682 and 0.129 as respectively.

According to analysis practicing levels of Employee Involvements on safety programs and Implementation of Operational Controls and Procedures comes very low compared to other management practices. This should be further study when compare effectiveness of safety management strategies.

Safety Training and Competence programs comes as most practicing safety management control action (SMCA) according to views of respondent. Lowest practicing SMCA is Implementation of Safe Work Procedures compared other control actions to reduce accidents in the company. Safe work procedure is very important for electrocution accidents which is one of the dangerous accident. To minimize Hazard Material Exposure accidents safe work procedure are very important so then employees can follow the procedures and prevent exposures.

According to table 4.3 Employee Involvements on safety programs practicing level is low. To step up upper level of safety programs employee participation is very important if company is looking for safety culture program.

4.6 Analysis of the Effectiveness of Management Controls.

T-test was carried out to assess the effectiveness of the management controls based on their t-value. All the controls are statistically significant except last two management controls (p value is more than 0.05) as the p-value is varies between 0.000 and 0.781. The t - test was done at 0.05 significance level (at a 95% Confidence level).

Table 4.4 One-Sample t-test to Analysis Effectiveness of Safety Management Controls

Safety Management Strategies	Test Value =3			
	t- value	Mean	Sig. (2-tailed)	Rank
Risk Management and control actions	4.901	3.71	0	1
Accident Investigation and take control actions	4.773	3.7	0	2
Safety Training and Competence programs	4.476	3.69	0	3
Use of Provided Personal Protective equipment	4.411	3.67	0	4
Management Leadership and Personal Commitment for safety	4.067	3.62	0	5
Employee Involvements on safety programs	3.563	3.57	0.001	6
Implementation of Safe Work Procedures	3.106	3.57	0.003	7
Implementation of Hazard control method	2.297	3.36	0.027	8
Readiness of Emergency Preparedness	1.915	3.31	0.062	9
Comply with Legal and Other Obligations	0.28	3.05	0.781	10

As per Table 4.4, Risk Management and control actions most effective management strategy in the company according to indications of managerial staff. This indicate that outcomes of Risk Management and control actions is most contributing factor reduce accident among the other management practices.

The second highest effective management strategy is Post Incident Investigation and take control actions and t-value found to be 4.773 and mean value was found to be 3.70 according to views of management staff. The third highest effective management strategy is Safety Training and Competence programs as the t-value found to be 4.476 and mean value was found to be 3.69. The fourth highest effective management strategy is Use of Provided Personal Protective equipment as t-value was found to be 4.411, the mean value was found to be 3.67. The fifth highest effective management strategy is Management Leadership and Personal Commitment for safety and t-value was found to be 4.067 and the mean value was found to be 3.62. The sixth highest effective management strategy is Employee Involvements on safety programs and its t-value was found to be 3.563 and the mean value was found to be 3.57.Implementation of Operational Controls and Procedures and Implementation of Hazard control method comes as seven and eight practicing management strategies according to view of respondents where t value comes as 3.106 and 2.297 as respectively. Readiness of Emergency Preparedness and Comply with Legal and Other Obligations comes as ninth and tenth practicing management strategies according to view of respondents where t value comes as 1.915 and 0.282 as respectively.

4.7 Accidents Records of Transformer Manufacturing Company

The Figure 4.5 shows the accident reduction percentage of the company from year 2011 to 2020. Total lost time accidents from the company documents and data was taken into the graph.

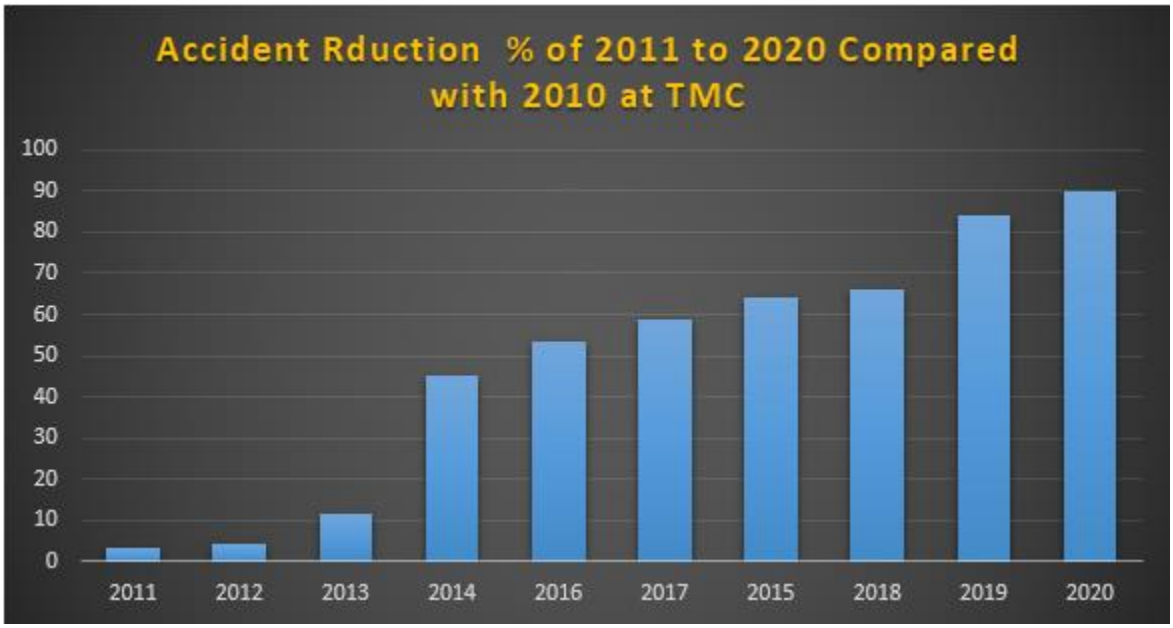


Figure 4.5: Percentage of Lost Time Accident Reduction Comparison in TMC from 2011 up to 2020 base Year as 2010

Source: Lost Time Injuries Information of TMC Reported to District Factory Inspection Engineer's Office Gampaha

As shown in Figure 4.5, a sharp decaying of number accidents from 2012 to 2020 was recorded. This could be recognized to the positive impact of implementing safety management strategies. Still there are injuries at Transformer Manufacturing Company enterprises are evident that the safety strategies are further need to be practiced and followed. Subsequently 2010, there are incidents and accidents recorded and it is decreasing drastically this means that company has obtained the effectiveness of the implemented safety management strategies.

CHAPTER 05
CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

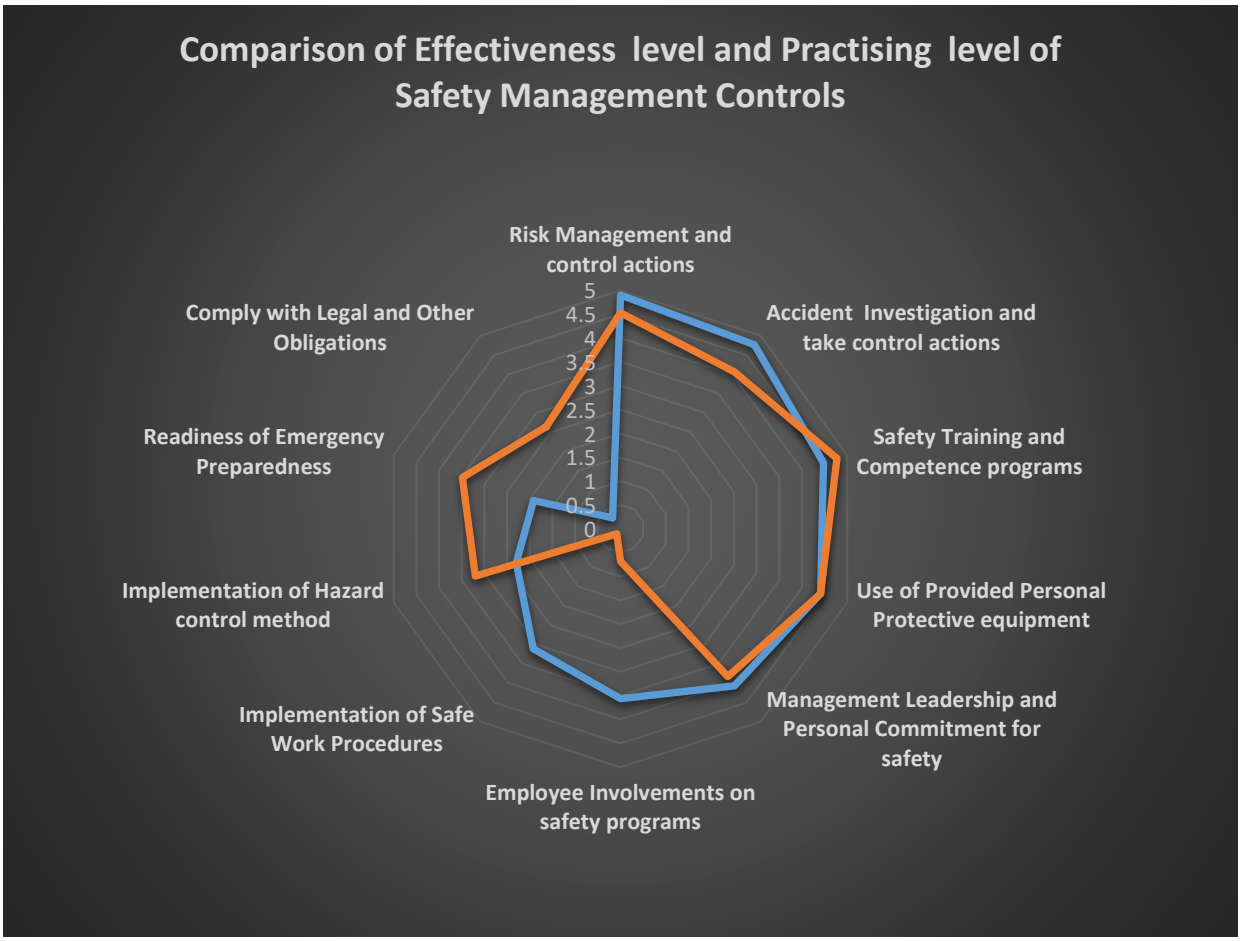
This study is to identify the accidents in transformer manufacturing industry, investigate the risk levels and severity levels of injuries and to observe the effectiveness of occupational safety and health management practices in Transformer manufacturing industry. The objective of this study was achieved through questioners and analysis of accident in the company. Among the objectives of the study is to identify the effective Safety and Health management practices and to see the how management effective control controlling occupational accidents.

5.2 Conclusion

TMI is identified as high risk industry. The accidents and injuries identified in the TMC can be classified as minor injuries, basic type injuries and major type of injuries. Minor type of injuries are first-aid type injuries which will not affect the work places that much that is after having a first aid treatment employee can come back to normal working conditions. According to research information beyond first aid type injuries which, are likely to be occur in the TMC in Sri Lanka as well lost time accident. Some of lost time injuries are less than three days it is happening occasionally occur and more than 3 days take place seldom. Major type of injuries caused to permanent disable or fatal accidents which are rare in TMC in Sri Lanka.

According to Figure 4.4 Risk levels of eye injuries and electrocution injuries are relatively extremely high. The risk levels of being caught in machinery or being struck by moving objects injuries and hazard material exposer are high risk accidents in transformer manufacturing sector. Falling from height, overexertion injuries and cut and laceration are moderate risk accidents. Slipping, tripping accidents are moderate risk injuries but risk level is lower compare to previous accidents.

Figure 5.1: Comparison of Effectiveness level and Practicing Level of Safety Management Controls



Most of the Safety Management Controls are align with effectiveness level and practicing Level when compared to figure 5.1 and blue colour graph shows the effectiveness and red colour shows the practicing level of safety management control actions. Since the introduction of the occupational safety and health management practices the work environment has become safer and there has been a decline in the number of accidents recorded each year thereafter with compared to Figure 4.5.

Risk management and control actions, accident investigation and take control actions, safety training and competence programs, use of provided personal protective equipment, and

management leadership and personal commitment are tightly align with practicing level and effectiveness level.
Employee involvements on safety programs, Implementation of safe work procedures and Comply with legal and other obligations are having low practice level but their effectiveness level is high. Therefore practicing level of theses management controls should be increased.

The existing occupational health and safety management practices at TMC effective and it met the majority of the requirements accident controlling requirements. There are some management practices that need put more attention since their effectiveness is less to control the accidents. There are fundamental safety practices that has been implemented effectively and those are Risk Management and control actions, Accident Investigation and take control actions, Safety Training and Competence programs Use of Provided Personal Protective equipment and Management Leadership and Personal Commitment for safety and both the workers and management in should keep in touch to keep the same momentum.

According to information there were highlighted hazard in transformer manufacturing industry. Those hazard are poor work station, welding, electricity, chemicals, noise, heavy weight handling, and minor cuts and lacerations etc. Most of workers have been provided personal protective equipment and safety glass is the most important PPE which will protect the employee from eye injury.

Based on questionnaires, the most of the safety and health management practices are effective to reduce accidents and injuries in the TMC. Practicing level of are safety and health management practices run the active is the health and safety program? The benefit of OSHP is to maximize the organization performance which increased the productivity because the accident had been prevented.

The most common injury or accident is slips and trips and Cut and laceration. Due to effectiveness of Occupational Safety and Health Practices, the accident and injury happen in the workplace will relatively reduce year by year

5.3 Recommendations

In general management should work for increase the effectiveness of implementation of Safe work procedures, implementation of hazard control method, readiness of emergency preparedness and comply with legal and other obligations. These management controls will contribute to reduce accidents and injuries.

Furthermore, the employers should take more care about eye injuries and electrocution injuries and to control those areas employee should wear safety glasses and lock out and tag out systems when working on electrical works since those are extreme risk accidents. On the other hand Management can increasing the practicing level of Employee Involvements on safety programs Implementation of Safe Work Procedures.

In addition management should increase the employee involvements on safety programs implementation of safe work procedures, implementation of hazard control method, and readiness of emergency preparedness and comply with legal and other obligations.

Since the electrocution and eye injuries are high risk accidents strict actions should be taken to control those accidents. There should a strict rules regulations those who do not wearing the PPE and not following the other preventive actions. The review process and the new process shall ensure necessary evidence is collected to before implement those process.

5.4 Implications

Safety management practices has been implemented from 2011 by TMC. Most high risk accidents are considered as eye injuries and electrocution as well as slips and trips and cut and laceration accident has identified as less risk accident. According to accident data there is remarkable reduction in lost time injuries from 2010 to 2020 in TMC. That means that safety management

practices are very effective and the results obtained from the questioners survey is tallying with the out comes with the lost time accident reduction graph in TMC.

That implicate that the research outcome is more accurate so the need to take actions to further strength effectiveness of Safety Management Practices.

5.5 Limitations

According to information of literature review there is lack of research papers in transformer manufacturing industry. Main aim of this research is to identify the effectiveness of safety management in controlling occupational accidents in transformer manufacturing industry in Sri Lanka in management perspective. Therefore, for the data collection process supervisory level (line managers) and above managerial staff have been selected. Therefore there is no view of workers considered and it is limitation of the research process. In addition for the research, only one transformer manufacturing company had to be used due to covid 19 pandemic situation and it is another limitation.

5.6 Further Research

Further Research is necessary to determine view of operators level which could further strength the outcome of the research objectives. In addition research should be extended to covering both main transformer manufacturing companies together with small scale transformer manufacturing companies. Furthermore it is better to use both primary and secondary data for the further research process which will more strength the research objectives.

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APPENDICES

Risk rating matrix: Appendices -A

Risk Rating Matrix

		PROBABILITY				
		1.Unlikely	2.Seldom	3.Occasional	4.Likely	5.Most Likely
SEVERITY	5.Total permanent Disable/Fatal	5	10	15	20	25
	4. LTA and more than 3 days	4	8	12	16	20
	3. LTA but not more than 3 days	3	6	9	12	15
	2. Beyond first Aid but not LTA	2	4	6	8	10
	1.First Aid only	1	2	3	4	5

1-3-Low Risk, 4-6=Moderate Risk, 8-12=High Risk, 15-25=Extreme Risk

Sample Questionnaire

HOW MANAGEMENT EFFECTIVE IN CONTROLLING OCCUPATIONAL ACCIDENTS IN TRANSFORMER MANUFACTURING INDUSTRY SRI LANKA

Section A; Respondent profile.

1. Gender – Male ☐ Female ☐
2. Marital status - Married ☐ Single ☐
3. Designation : -
   Managers Executives Supervisors
4. Experience in the field (years)

Less than 5	6 -10	11 -15	16 – 20	More than 21

5. Department of working Types of projects handle/supervise

Production	Maintenance	Quality Assurance	Purchasing and Stores	Other

Section B

6. Indicate the severity and Probability of occurrence of the accident in your organization.

No	Severity of occurrence of accident according to lost time	Probability of occurrence				
		1. Unlikely	**2**. Seldom	**3**. Occasional	**4**. Likely	**5**. Most likely
6.1	First Aid only					
6.2	Beyond first Aid but not LTA					
6.3	LTA but not more than 3 days					
6.4	LTA and more than 3 days (Reportable accident)					
6.5	Total permanent Disable/ Fatal					

*LTA – Lost Time Accident.

7. Indicate the type of OSH accidents in your organization (follow the above scale for Severity and Probability of occurrences).

No	Type of accident	Severity of occurrence					Probability of occurrence				
		1.	**2.**	**3.**	**4.**	**5.**	**1.**	**2.**	**3.**	**4.**	**5.**
7.1	Slips and Trips										
7.2	Falls and Falling from Height										
7.3	Being caught in or Stuck by Moving Machinery										
7.4	Hazard Material Exposure										
7.5	Cut and laceration										
7.6	Eye Accident										
7.7	Overexertion injuries										
7.8	Electrocution										
7.9	Others ……										

Section C

8. As a member of Management/Supervisory staff you indicate the **Practising level** of following management Strategies to reduce accident in the company.

No	Management Strategies	Practicing Level				
		Very Low	Low	Medium	High	Very high
8.1	Post Incident Investigation and take control actions					
8.2	Management Leadership and Personal Commitment					
8.3	Implementation of Hazard control method					
8.4	Risk Management and control actions					
8.5	Use of Personal Protective equipment					
8.6	Comply with Legal and Other Obligations					
8.7	Implementation of Operational Controls and Procedures					
8.8	Reediness of Emergency Preparedness					
8.9	Safety Training and Competence programs					
8.10	Employee Involvements on safety programs					

9. As a member of Management/ Supervisory staff you indicate the **Effectiveness level** of following management practises to reduce accident in the company

No	Management Strategies	Effectiveness				
		Very Low	Low	Medium	High	Very high
9.1	Post Incident Investigation and take control actions					
9.2	Management Leadership and Personal Commitment					
9.3	Implementation of Hazard control method					
9.4	Risk Management and control actions					
9.5	Use of Personal Protective equipment					
9.6	Comply with Legal and Other Obligations					
9.7	Implementation of Operational Controls and Procedures					
9.8	Readiness of Emergency Preparedness					
9.9	Safety Training and Competence programs					
9.10	Employee Involvements on safety programs					