

**RISK ASSESSMENT ON COMBINED CYCLE POWER PLANT  
MECHANICAL MAINTENANCE**

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### **SUPERVISOR DECLARATION**

“I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant and Maintenance)”

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RISK ASSESSMENT ON COMBINED CYCLE POWER PLANT MECHANICAL  
MAINTENANANCE

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This report is submitted in partial fulfilment of requirement for Degree of Bachelor  
of Mechanical Engineering (Plant and Maintenance)

Faculty of Mechanical Engineering  
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JUNE 2015

## DECLARATION

“I hereby declare that the work in this report is my own except for summaries and quotation which have been duly acknowledge.”

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*I dedicate my final year project to my beloved parent, Mr Harold Sinpong for his encouragement, support and undesired love throughout my study.*

## ACKNOWLEDGEMENT

Special thanks dedicated to all individual that helped directly or in directly on accomplishing my Final Year Project.

My heartfelt thanks to my supervisor Dr. Abdul Munir Hidayat Syah Lubis for giving me an opportunity to be taken under his brilliant guidance in preparing my Final Year Project report. My sincere gratitude to Dr. Nona Merry Merpati Mintan as my academic advisor whom given me a lot of advices throughout my study at the university. In addition, a special appreciation to Mr. Charlie Oliver (Head of Mechanical) and also to Mr. Abdul Hanif Mohd Helmi@Carl (Mechanical Engineer) for guiding and assist me during my site visit at the combined cycle power plant. Lastly, to my friend and family, thank you for the encouragement.

## ABSTRACT

This study is subjected to investigate risk and hazard exposed by employee of mechanical maintenance department at the combined cycle power plant as well as to assess risk probability and to study risk management of boiler, gas turbine and water treatment plant maintenance activities at Kota Kinabalu Industrial Park (KKIP), Sabah. The assessment was conducted based on HIRARC method which typically used to identify hazards that will cause a threat to the operation and maintenance of the plant. Three main stations were chosen for the study site in the combined cycle power plant which were the boiler, gas – turbine and water treatment plant stations. Risk and hazard were determined based on these three stations during the maintenance activities. The survey was conducted by work place inspection scheme method that including interview, task observation, reviewing standard operation procedure (SOP) as well as accident and incident investigation. The hazards identification was analysed through risk evaluation based on likelihood and severity of the hazards. A total of thirty-one hazards were identified in the combined cycle power plant at the three stations maintenance activities. The data acquired was summarized and categorized into three levels which were high, medium and low risks. Generally, 6% of the hazards identified were at low risk, 84% at medium and 10 % at high risk. In addition, 88.2% of the hazards were at medium risk at the gas-turbine station as well as at the boiler and water treatment plant stations with 85.7% and 71.4% of the hazards were at medium risk. From the results, the preventive or control measure such as elimination, substitution, engineering and administrative control as well as personal protective equipment (PPE) were recommended.

## ABSTRAK

Kajian ini adalah untuk mengkaji risiko dan bahaya terdedah oleh pekerja jabatan penyelenggaraan mekanikal di loji kuasa kitaran gabungan dan juga untuk menilai kebarangkalian risiko dan mengkaji pengurusan risiko aktiviti penyelenggaraan di stesen dandang, turbin gas dan loji rawatan air di Taman Perindustrian Kota Kinabalu (KKIP), Sabah. Penilaian ini dijalankan berdasarkan kaedah HIRARC yang biasanya digunakan untuk mengenal pasti bahaya yang akan menyebabkan ancaman kepada operasi dan penyelenggaraan loji tersebut. Tiga stesen utama telah dipilih untuk dijadikan tapak kajian di loji kuasa kitaran gabungan iaitu stesen dandang, gas - turbin dan loji rawatan air. Risiko dan bahaya akan dikaji berdasarkan ketiga-tiga stesen ini semasa aktiviti penyelenggaraan. Kajian itu dijalankan oleh dengan menggunakan kaedah pemeriksaan tempat kerja termasuk temu bual, pemantauan kerja, mengkaji prosedur operasi sederhana (SOP) serta mengkaji rekod kemalangan dan kejadian. Pengenalpastian bahaya dianalisis melalui penilaian risiko berdasarkan kemungkinan dan tahap bahaya. Sebanyak tiga puluh satu bahaya telah dikenal pasti di dalam loji kuasa kitaran gabungan pada ketiga-tiga aktiviti penyelenggaraan di stesen tersebut. Data yang diperolehi telah diringkaskan dan dikategorikan kepada tiga peringkat iaitu berisiko tinggi, sederhana dan rendah. Secara umumnya, 6% daripada hazard yang dikenal pasti berisiko rendah, 84% pada sederhana dan 10% berisiko tinggi. Di samping itu, 88.2% daripada bahaya di stesen gas turbin adalah berisiko sederhana, pada stesen dandang dan loji rawatan air dengan 85.7% dan 71.4% juga adalah bahaya berisiko sederhana. Daripada keputusan, langkah pencegahan atau kawalan seperti penghapusan, penggantian, kawalan kejuruteraan dan pentadbiran serta peralatan perlindungan peribadi (PPE) telah disyorkan.



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## LIST OF ABBREVIATIONS

DOSH	–	Department of Occupational Safety and Health, Malaysia
OSHA	–	Occupational Safety and Health Administrative
HIRARC	–	Hazard Identification, Risk Assessment, and Risk Control
HSE	–	Health and Safety Executive
PPE	–	Personal Protection Equipment
BIS	–	Bureau of India Standard
IS	–	Irish Standard
PSC	–	Public Safety Canada
CCOHS	–	Canadian Centre for Occupational Health and Safety
ISO	–	International Standard Organization
SOP	–	Standard Operating Procedure
WTP	–	Water Treatment Plant
PTW	–	Permit to Work
HRSG	–	Heat Recovery Steam Generator
FMA	–	Factories and Machinery Act

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## SUMMARY

Chapter I briefly elaborate background of study regarding the problem statements, objectives of the study and lastly the scope related. The end result of the study is to cover all the objective and scope mentioned as well as to solve the problem stated.

In chapter II, the related literatures are reviewed for better understanding towards the study. The information gathered in this chapter was used to generate theory to achieve the objectives of this project.

In chapter III, the flow and methods of study were explained. This also included on how the data was collected through the survey and the method to use during the survey. In the same time, the steps for HIRARC and risk evaluation also explained briefly in the chapter.

Chapter IV presenting the finding of the research of risk assessment on combined cycle power plant mechanical maintenance activities. The evaluation of the gathered results shows the risks in maintenance activities and the control measures taken for each activity.

Chapter V concluded the finding and recommendation towards the study conducted on risk assessment at combined cycle power plant maintenance activities based on the objectives of the study.



## CHAPTER I

### INTRODUCTION

#### 1.1 Study Background

Combined cycle plant for power generation is a plant that converting the energy in natural gas/fuel into electrical power involves the creation of mechanical work which is then transformed into electric power by a generator. The term “combined cycle” referred to the multiple combination of thermodynamics cycle to generate electricity. In Malaysia, combined cycle power plant has been the common ways of generating electricity beside hydroelectric power generation and coal power generation plants.

Power plants are much safer than they once were; however, employees still encounter hazards. In order to operate without a threat to the employee and the environment, it is undeniably essential to have a safety management system (SMS) for a power plant. In concern with this, a strategy involving the identification and evaluation of major hazards is essential in order to obtain and implement steps for identifying risk elements during operation and maintenance as well as to predict their likelihood and severity. The safety management system includes choosing risk analysis methods and their outcomes in terms of frequency of occurrence and extent of consequences (*A.M. Saedi et al, 2014*).

There are many formal techniques for the systematic analysis of occupational safety and health in general, and risk analysis in particular for combine cycle power plant (*A.M. Saedi et al, 2014*). One of the techniques is risk assessment. Risk assessment is

a form of documentation written to express an organization's dedication to employee health, wellbeing and safety. It is the most common ways of ensuring a proper workplace environment and to access the nature of risks and hazards in the workplace.

The method chosen to conduct the risk assessment is the HIRARC model. Hazard identification, risk assessment and risk control or HIRARC is a process in accessing the risk as well as to determine the level of hazard and risk assessment in accordance with Occupational Safety and Health Act (OSHA, 1994) for employer to provide a safe workplace to employees under the responsibility of the employer (DOSH, 2008).

## **1.2 Problem Statement**

Risk assessment is used for risk management decision to ensure the hazards present in the plant industry are reduced or eliminated if possible, so that the risk itself also deducted. However, this assessment was not conducted by all companies. Study was conducted at an Independent Power Plant (IPP) in Sabah. Currently, this company is the largest IPP in Sabah with total generating capacity of 380MW of electricity by using two gas-fired combined cycle gas turbine (CCGT) power plant and contributed 43% to the maximum load demand to the Sabah grid. Maintenance operation has occasionally being done, but there were no risk assessment has been documented for this operation.

### **1.3 Objectives**

This study is performed to conduct risk assessment in combined cycle power plant industry to ensure risk exposed to the employee is reduced and threatened during operation and maintenance activities. Main objectives of the study are:

- I. To investigate risk and hazard exposed by employee of mechanical maintenance department at the combined cycle power plant.
- II. To assess risk probability at boiler, gas turbine and water treatment plant during maintenance.
- III. To study risk management of boiler, gas turbine and water treatment plant maintenance.

### **1.4 Scope**

The study focused on the accessed hazards exposed to the employee of mechanical maintenance department during maintenance work in the combined cycle power plant through systematic identification and documentation of the major hazard. The study was done using Hazard Identification, Risk Assessment and Risk Control (HIRARC) worksheet based on the information supplied or relevant experience from the combined cycle power plant employee. In addition, the management of risks and hazards was conducted by choosing the most reasonable preventive measures through a rational judgement and modification of existing preventive measures (control measure). The study was conducted to assess risk at certain station in the power plant which is the boiler, gas turbine and water treatment plant.

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **2.1 Introduction to Risk assessment**

In the past several decades, power plant owners and industry in general have been vastly improved employee safety (Hansen. T, 2005). Although power plant safety is consider safer compare to a few decades ago, plant employee still encounter numerous hazards. Thus, it is up to employers to implement program or policies aimed to eliminate the hazards to reduce risks faces by the employee. Risk assessment is a practice or program that changes the working practice of the employees. It has become fundamental to the practice of planning, management and the operation of a business as a basic of risk management (DOSH, 2008). Ongoing hazard monitoring and effective control measures are essential to ensure that improvement in occupational safety and health is continued (Smith, 2010). Through risk assessment, employer can ensure that the hazard exposed by the employee is reduced or perhaps the risk of causes by the hazard is controllable.

Risk assessment means the process of evaluating the risk to safety and health arising from hazards at work. Risk assessment is the part of risk management. To be exact, it is the second stage of the procedure towards risk management. Risk management is basically the overall procedure correlated to identification of risk, risk accessing, adapted control measure and the outcomes of it (DOSH, 2008). Several common terms are defined below (Fred A. M, 2005):

- **Hazards** are defined as the potential for harm. The dual nature of hazards must be understood. Hazards include any aspect of technology or activity that produces risk. Hazards include the characteristics of things and the actions or in actions of people.
- **Risk** is defined as a combination of the probability of a hazard-related incident occurring and the severity of harm or damage that could result.
- **Probability** is defined as the likelihood of a hazard being realized and initiating an incident or series of incidents that could result in harm or damage for the selected unit of time, events, population, items or activity being considered.
- **Severity** is defined as the extent of harm or damage that could result from hazard-related incident.

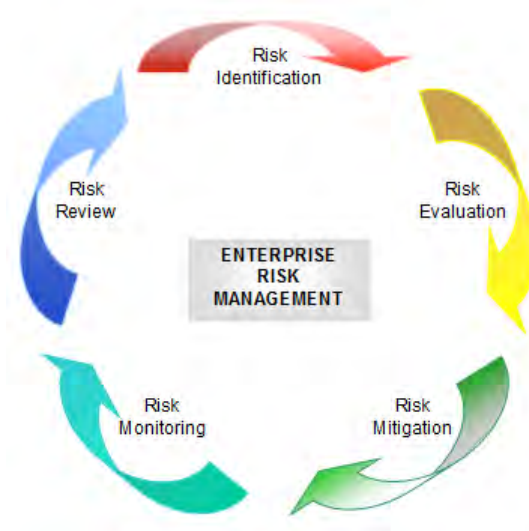


Figure 2.1: Risk Management Process (Source: British American Tobacco, Malaysia, 2014)

### 2.1.1 Purpose of Risk Assessment

Although risk assessment will not prevent any unwanted accidents, but it plays a very crucial part in minimize the likelihood of the risk to be happened (Fred A. M, 2005). Risk assessment is legally required from an ethical perspective, the main reason this assessment is carried out is to prevent or make sure that employee is not killed, injured or become ill at the workplace.

Risk assessment also forms an integral part of a good occupational health and safety management plan (DOSH, 2008). That helps to:

- Create awareness of hazards and risks in workplace
- Identify who may be at risk
- Determine and modified the control measures
- Prioritize hazards and control measures

Problems related to the hazards and risks in the industry are:

- Maintenance activities risks associated with hazards that can cause injuries such as accidents, health problem and other problem related to physical hazards. Hazard is the major causes of the risks.
- Exposure to long period of hazard area can resulted to decrease in working performance, motivation and efficiency of the worker.
- Occupational injuries and illness not only impact on safety and health but also economics due to high costs related with work injuries (*Pinto et al.*, 2011). Therefore, the company needs to spend a lot on medical expenses to the workers.
- Occupational injuries of the employee will lead to production loss of the industry due to lack of manpower for the maintenance job that may cause a certain work related to maintenance is delayed.

### 2.1.2 Risk Assessment's Elements

In conducting risk assessment, there are general elements that should be followed based on International Organization of Standardization (ISO) which is the ISO 31000:2009 version. The Figure 2.2 below shows the elements in risk assessment based on DOSH, Malaysia HIRARC guidelines which adapt ISO 3100.

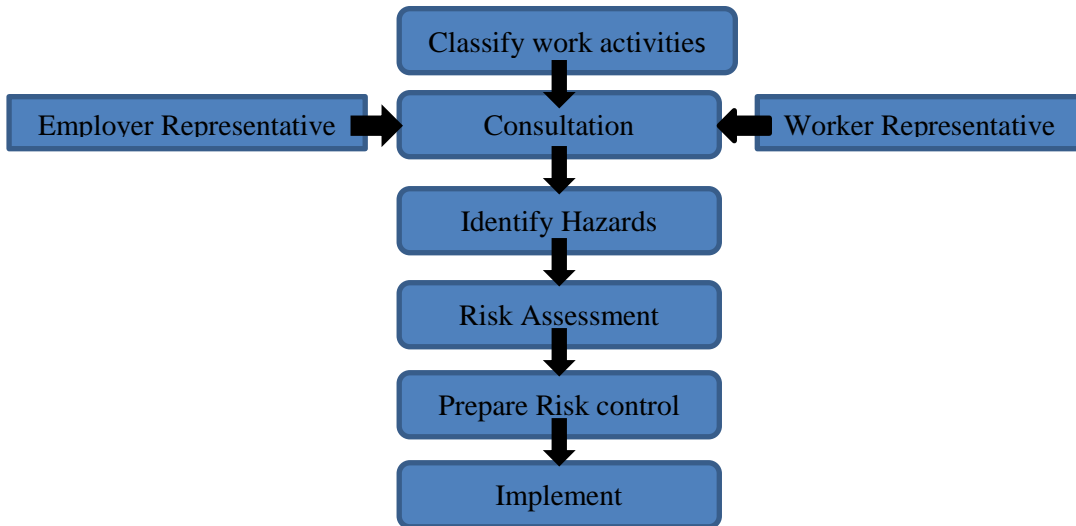


Figure 2.2: Elements in conducting Risk Assessment (DOSH, 2008).

#### 2.1.2.1 Classification of Work Activities

In the beginning of risk assessment procedure, recorded activities of the employees in concerned should be reviewed. From the survey, determination of either the tasks or activities done is risky or not can be evaluated. The work activities can be classified according to their similarity, for example:

- Geographical area of the working station in power plant
- Process flow of the production and maintenance.
- Define tasks related to the work such as lifting, assembling, etc.

### 2.1.2.2 Hazard Identification

Hazard can be assigned as something that may cause potential harm or damage, potential harm that contribute to any accident or mishap. Hazard can also assigned as anything that can directly produce risks either action/inaction of people or characteristic of things.

Hazard identification served the purpose of emphasizing the critical operations of tasks or activities that possess significant risks to the health and safety of employee or any related individual. In the same time, it also identify those hazards belong to certain equipment due to energy sources, working conditions or activities performed (DOSH, 2008).

Generally, hazards can be categorized into three major groups which are health hazards, safety hazards and lastly environmental hazards.

#### i. Health hazards

Health hazards defined as any agent that can lead to illness to an individual. It may produce serious and immediate affects, or even lead to chronic problems which affected all or certain part of the body. Someone with a job-related illness may not notice the symptoms immediately. For example, noise-induced hearing loss is often difficult for the affected individual to detect until it is well advanced.

Heath related hazards itself can be divided into four groups which are chemicals, biological, physical agents and lastly ergonomic.

- Chemical Hazards – substances in any forms of solid, liquid or gas elements, compound or mixture that pose a wide range of health hazards (such as irritation, sensitization, and carcinogenicity). Example: Battery acid, solvents. Etc.