QUALITATIVE AND QUANTITATIVE RISK ANALYSIS IN MECHANICAL LABORATORIES OF UTeM

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APPROVAL

'I / We admit that have read this composition and from my / our opinion this composition is enough from scope and quality for purpose of bestowal Bachelor of Mechanical Engineering (Structure & Material)'

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DECLARATION

"I hereby, declared that all part of this thesis is the results of my own work except for a few section which extracted and quoted from other resources that as been mentioned"

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ABSTRACT

Risk analysis is about probability, modeling, prediction and making decision according to the results of analysis. The aim of this project is to carry out the risk analysis study on mechanical laboratories of UTeM both qualitatively and quantitatively. Besides, the differences between these two major aspects of risk analyses study will also be compared. To complete the analysis, it must includes these three steps; risk assessment, risk management and risk communication. Risk assessment is a widen scope needed to be analyzed much in quantitative perspective. It will be started by collecting data, probabilistic analysis (probabilistic risk assessment or PRA) with fault tree analysis Following that, risk management will be done based on the achievement of risk assessment. Lastly, risk communication will be come up with transferring and exchanging data, risk assessment result, and information and knowledge of the risk. This research will be done at mechanical laboratories B phase complex of UTeM only, limited to five high risky laboratories; hydraulic and pneumatic laboratory, thermodynamic laboratory, combustion laboratory, material science laboratory and heat transfer laboratory. The information will be gathered from the internet sources, journals, previous research and risk analysis book's guide. This thesis is seen to be highly beneficial for those who are using the mechanical laboratories especially students, lecturers and technicians, to provide them with information on safety level and risk probability at the laboratories' surroundings.

ABSTRAK

Analisis risiko ialah tentang kebarangkalian, pembinaan model, ramalan, dan membuat keputusan berdasarkan kepada keputusan analisis tersebut. Tujuan projek ini adalah untuk melakukan kajian analisis risiko secara kualitatif dan kuantitatif di makmal-makmal mekanikal UTeM. Selain itu, perbezaan diantara dua aspek kajian analisis risiko juga akan dibandingkan. Untuk menyiapkan analisis ini, terdapat tiga langkah penting iaitu; analisis penilaian, analisis pengurusan, dan analisis perhubungan. Analisis penilaian ialah skop terbesar kuantitatif yang perlu dianalisis secara mendalam. Proses ini akan dimulakan dengan mengumpul data, analisis kebarangkalian (analisis penilaian kebarangkalian atau PRA) dengan menggunakan analisis 'fault tree'. Seterusnya, analisis pengurusan akan dilakukan berdasarkan kepada pencapaian keputusan analisis penilaian. Akhirnya, analisis perhubungan akan dikemukakan dengan pemindahan dan penukaran data, keputusan analisis penilaian, dan maklumat dan pengetahuan tentang risiko. Kajian ini hanya akan dijalankan di kompleks fasa B makmal mekanikal UTeM, terhad kepada lima makmal yang berisiko tinggi; makmal hidraulik dan pneumatik, makmal termodinamik, makmal pembakaran, makmal sains bahan, dan makmal pemindahan haba. Maklumat kajian ini akan dikumpulkan daripada sumber internet, jurnal, kajian-kajian terdahulu, dan buku panduan analisis risiko. Tesis ini dilihat menjadi bermanfaat kepada pengguna-pengguna makmal mekanikal seperti pelajar, pensyarah, juruteknik, untuk menyediakan mereka pengetahuan tentang tahap keselamatan dan kebarangkalian risiko di persekiran makmal.

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LIST OF ABBREVIATIONS

PRA	: Probabilistic risk assessment
QRA	: Qualitative risk assessment
UTeM	: Universiti Teknikal Malaysia Melaka
RRW	: Risk reduction worth
RAW	: Risk achievement worth
et al.	: and others
i.e.	: that is to say
NIL	: nothing or zero
VLO	: very low
VHI	: very high
HSE	: Health and Safety Executive
R	: reliability
LHS	: Latin Hypercube Sampling

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CHAPTER 1

1.0 INTRODUCTION

1.1 Background of the Problem

Risk analysis is usually defined as the combination of the severity and probability of an event. In engineering system, risk analysis is performed to measure the amount of potential loss and more importantly the elements of the system that contribute to that loss (Macdonald, 2004). It is the process of characterizing, managing and informing others about existence, nature, magnitude, prevalence, contributing factors, and uncertainties of the potential losses (Modarres, 2006). Risk analysis can be evaluated qualitatively or quantitatively. Qualitative and quantitative risk analysis is covered on overall aspects of engineering as well as on building and plant. The quantitative value is an indicator of the qualitative analysis. They are both complete each other to make the analysis perfect and give the better result.

For public, mechanical laboratories are hazardous places and cautions shall be put up once entering these places. However, for mechanical engineering students, these are place where knowledge could be gained. With appropriate safety guidelines and regulations, any hazardous situations can be avoided. On the other hand, hazards can be arisen from the systems and apparatus itself. There are several types of hazards' that can be found such as mechanical hazards, electrical hazards, thermal hazards,

noise hazards, vibration hazards, and radiation hazards. Sometimes, there will be a combination of these types of hazard. Mechanical, thermal and electrical hazards are always the main factors of risky conditions.

Mechanical hazards come from that machine itself. All the machines have their own ability and specification. The improper condition or any other chemical reactions may cause the machine become fatigue all over the years of usage. Rotary movement, sliding movement or reciprocating movement are typical mechanical hazards type. Machine parts or workpieces present mechanical hazard too. For instance, high kinetic energy such as flywheels, high acceleration and velocity or inadequate strength of material of construction may cause the hazardous situations. This study will focus only the hazards which are created by the systems and machinery factor. The study will not involve risks that arise from human errors. Besides the investigation of the risk analysis in the laboratories complex, the study will be important to determine the risk level of several mechanical engineering laboratories in UTeM. The investigation and information gathered are being useful to get better safety improvement soon.

1.2 Problem Statement

The qualitative and quantitative risk analysis case study on B phase mechanical laboratories of UteM will be done to investigate any potential loss of the system in the laboratories itself. These potential losses may be caused by the inappropriate system subject to improper arrangement and conditions. Any risky situation will contribute to injury and accidents. Even the preventive maintenance and inspection are being done periodically, this investigation will help to enhance the safety level in those laboratories' equipments. Moreover, the conducive and comfortable learning rooms are important and better for the students' lesson processes. It will not be safer only for the students, but also for those who will be

using the laboratories especially for research assistants as well as technicians. This study is also being carried out since there was no previous study done on it. Hopefully, this risk analysis study somewhat will give beneficial information and improvement for better achievement in the future.

1.3 Objective

The objective of this project is to carry out the qualitative and quantitative risk analysis study in B phase mechanical laboratories of Mechanical Engineering Faculty of Universiti Teknikal Malaysia Melaka (UTeM). Besides, the objective is also to compare the qualitative and quantitative risk analysis of the mechanical laboratories complex of B phase in UTeM.

1.4 Scope

The scope and limitations of this project include:

1) Qualitative and quantitative risk analysis study at five laboratories of B phase mechanical laboratories complex in UTeM.
2) Evaluation on differences from both studies of B phase mechanical laboratories complex of UTeM.
3) Uncertainty analysis and probabilistic risk assessment of safety risk analysis (i.e.: human-made products, technologies, and systems) in B phase mechanical laboratories complex of UTeM.
4) Evaluation and recommendation to improve and increase safety in B phase mechanical engineering laboratories of UTeM.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introduction to the Risk Analysis in Mechanical Laboratory

Generally, risk analysis is best described as the systematic study of uncertainties and risks encounter in business, engineering, public policy, and many other areas (Macdonald, 2004). In engineering perspective, it is well defined as the process of characterizing, managing and informing others about existence, nature, magnitude, prevalence, contributing factors, and uncertainties of the potential losses of the engineering elements. Risk analysis is performed to measure the amount of potential loss and more importantly the elements of the system that contribute to that loss (Speegle, 2005).

Typically, the safe machinery workshops are found to be physically safe, mechanically safe, electrically safe and functionally safe (Macdonald, 2004). Safety risk analysis can be best described as estimating potential harms caused by human-made products, technologies, and systems such as stress or damage on the barrier due to forces and pressure penetration. Also, there are six types of hazards that can be found in mechanical laboratories i.e.: mechanical hazards, electrical hazards, thermal hazards, noise hazards, vibration hazards, and radiation hazards (Speegle, 2005).

The studies of risk analysis in commercial mechanical workshops industry have been done by many researchers lately (Garrick, 1991, Donnely, 1991, Purdue, 1991, Long, 1991, Kaplan, 1991, Marsch, 1991, Simmon, 1991, et al.). But, none are doing risk analysis study in mechanical laboratories of university itself. People may not realize those fires, explosions, chemical leaks, and other bad incidents would happen in the mechanical laboratories. The investigation will find the potential loss in the mechanical complex due to the lacking of the systems. Thus, this can provide and assure systems and machine in the laboratories are in good and safe conditions (Speegle, 2005).

2.2 The Process of the Risk Analysis

Theoretically, the process of risk analysis includes identifying and quantifying uncertainties, estimating their impact on outcomes, building a risk analysis model that expresses these elements in quantitative form, exploring the model through simulation and sensitivity analysis, and making risk management decisions. There are three elements in risk analysis (as in Figure 2.1) and four steps towards the risk analysis process (Speegle, 2005):

- Identify and quantify uncertainty.
- Compute the impact of uncertainty.
- Analyze the model results.
- Make decisions to better manage risk.

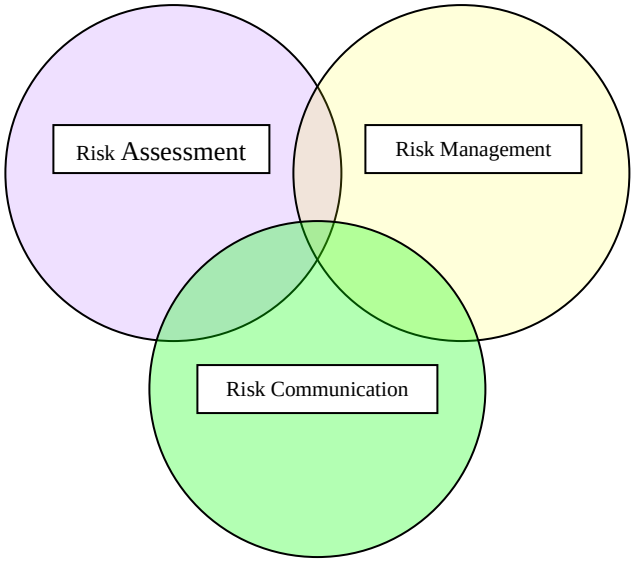

Figure 2.1: Elements of risk analysis
(Source: Modarres, 2006)

The risk analysis process starts with the determination of scope and objectives for the analysis. These scope and objectives are really emphasized to make sure the goal can be achieved appropriately. Before going further, there are three basic steps to achieve the risk analysis result respectively, i.e.; risk assessment, risk management and risk communication (Taylor, 1994). The three basic steps could be classified into qualitative and quantitative analysis. Overall briefly, qualitative is the analysis about the value of 'low', 'medium', or 'high'. Whereas, quantitative is the analysis about numerical value derived from the probability and calculation that have been made.

2.2.1 Qualitative and Quantitative of Risk Analysis

As mentioned earlier, risk can be evaluated qualitatively or quantitatively. Qualitative risk analysis is most widely used because it is simple and quick to perform (Vose, 2001). It is estimated using linguistic scales i.e.; low, medium and high

(Modarres, 2006). Sometimes, the indication of prediction could be 'NIL', 'very low' (VLO) and 'very high' (VHI). This method seems not to rely on actual data and probability, but extremely subjective. Frequently, it is a choice for a very simple system (Vose, 2001).

Quantitative descriptions of risk use numerical values such as 'one irreversible injury per 1000 years', this might be the equivalent of a 'medium but unacceptable risk'. If the quantitative risk is reduced to say 'one irreversible injury per 100 000 years', it might be described as 'low and acceptable risk' (Garrick, 1991). Quantitative risk analysis is to estimate the risk in form of the probability of any losses. The quantitative analysis is usually complicated, time-consuming and expensive (Vose, 2001). The process begins by collecting the data and doing probability and uncertainty analysis (Macdonald, 2004). However, this method analysis is very particular for complicated system engineering as in machinery workshops as well as mechanical laboratories such as hydraulic and pneumatic laboratory, thermodynamic laboratory, combustion laboratory, material science laboratory and heat transfer laboratory (Vose, 2001).

2.2.2 Risk Assessment

Risk assessment is the process of collecting data begins. The historical data also included if any. What goes wrong in one system of machinery workshops will be found out and determined (Macdonald, 2004). A simple mathematical representation of the expected loss found in the literature as (Modarres, 2006) as shown below;

$$risk\left(\frac{consequense}{unit}\right) = frequency\left(\frac{event}{time}\right) \times magnitide\left(\frac{consequence}{event}\right)$$

(Source: Modarres, 2006)