SAFETY EVALUATION AND RISK ASSESSMENT ON A SELECTED PIPE WELDING SERVICES WORKSHOP FOR OIL AND GAS INDUSTRY

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ABSTRACT

This study was conducted on a selected pipe welding workshop for the oil and gas industry. The objectives of the study are to identify hazards, assess and evaluate the inherent risks in the pipe welding and related activities. Control measures will be proposed to reduce risks associated with the hazards. In order to achieve that goal, several methods have been implemented to obtain the essential information and data. Workplace visits were conducted to feed more detailed information on the pipe welding process and monitor the hazards at work. Existing control measures were recorded for the risk assessment process. The results of the workplace assessment shall determine the risk rating. By applying this assessment method, hazards at the workplace shall be divided according to the level of risk rating whether HIGH, MEDIUM or LOW. Result of the risk rating study shows no risk of HIGH, while 37 hazards were MEDIUM and 8 hazards were LOW. Installation of Local Exhaust Ventilation (LEV) is highly recommended for all welding stations to reduce exposure to welding fumes. The installation of portable sound dampener is also recommended for pipe beveling machines to reduce loud noise at the workplace. Workers' commitment and support from company management are crucial for creating and pursuing a healthier and safer workplace.

ABSTRAK

Kajian telah dijalankan ke atas sebuah bengkel pengimpalan paip bagi industri minyak dan gas. Objektif kajian adalah untuk mengenalpasti bahaya, menaksir dan menilai risiko yang wujud ketika kerja-kerja pengimpalan paip dan aktiviti yang berkaitan dengannya. Seterusnya langkah-langkah kawalan akan dicadangkan bagi memastikan risiko terhadap bahaya tersebut dikurangkan. Bagi tujuan itu, beberapa kaedah telah dilaksanakan bagi mendapatkan maklumat yang diperlukan untuk mencapai objektif tersebut. Lawatan tempat kerja dilakukan untuk mendapatkan maklumat yang lebih jelas berkenaan proses kerja-kerja pengimpalan paip serta melihat dengan lebih jelas hazard di tempat kerja. Seterusnya, langkah kawalan yang sedia ada dapat direkodkan bagi proses penaksiran risiko. Hasil penilaian tersebut kadar risiko dapat ditentukan. Melalui kaedah ini, hazard yang terdapat di tempat kerja boleh dibahagikan mengikut tahap risiko sama ada TINGGI, SEDERHANA atan RENDAH. Hasil kajian mendapati tiada risiko TINGGI, manakala 37 hazard adalah SEDERHANA dan 8 hazard adalah RENDAH. Sebagai cadangan penambahbaikan terhadap langkah pencegahan yang sedia ada, pemasangan Pengudaraan Ekzos Setempat (LEV) adalah sangat digalakkan bagi setiap stesyen kimpalan bagi mencegah pendedahan terhadap wasap kimpalan. Pemasangan perendam bunyi mudah alih turut dicadangkan kepada mesin bevel paip untuk mencegah penghasilan bunyi bising di tempat kerja. Komitmen pekerja dan sokongan dari pihak pengurusan syarikat sangatlah penting bagi mewujudkan dan menjayakan tempat kerja yang lebih sihat dan selamat.

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LIST OF SYMBOLS AND ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
AUT	Automatic Ultrasonic Test
DOSH	Department of Occupational Safety and Health
FMA	Factory and Machineries Act
HAVS	Hand Arm Vibration Syndrome
HIRARC	Hazard Identification, Risk Assessment and Risk Control
ILUC	Internal Line Up Clamp
JSA	Job Safety Analysis
LEV	Local Exhaust Ventilation
MUT	Manual Ultrasonic Test
NIOSH	National Institute of Occupational Safety and Health
NRV	Non-Return Valve
OSHA	Occupational Safety and Health Act
PEL	Permissible Exposure Limit
PFM	Pipe Facing Machine
PIC	Person In Charge
PPE	Personal Protective Equipment
PTW	Permit To Work
QC	Quality Control
SOP	Standard Operating Procedure
UT	Ultrasonic Test
VWF	Vibration White Finger

LIST OF APPENDICES

-NIL-

CHAPTER 1

INTRODUCTION

1.1 Research Background

Cutting and welding are main activities for pipe laying project for oil and gas industries. These activities pose a combination of hazard for both safety and health risks to workers in the industries. This research was conducted at a selected company which provide pipe welding services in a workshop/warehouse working environment.

SMX Welding Services (M) Sdn Bhd is one of companies that offered automatic and manual welding services for oil and gas pipeline in this Asia-Pacific region. Their workshop is located at Warehouse AB & CD, Johor Port Berhad, Pasir Gudang, Johor. Apart from automatic and manual welding as their main activity, there are also other activities such as steel fabrication, destructive and non-destructive test, Internal Line-Up Clamp (ILUC) maintenance, pipe lifting and storage activities. Pasir Gudang workshop acts as a business hub and training centre due to its strategic location for Asia Pacific Region

This research study and assess hazards and risks associated with activities performed at SMX Warehouse AB & CD. The input to be processed and analyzed, then discussed for effective control measures. Best practice within the company to be highlighted and any observations or gaps to be addressed for improvement.

1.2 Problem Statement

In recent years, automatic welding has been widely applied in on-site welding oil and gas pipelines. It has offered the industry with good in welded joint appearance shape, low in labour intensity, fast in welding speed and high in first-time welding pass rate (Zeng et al., 2014). The implementation of automatic welding technologies has improved the quality aspect of welding and reduce the workers' exposure to hazard (Wang & Ruijie, 2011).

However, there are numbers of high risk activities involved in pipe welding (automatic or manual welding) which is need to be defined and assessed either in quantitative or qualitative way. To assess the risks, suitable risk assessment method need to be conducted such as site observation, data analysis and interview sessions.

With reference to laws and regulations such as Occupational Safety and Health Act (OSHA) 1994 and Factory and Machineries Act (FMA) 1967, an employer must ensure and provide a safe and healthy work environment to their workers and people surroundings by implementing the appropriate safety practices and continuous safety awareness program towards promoting safe work culture within the industries.

1.3 Research Aim, Purpose and Objectives

There are important elements in conducting risk assessment starting with identification of existing hazards, assess the probability or possibility, and propose relevant controls. Significant hazards in pipe welding service and related activities are varied and could pose impact on employees, facilities and the environment. Therefore, the current study was conducted to identify hazards, estimate risks and determining control measures based on the data collected to obtain a comprehensive model for the study HIRARC pipe welding services in Malaysia.

The objectives of this study are to examine the issues associated with health, safety and environment aspects in the selected pipe welding services workshop.

The objectives of this study are:

1. To identify the hazards associated with the pipe welding service activities conducted at the selected workshop
2. To assess and evaluate the risks associated with the activities to the safety and health of the workers, facility and the environment
3. To recommend mitigation plan and control measure to reduce the likelihood impact and risk rating level

1.4 Research Approach

This study started with defining the issues regarding health, safety and environment thus leading to the identification of problems and research statement. Literature review was conducted for better understanding and knowledge of current perspective. Next is to define and achieve the research objectives and using the listed research methodology. Data from research finding is analyzed and discussed which had drawn to a conclusion of this study. Recommendation for future study is also discussed for better results and conclusions.

1.5 Report structure

The introduction of this research report is presented in Chapter 1 which is focused on research background, problem statement, research aim, purposes and objectives, research approach and also this research structure.

In Chapter 2, a literature study comprises current knowledge of welding activities in general and pipe welding activities for oil and gas industry in understanding the research concept and justify the needs of research.

Chapter 3 shall explain on the methodology of the study which adopting the HIRARC guidelines from Department of Occupational Safety and Health (DOSH), Malaysia.

In Chapter 4, hazards based on work sequences are identified and evaluated. Then, results from site assessment are recorded and documented into the HIRARC form for risk assessment to determine the risk rating based on the likelihood against severity.

From the data analysis, a summary of risk rating are produced for discussion purposes. The existing control measures are discussed and evaluated. Furthermore, recommendations control measures are proposed to ensure a safer workplace. This will be discussed in Chapter 5.

Chapter 6 shall conclude the study and recommendations for future study.

CHAPTER 2

LITERATURE REVIEW

2.1 Common Hazards Related with Pipe Welding Activities

Pipeline welding can be considered as one of the most hazardous occupation in pipeline project and construction phase. Welders and people surrounding are exposed to excessive heat and noise, welding fumes, fires and explosion, and can affect health conditions. Recent studies have indicated that there are many chemicals produced and released from welding activities which can pose hazards to welders in long term effect such as lung, brain and nerve damage, such as manganism (Welders' Parkinson's disease), while short-term exposure can result in nausea, dizziness, or eye, nose and throat irritation. High exposure to manganese at work may lead to adverse neurological effects (Bailey et al., 2017)

Electrical shock is one of most common accidents for welders due to damaged welding cables or exposed cable connection. Welding activity produces toxic chemicals such as harmful metal oxide compounds, basic metals and minerals such as manganese molecules which can be inhaled by welders and nearby observers.

Welding and other hot work activities such as grinding and gouging could produce loud noise and may cause hearing loss. Flying object from grinding activity may penetrate into eyes or ear canal and resulting permanent injury.

Welders are also exposed to excessive hot metals such as metal slag or spatter during welding activity which may cause serious burns if made contact with skins.

2.2 Safety Tools used for Hazard Identification

It is responsibility of the employer to identify where the risks are in their organization and to take necessary actions to control them to prevent any mishaps from occurring. The main purpose of risk management is to eliminate or isolate or reduce the risk by As Low As Reasonably Practicable (ALARP) principle. This can be done by performing hazard identification study and implementation of preventive or corrective measure to control associated hazard at workplace.

In this study, the HIRARC model proposed by the National Institute of Occupational Safety and Health (NIOSH) of Malaysia to be used to investigate the safety and health in the study of pipe welding services workshop, Johor, Malaysia.

2.3 Laws and Legislations

Health and safety bounds with laws and legislations in Malaysia. There are two primary acts which are related to Health and Safety at workplace namely Factory and Machineries Act (FMA) 1967 and Occupational Safety and Health Act (OSHA) 1994.

FMA 1967 specifically control the registration and inspection of factories and machinery at workplace and the health, safety and welfare of involved workers.

On the other hand, OSHA 1994 is more to self-regulation approach. The main principle of the OSHA is to ensure provision for safety, health and welfare of workers at work area, and also protecting others against risks to health and safety related to the activities of persons at work.

2.4 Heinrich Domino Theory – Sequence of Accident Causation

In 1929, Herbert William Heinrich developed a theory called Domino Theory. Heinrich's domino theory was a theory of accident causation presented from H.W. Heinrich 'Axioms of Industrial Safety' which was the first guidelines in industrial safety. The theory has been applied many times over the years. The steps of accident prevention were categorized into five metaphorical dominos in the orders as shown below:

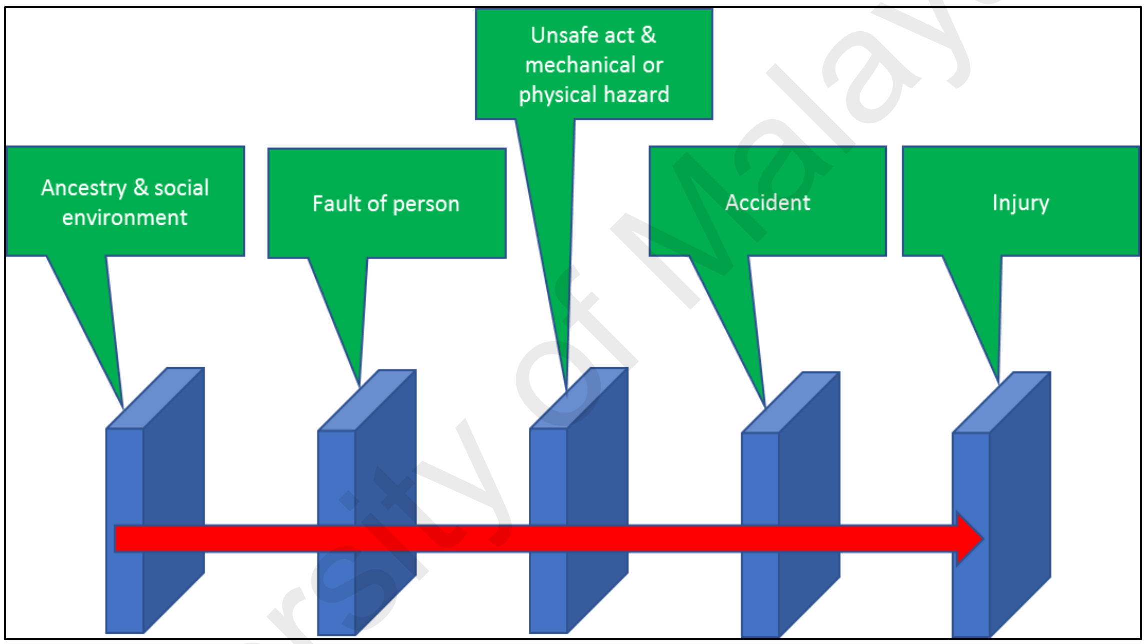

Figure 2.1 Heirich's Domino Theory

Figure 2.1 shows that the Domino Theory have five blocks arranged in alignment which exactly representing the arrangement of domino. Each one of the block will indicated their own factor, which are:

First Block – ancestry and social environment

Second Block – Fault of person

Third Block – Unsafe act / physical hazard

Fourth Block – Accident

Fifth Block – Injury

These domino block represent accident causation series that may contribute to a subsequent incident. The accident or injury can be avoided by eliminating one of the domino block. Risk assessment from HIRARC activity will require an organization to control the hazard by eliminating or reducing the exposure to the workers. This represent the eliminating of the third piece of domino (unsafe acts or physical factors) from the row of dominos (Agwu, 2012).

2.5 Hazard Identification, Risk Assessment and Risk Control (HIRARC)

2.5.1 Hazard identification

Hazard identification is the process of identifying any type of hazard that occurs in the workplace that may cause any injuries to employees. Overall, there are no particular method in identifying hazards in the workplace. In a nutshell, process of hazard identification and risk assessment to be done when there is a major change in the safe work procedure, operations or work instruction.

The main purpose of hazard identification is to highlight the critical operations of tasks, those tasks posing significant risks to the health and safety of employees as well as highlighting those hazards pertaining to certain equipment due to energy sources, working conditions or activities performed.

Hazard in definition is a source condition or situation that could cause harm or injury to people. Hazards can be divided into three main groups, health hazards, safety hazards, and environmental hazards (Saedi et al., 2014).

Occupational health hazard is any agent that can cause illness to an individual. A health hazard may produce serious and immediate (acute) affects, or may cause long-term(chronic) problems. All or part of the body may be affected. Someone with an occupational illness may not recognize the symptoms immediately. For example, noise-induced hearing loss is often difficult for the affected individual to detect until it is well advanced.

A safety hazard is any force strong enough to cause injury, or damage to property. An injury caused by a safety hazard is usually obvious. Safety hazards could pose serious injury when hazards at workplace are inadequate. Some examples of safety hazards include, but are not limited to:

1. Slipping/tripping hazards (such as wires run across floors);
2. Fire hazards (from flammable materials);
3. Moving parts of machinery, tools and equipment (such as pinch and nip points);
4. Work at height (such as work done on scaffolds);

An environmental hazard is a substance, state or event which has the potential to threaten the surrounding natural environment and / or adversely affect people's health. These environmental hazards can be categorized into 4 types of hazards which are chemical, mechanical, biological and psychosocial hazards.

2.5.2 Risk Assessment

Risk has different meanings and perspectives to different people. The concept of risk varies according to point of view, attitudes and experiences. Engineer, designers and contractors view risk from the technological perspective; lenders and developers tend to view it from economic and financial side; health professionals, environmentalist, chemical engineers take a safety and environmental perspective. Risk is therefore generally seen as an abstract concept whose measurement is very difficult (Raftery, 1994).

Risk assessment involves data collection about the identified hazards at workplace and assessing the likelihood and severity of each hazard by creating a qualitative or quantitative table. Inputs from hazard identification will be used to perform risk analysis which can be done qualitatively, quantitatively or semi-quantitatively.

Qualitative analysis required expert knowledge and in-depth experience with the work to produce a quality reporting of potential severity and likelihood that will occur. Quantitative analysis is generally uses probabilistic analysis approach that uses numerical numbers for both severity and likelihood data from a variety of sources (Gholami et al., 2015). Semi-quantitative analysis is used to outline the respective risk scale such as likelihood versus severity and their consequences. A study by Radu (2009) indicates that semi-quantitative approach is effective in quantified risks by establishing a hierarchy of risks.

Risk Assessment is where the severity of the hazards and its potential outcomes are considered in conjunction with other factors including the level of exposure and the numbers of persons exposed and the risk of that hazard being realized. There are a number of different formulae used to calculate the overall risk from basic calculations using high, medium and low categories to complicated algorithms to calculate risks at high risk work locations such as oil refinery plant.

It is important to ensure that the residual risk following implementation of control measures is ‘As Low As Is Reasonably Practicable’ (ALARP). For a risk to be ALARP it must be possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained.

Risk can be presented in variety of ways to communicate the results of analysis to make decision on risk control. For risk analysis that uses likelihood and severity in qualitative method, presenting result in a risk matrix is a very effective way of communicating the distribution of the risk throughout a plant and area in a workplace.

Risk can be calculated using the following formula:

L x S = Relative Risk

L = Likelihood

S = Severity

Table 2.1 Risk Matrix (DOSH Malaysia, 2008)

	Severity (S)				
Likelihood (L)	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Table C

High

Medium

Low

Where;

Table 2.2 Likelihood table (DOSH Malaysia, 2008)

Likelihood (L)	Description	Rating
Most Likely	The most likely of hazard/event being realized	5
Possible	Has a good chance of occurring and it is not unusual	4
Conceivable	Might be occur at sometimes in future	3
Remote	Has not been known to occur after a period of time	2
Inconceivable	It practically impossible and has never been occurred	1

Table 2.3 Severity table (DOSH Malaysia, 2008)

Severity	Description	Rating
Catastrophic	Numerous fatalities, irrecoverable property damage and productivity	5
Fatal	Approximately on single fatality or major property damage if hazard is realized	4
Serious	Non-fatal injury, permanent disability	3
Minor	Non-fatal injury, temporary disability	2
Negligible	Minor abrasion, bruises, cuts, first aid type injury	1

Advantages of semi-quantitative risk evaluation:

1. Clarity of thinking
2. Consistency of approach
3. Prioritization
4. Timescale

Priorities and timescales are factors that should be taken into account in order to implement accident prevention measures. High risk rating shall be given priority against low risk.

High Risk Rating = high priority actions

Low Risk Rating = low priority

However, risk and timescale are not working on the same judgement. If a preventive measure does not involve a high cost, it should be immediately implemented even if it is only a low risk rating. Low cost, easy actions should be done even if low priority. Medium risk rating still needs rapids action and attention.

2.5.3 Risk Control

Risk control is the elimination or inactivation of a hazard in a manner such that the hazard does not pose a risk to workers who have to enter into an area or work on equipment in the course of scheduled work.

According to DOSH (2008), there are five tiers in the hierarchy of risk control, namely elimination, substitution, engineering control, administrative control and personal protective equipment (PPE) as shown in **Figure 2.2.**

Elimination should be the first step of risk control; however, it is not possible to totally eliminate the hazards if they are inherent of the activities themselves (Marhavilas & Koulouriotis, 2008).

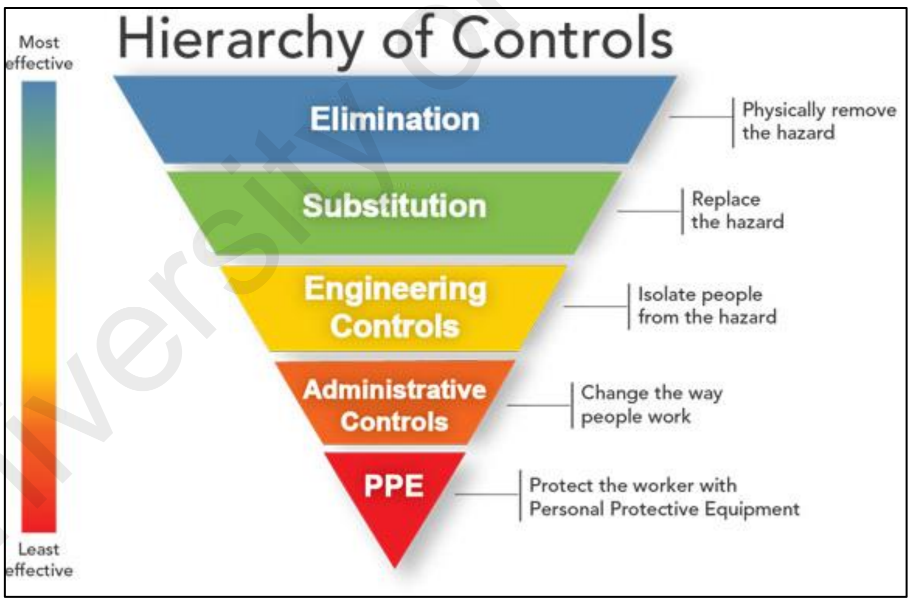

Figure 2.2 Hierarchy of risk control (Wikipedia, accessed on 11th September 2017)

If elimination is not a practical option, substitution should be used instead. For example, replacing a hazardous substance with a safer one or substituting a more hazardous process with a less hazardous one. Both elimination and substitution are difficult to be implemented in an existing process. On the other hand, it is inexpensive and simple to implement during the design and development phase of the process (NIOSH US, 2017).

Engineering controls are methods or tools used to remove hazard at its source before it comes into contact with workers (NIOSH US, 2017). The methods include ventilation, enclosure and isolation.

Administrative controls are methods used to change the way job steps are carried out by workers (DOSH, 2008). Examples of administrative control methods are safe work procedures, job rotations, housekeeping and hygiene.

Personal protective equipment should only be used when other method fails to reduce or eliminate the hazard (Spellman & Whiting, 2005). The types of personal protective equipment are respiratory protection, protective clothing and head, eye, hand and foot protection.

CHAPTER 3

METHODOLOGY

3.1 Methodology Framework

In this chapter, methodology of the research study is explained. At the initial stage, literature reviews were conducted to obtain the background of the current study and relevant methods for this study.

Site visits were conducted to obtain the actual situation at the workplace and to observe the pipe welding activities. From there, hazards and risks associated to the pipe welding activity can be assessed and evaluated by the severity and likelihood of the event. From the site visits, evaluation on the current control measures are recorded. The effectiveness of accident prevention measures can be assessed and recorded.

General information and documents related to health and safety are accessible. However, company-related information and documents are confidential, only for reading and as reference notes.

From the collected information obtained at workplace observation, data is extracted into the HIRARC form for hazard identification and risk assessment purposes. Through such information, possible hazards can be classified into HIGH, MEDIUM and LOW according to risk rating. Effectiveness of subsequent control measures are discussed in reducing risk.

For hazards with significant risks, recommendations on control measures are presented to make the workplace safer.

3.2 Site Observation and Monitoring

In order to identify the hazards that exist in the study area, site visits were planned in advance and site assessments were carried out at the workplace. For this purpose, each visit was focusing to specific work activity of the work area in the workshop for the pipe welding activity. General workplace inspection checklists are prepared and tailored to suit with work based on several criteria to identify the hazards that exist for each of the activities carried out at the workplace. Observation are directly to real practices within the welding workshop for pipe welding activities.

Implementation of hazard identification and evaluation of risks associated to the welding activity is very crucial. Most of the incident happen due to lack of identification of hazard for each work performed.

A hazard identification checklist was used as a tool to identify workplace hazard, in order to study and produce a list of hazards associated with work activities that are expected and not expected. Hazard identification checklist is primarily intended to evaluate each task related in the process and to review the effectiveness of the current safety measures that have been selected or implemented by the management.

3.3 Review of Documents and Interview Sessions

Documents such as Job Safety Analysis (JSA), incident reporting and statistic, and Standard Operating Procedure (SOP) were reviewed and used as references in determining the risk rating and control measures that need to be emphasize. For machineries such as Pipe Facing Machine (PFM) and Internal Line Up Clamp (ILUC), the machine manual standards were also reviewed and safety precautions were noted.

3.4 Data Collection and Analysis

Based on data collected from site observation, review of documents and interview session, HIRARC forms as per Department of Occupational Safety and Health (DOSH) Malaysia guideline were used to assess and evaluate the risks associated with the activities at work area. This assessment includes the estimation and evaluation of risks by considering the existing control in the workplace. Risk assessment uses likelihood and severity to produce a risk matrix which is a very effective way in converting information on risks into a risk matrix table (DOSH, 2008). Based on input and processed data in the HIRARC, current control measures will be evaluated and further mitigation action to be proposed to minimize the risks. ALARP practices and implementations will reduce the risks in order to establish a safe working environment.

3.5 Research Limitation

The main constraints to carry out this study are that most of the company-related documents are confidential. Only general and general information on activities can be obtained and read during visits. The situation at the workshop was rather calm due to the lack of projects following the slowdown in the market economy and the drop in world's oil prices.

CHAPTER 4

RESULTS

In this chapter, results obtained from the study will be transferred into HIRARC form. Scope of study have been divided into THREE main activities for pipe welding, which are:

1. Preparation of pipe coupon
2. Pipe welding (automatic and manual) and Quality Control Inspection
3. Operation of generator sets

4.1 Preparation of Pipe Coupon

Normally pipes will be transferred from lorry by using a mobile crane and stored at pipe storage area. This lifting work is usually done by a group of competent riggers; and a signalman to provide instruction to the crane operator.

The pipe will be taken to the pipe cutting area and to be cut according to the required sizes. The pipe cutting process is performed using oxy-acetylene cutter which is commonly used in heavy industry. Before performing cutting task, the fitter will ensure that the pipe is secured by using wooden wedges. This will prevent the pipe from moving during and after the cutting process.

Once the pipe is cut, it will be transferred to the beveling station by a forklift. The forklift should be operated by competent forklift operators to avoid any incidents involving forklift handling.

At the beveling station, the pipe coupon will be placed on the pipe rest and Pipe Facing Machine (PFM) will be inserted into the end of the pipe for the beveling process. The pipe should be secured with cargo strap to avoid any undesired pipe movement which can harm the PFM operator during the beveling process. The PFM will be hung on the sling belt and moved towards the pipe end by using the overhead crane. PFM operators will ensure that they always wear and equipped themselves with PPE clothing needed for this activity such as Kevlar gloves and face shield. Wearing loose clothing is prohibited when handling PFM because loose clothing can cause entanglement with the rotating PFM. Loud noise will be produced during bevel activities thus wearing a hearing protection is a mandatory for PFM operator.

Upon completion of pipe beveling activities, the pipe coupons will be taken to the welding workshop for next step. Slip, trip and falls hazards need to be take into account when transferring pipe coupons and other material within the workshop area.

Table 4.1 shows the results of HIRARC for the Preparation of Pipe Coupons.

Table 4.1 HIRARC Form: Preparation of Pipe Coupon

Hazard Identification			Risk Analysis			
Work Activity	**Hazard**	**Which can cause / Effect**	**Existing Risk Control (if any)**	**Likelihood**	**Severity**	**Risk**
Pipe loading and unloading to storage area using cranes	Dropped object	Bodily injury	1) Barricade work area 2) Competent workers	2	4	8
	Hit by moving vehicles on main road	Bodily injury and / or fatality	Single point of communication	2	4	8
Pipe cutting into coupon sizes using oxy-acetylene gas	Fire / explosion due to damaged hose or valve	Bodily injury	1) Competent worker 2) Install Non-Return Valve (NRV)	2	4	8
	Hot object / surface from pipe cutting activity	Burn	1) Compulsory to use long sleeve shirt/jacket 2) Provide worker with leather glove	3	2	6
	Pipe movement and arrangement to be cut as per procedures	Finger pinch / hand injury	Secure pipe using strap and wood wedges	2	3	6
Transfer material using forklift	Dropped object due to uneven ground	Bodily injury Equipment / material damage	Use designated routes for forklift	2	4	8
	Blind spot	Workers got hit by forklift Material / equipment damage due to collision	Competent forklift operator	2	4	8

Table 4.1, continued

Hazard Identification			Risk Analysis			
Work Activity	**Hazard**	**Which can cause / Effect**	**Existing Risk Control (if any)**	**Likelihood**	**Severity**	**Risk**
Transfer and setting up pipe coupon into Pipe Facing Machine (PFM)	Manual handling continuous manual lifting on the cutting set and the pipe coupons could affected human body	Can cause muscular strain / back pain	1) Apply good manual handling technique 2) Use mechanical lifting e.g. overhead crane and forklift	4	2	8
	Crane failure can cause dropped object	Struck by crane's load	1) Overhead crane inspection and servicing 2) Good condition of web sling	2	4	8
Pipe beveling using Pipe Facing Machine (PFM)	Hot object / surface due to beveling activity	Burn	1) Provide Kevlar gloves 2) Compulsory to wear long sleeve shirt/jacket	4	2	8
	Loud noise due to beveling activity	Hearing impairment	1) Use ear protection 2) Warning sign in place	4	3	12
	Sharp object i.e. metal chips or pipe residues which generated during the beveling process	Bodily injury	Kevlar glove MUST be worn	4	2	8
	Projectile metal chip from beveling activity	Bodily injury	1) Kevlar glove MUST be worn 2) No loose shirt/jacket allowed for this activity	4	2	8
	Unsecured hoses laying on the floor can cause slip, trip and falls on same level	Bruised, broken bones	Secure hoses and wires into trunking	2	2	4

4.2 Pipe Welding (Automatic and Manual) and Quality Inspection

Pipe coupons will be taken to the welding workshop station by forklift. Pipe coupons will be placed on a wooden pallet and transferred to the welding workshop station. A pipe coupon will be lifted by an overhead crane and to be attached to a pipe nest using tack weld technique.

After that, the Internal Line Up Clamp (ILUC) will be inserted into the pipe coupon by the overhead crane. Next, another pipe coupon will be lifted using overhead crane and beveled pipe end will be aligned by using ILUC by pipe fitters. Use of impact gloves is vital to protect hands and fingers in the event of unwanted pipe movement or dropped object during line-up and alignment in progress

Once pipe line-up is completed, the welding guide rail will be installed on the pipe coupon. Next, a welding torch carrier will be installed on the guide rail. Before welding activity is carried out, the pipe line up will be heated until it reaches the desired welding temperature. Quality Control (QC) Inspector will perform welding inspection from time to time. Welding activity will be carried out according to specified specifications and procedures.

When welding activity is performed, welding fumes will be produced which may affect the health and safety of workers, especially the welders and QC Inspectors. Illumination resulting from arc welding activity also pose health hazard to welders and people surrounding.

Welders also regularly manual lifts welding torch carrier in order to check the torch head condition and also when changing welding wire. This condition requires repeated activity which can cause strain muscle and back pain.

Angle grinder is used to grind and smooth off the weld on pipe joint. Vibration from this activity can pose hand-arm vibration syndrome (HAVS) or Vibration White Finger (VWF) if exposed for continuous and repetitive duration over a long period of time.

The use of off-specs grinding discs may also affect workers. There are many cases of accidents occurring within oil and gas industries due to the use of substandard discs and non-compliance with the manufacturer's specifications.

Welders also required to perform visual inspection before using angle grinder. Damaged equipment and torn cables can cause electrocution while using electrical powered hand tools.

Upon completion of welding activity, the pipe joint will be transferred to Ultrasonic Testing station either Automatic Ultrasonic Test (AUT) or Manual Ultrasonic Test (MUT). The pipe joint will be placed on the pipe holder or pipe rest for this activity. For AUT activities, operators need to manually lift AUT scanner repeatedly which may cause strain muscle and back pain.

AUT operators also exposed to sharp edges of pipe ends during performing their task. Suitable footwear selection such as rubber boots with slip resistant is essential due to AUT work area is always watery causing the floor become wet and slippery.

Table 4.2 shows the results of HIRARC for the Pipe Welding (Automatic and Manual) and Quality Inspection

Table 4.2 HIRARC Form: Pipe Welding (Automatic and Manual) and Quality Control Inspection

Hazard Identification			**Risk Analysis**			
Work Activity	**Hazard**	**Which can cause / Effect**	**Existing Risk Control (if any)**	**Likelihood**	**Severity**	**Risk**
Setting up pipe coupon into welding workshop using forklift	Pinch point during fixing and weld tacking the pipe coupon	Finger pinch / hand injury during pipe fitting	1) Apply buddy system 2) Impact glove MUST be worn for pipe fitting	3	3	9
	Dropped object due to uneven ground	Bodily injury Equipment / material damage	Competent forklift operator	2	4	8
Setting up Internal Line Up Clamp (ILUC) into main pipe and pipe coupon	Heavy load	Struck by pipe coupon	Pipe coupon was placed on the pipe support stand, tack welded, and tightened with suitable sling belt.	2	4	8
	Pipe movement	Bodily injury, hands and fingers injuries	Tighten the pipe using sling straps and tack weld between the pipe joint	2	4	8
Main power supply for welding activities are from portable generator sets	Electricity which supplied by generator set leaked due to improper connections or damaged wires and cables	Electrocuted	Cable trays were placed above head height and no laying electrical cables on the floor	2	4	8

Table 4.2 continued

Hazard Identification			Risk Analysis			
Work Activity	**Hazard**	**Which can cause / Effect**	**Existing Risk Control (if any)**	**Likelihood**	**Severity**	**Risk**
Pre-heat pipe coupon using propane gas	Fire / explosion	Bodily injury Equipment / material damage	Propane cylinder was tightened firmly on the standing trolley and kept away at least 3 meters from the heat sources during welding operation.	2	4	8
Perform pipe welding (automatic and / or manual welding)	Illumination from arc welding	Eye injury	1) Use of eye protection for welding activity 2) Welding screens were placed in front of the activities area to protect the peoples surrounding	3	3	9
	Manual handling due to repetitive manual lifting of welding head torch	Can cause muscular strain / back pain	Suitable racking to place the welding equipment are in place.	4	2	8
	Sharp object	Cuts	Welding leather gloves must be worn during operating this activity	3	2	6
	Welding fumes generated from welding activity	Health issues - chronic and acute health effect to respiratory systems	1) Adequate ventilation 2) Use approved respirator	4	3	12

Table 4.2 continued

Hazard Identification			Risk Analysis			
Work Activity	**Hazard**	**Which can cause / Effect**	**Existing Risk Control (if any)**	**Likelihood**	**Severity**	**Risk**
Grinding using angle grinder	Vibration of hand tools during operation	Health issues - Hand Arm Syndrome (HAV) and / or White Finger	Ensure all the hand grinder equipped with the proper attachment holder. Monitor the relevant employees who working with hand grinders to do the grinding in partially time. NO continuous operation allowed	3	2	6
	Flying fragment	Cuts / eye injury	1) Warning sign in place 2) Compulsory PPE MUST be worn during performing this activity	3	3	9
	Hot surface during grinding activity	Burn	Compulsory PPE MUST be worn during performing this activity	4	2	8
	Electricity	Electrocuted	Check cables and equipment condition. Replace if broken/damage	2	4	8
	Equipment failure	Cuts / bodily injury due to rupture disc	Hand tools and portable equipment MUST be checked and tested before use	2	4	8
Main power supply for Ultrasonic Testing (automatic) cabin are from portable generator sets	Electricity which supplied by generator set leaked due to improper connections or damaged wires and cables	Electrocuted		2	4	8

Table 4.2, continued

Hazard Identification			Risk Analysis			
Work Activity	**Hazard**	**Which can cause / Effect**	**Existing Risk Control (if any)**	**Likelihood**	**Severity**	**Risk**
Setting up welded pipe coupon onto pipe holder	Struck by welded pipe or UT equipment during handling	Bodily injury	Use forklift for lifting during set up and positioning the pipe coupon on to the pipe holder	2	4	8
	Unsecured hoses laying on the floor can cause slip, trip and falls on same level	Bruised, broken bones	Hoses were placed above head height and no laying cables on the floor	2	2	4
	Slippery floor can cause slip and fall on same level	Bruised, broken bones	Designated working area	2	2	4
Perform Manual Ultrasonic Test using UT probe	Manual handling for using sensor probe	Muscular strain / back pain		2	2	4
	Sharp edges of pipe ends	Cuts	Compulsory the used of the leather gloves during performing the UT activities	2	2	4

4.3 Operation of Portable Generator Sets

Generally, welding activity requires large electrical energy to carry out such activities. Therefore, portable generator sets are used to supply electric power to the welding workshop station. The diesel-powered portable generator sets can pose hazardous effect if control measures are not implemented accordingly. **Table 4.3** show the result of HIRARC for Operation of Portable Generator Sets.

Among the hazards recorded during site assessment and monitoring are electrical shock due to incomplete or damaged electrical cable connection. In addition, the smoke generated from diesel combustion for electricity generation may also pose a risk to workers' health.

During oil filling or bunkering activity, diesel produces chemical vapor causing the worker to be exposed to the vapor. Loud noise also produced by these generator sets during operation and may cause hearing loss or hearing impairment to nearby workers. Noisy work area can also affect the quality of work. Improper wires and cables arrangement can cause slip, trip and fall hazards on the same level.

In addition, electrical installation is also a common task for pipe welding activities. Electrical connections to welding machines require competent and skilled workers to prevent any electrical shock incident especially when welding activity is underway.

For maintenance activities, workers must ensure that power connectivity is turned off before starting work. This is important to ensure that the machine does not operate or being energized during maintenance work.

Workers need to protect themselves when working at height. The use of good and well-maintained ladder is the main factor to prevent to fall from height. Use of suitable fall arrestor such as full body harness is compulsory when working more than 2 meters. Improper wires and cables arrangement can cause slip, trip and fall hazards on the same level.

Table 4.3 HIRARC Form: Operation of Portable Generator Sets

Hazard Identification			Risk Analysis			
Work Activity	**Hazard**	**Which can cause / Effect**	**Existing Risk Control (if any)**	**Likelihood**	**Severity**	**Risk**
Operating portable diesel engine generator	Electricity which supplied by generator set leaked due to improper connections or damaged wires and cables	Electrocuted	Competent charge man to supervised the operation of the genset includes the periodic inspection checklist monitoring of the safety devices	2	4	8
	Fire / explosion	Burn Equipment / material damage	Periodic inspection by the charge man and the supplier. ALL the genset we under leasing from the supplier with 'hours of used contract' and will be sent it back for major servicing at their places once achieved the hours of used.	2	4	8
	Chemical fumes from diesel filling and smoke from generator's set exhaust	Health issues	1) Diesel refueling SHALL using the transfer hose to prevent any spillage 2) Compulsory proper and suitable PPE MUST be worn 3) Installation of the flexible exhaust higher from the ground	3	2	6
	Hot surface	Burn	Generator set body and the exhaust system were already insulated with the insulation material by the manufacturer to secured the heat	2	2	4
	Noise	Hearing impairment	Generator sets with sound proof body	2	4	8
	Unsecured wires and cables laying on the floor can cause slip, trip and falls on same level	Bruised, broken bones	Cables were placed above head height and no laying cables on the floor	2	2	4

Table 4.3, continued

Hazard Identification			Risk Analysis			
Work Activity	**Hazard**	**Which can cause / Effect**	**Existing Risk Control (if any)**	**Likelihood**	**Severity**	**Risk**
Electrical installation	Electricity which supplied by generator set leaked due to improper connections or damaged wires and cables	Electrocuted	1) Electrical cables were secured and away from water sources 2) Competent person to do the job	2	4	8
	Stored energy during the maintenance process which also may suddenly released	Bodily injury	1) Ensure to cut-off the power supply before start any electrical task 2) Proper grounding	2	4	8
	Working at height can cause fall from above	Bruised, broken bones and/or fatality	1) Use good condition ladder 2) Use of full body harness if working above 2meters 3) Apply buddy system	2	4	8
	Unsecured wires and cables laying on the floor can cause slip, trip and falls on same level	Bruised, broken bones	Ensure good housekeeping	2	2	4

CHAPTER 5

DISCUSSION AND RECOMMENDATION

5.1 Discussion

Based on the site assessment, a total of 45 hazards have been identified for pipe welding activities in the workshop. Of the 45 hazards, none of the hazard can be classified as HIGH RISK after taking into account existing risk control implemented by the company.

A total of 37 hazards have been identified as MEDIUM RISK and most of these hazards can be controlled by the current risk control established by the company for all employees. Current risk control that is appropriate and easy to be executed can further reduce the exposure to the hazards in the workshop.

For LOW RISK classification, there are 8 hazards that have been recorded during workplace inspection. Most of the hazards recorded are related to housekeeping and cable and hose management in the workshop.

5.1.1 Hazards with HIGH RISK rating (15 – 25)

No hazard is recorded during workplace assessment.

5.1.2 Hazards with MEDIUM RISK rating (5 – 14)

Of the 37 hazards recorded, welding fumes from welding activity and noise produced from pipe beveling activity gave a relatively significant risk rating compared to other hazards which are 12 rating.

Other hazards recorded as lower risk rating with lower likelihood and severity as a result of the current risk control which been implemented at workshops.

5.1.2 Hazards with LOW RISK rating (1 – 4)

8 hazards recorded were given as LOW RISK rating. Most of the hazards recorded were involving slip, trip and falls due to poor wiring cable and hose management that were placed on the floor and not properly managed. This can be overcome by providing good cable and hose management and performing good housekeeping at all times.

Additionally, watery and slippery floors, cuts due to sharp pipe end and hot surface hazards can be prevented by providing a dedicated work area for Ultrasonic Testing (UT) activities and use of correct type of hand gloves and protective clothing for work.

Table 5.1 show list of hazards with risk rating from the highest to the lowest risk. However, there is no high risk hazard recorded based on the risk rating. Jobs or tasks with medium risk hazards may proceed but need to be monitored and re-assessed at regular interval to establish additional measures or risk control if required. For jobs or tasks with low risk rating may proceed and further control measures may not be required.

Table 5.1 Summary of Hazards with Risk Rating

Hazards	Level of Risk	Risk	Current Control Measure Adequate (Yes / No)	Recommendations
Welding fumes generated from welding activity	Medium	12	Yes	1) To install portable fume extractor or permanent Local Exhaust Ventilation (LEV) 2) To conduct Chemical Hazardous to Health Risk Assessment 3) To conduct Chemical Exposure Monitoring for relevant personnel
Loud noise due to beveling activity	Medium	12	Yes	1) To design and install portable / fixed sound proofing for Pipe Facing Machine (PFM) 2) To conduct Noise Monitoring at workplace and Audiometric Testing for relevant personnel 3) To introduce Hearing Conservation Program
Pinch point during fixing and tack welding the pipe coupon	Medium	9	Yes	
Illumination from arc welding	Medium	9	Yes	
Flying fragment from grind and smooth off weld	Medium	9	Yes	
Dropped object during pipe loading / unloading using crane	Medium	8	Yes	
Hit by moving vehicles on main road	Medium	8	Yes	
Fire / explosion due to damaged hose or valve during oxy-acetylene cutting	Medium	8	Yes	
Dropped object due to uneven ground while transfer material	Medium	8	Yes	
Blind spot while operating forklift	Medium	8	Yes	
Repetitive manual handling on the PFM and the pipe coupons could affected human body	Medium	8	Yes	
Overhead crane failure can cause dropped object	Medium	8	Yes	

Table 5.1, continued

Hazards	Level of Risk	Risk	Current Control Measure Adequate (Yes / No)	Recommendations
Hot object / surface due to beveling activity	Medium	8	Yes	
Sharp object i.e. metal chips or pipe residues which generated during the beveling process	Medium	8	Yes	
Projectile metal chip from beveling activity	Medium	8	Yes	
Dropped object due to uneven ground during transfer by forklift	Medium	8	Yes	
Heavy load of Internal Line Up Clamp (ILUC)	Medium	8	Yes	
Unwanted pipe movement during setting up ILUC and pipe coupons	Medium	8	Yes	
Electricity which supplied by generator set leaked due to improper connections or damaged wires and cables	Medium	8	Yes	
Fire / explosion cause by propane gas	Medium	8	Yes	
Manual handling due to repetitive movement to lift welding head torch	Medium	8	Yes	
Hot surface during grinding activity	Medium	8	Yes	
Electric shock due to poor electric connection	Medium	8	Yes	
Equipment failure	Medium	8	Yes	
Electricity which supplied by generator set leaked due to improper connections or damaged wires and cables	Medium	8	Yes	
Struck by welded pipe or UT equipment during handling	Medium	8	Yes	
Electricity which supplied by generator set leaked due to improper connections or damaged wires and cables	Medium	8	Yes	

Table 5.1, continued

Hazards	Level of Risk	Risk	Current Control Measure Adequate (Yes / No)	Recommendations
Fire / explosion of overheated generator sets	Medium	8	Yes	
Noise produced by generator sets during operation	Medium	8	Yes	
Electricity which supplied by generator set leaked due to improper connections or damaged wires and cables	Medium	8	Yes	
Stored energy during the maintenance process which also may suddenly released	Medium	8	Yes	
Working at height during equipment installation can cause fall from above	Medium	8	Yes	
Hot object / surface from pipe cutting activity	Medium	6	Yes	
Unwanted pipe movement during cutting activity	Medium	6	Yes	
Sharp object during welding wire replacement task	Medium	6	Yes	
Vibration of hand tools during operation	Medium	6	Yes	
Chemical fumes from diesel filling and smoke from generator's exhaust	Medium	6	Yes	
Unsecured hoses laying on the floor can cause slip, trip and falls on same level at beveling station	Low	4	Yes	
Unsecured hoses laying on the floor can cause slip, trip and falls on same level	Low	4	Yes	
Slippery floor can cause slip and fall on same level	Low	4	Yes	
Manual handling for using Ultrasonic Test (UT) sensor probe	Low	4	Yes	
Sharp edges of pipe end during perform Manual Ultrasonic Test	Low	4	Yes	

Table 5.1, continued

Hazards	Level of Risk	Risk	Current Control Measure Adequate (Yes / No)	Recommendations
Hot surface during generator in operation	Low	4	Yes	
Unsecured wires and cables laying on the floor connected to machineries and equipment can cause slip, trip and falls on same level	Low	4	Yes	
Bad housekeeping of wires and cables laying on the floor during electrical work can cause slip, trip and falls on same level	Low	4	Yes	

5.2 Hazards with Significant Risk Rating

5.2.1 Welding Fumes

Welding fumes come from welding activities. Welding fumes contain various types of substances that can endanger human health, such as chromium, nickel, arsenic, manganese and others. For pipe welding activity, welding on the coated pipe can produce even more hazardous welding fumes. Exposure to welding fumes may affect to workers' health condition. The effects can be divided into short-term and long-term effects.

Exposure to welding fumes may affect the health of welders and people in the workshop. Health levels of limbs such as eyes, nose, chest, and respiratory tract can be affected by welding fumes. Welding smoke can also cause short-term effects such as cough, wheezing, shortness of breath and pneumonitis (inflammation of the lungs). Some gases produced by welding activity (e.g. cadmium, nickel) are deadly at high doses and can also cause irritation of the nose and throat and serious lung disease.

All welders are exposed to the hazardous effects of welding fumes. However, smoking welders may have a greater risk of health disorders than welders who practice healthy lifestyle with no smoking. Long-term effects of exposure to welding fumes are chronic respiratory problems (including lung), bronchitis, asthma and pneumonia.

Figure 5.1 Welding fumes generated by automatic welding

5.2.1.1 Existing Risk Control and Recommendations

During workplace assessment, it was observed that the workshop provides at least one industrial type ventilation fan at each welding station. It is not a preferred practice since the welding fumes and dust will be blown away from the location but accumulated in the workshop. Apart from that, all welders and relevant workers are well equipped with suitable and approved respirator

The best option to reduce the exposure of welding fume is to install Local Exhaust Ventilation (LEV) system at all welding workshop station. However, this may become costly since LEV may requires intensive maintenance to ensure the effectiveness of the system. The company may start with a few numbers of portable LEV systems which requires less maintenance to show the commitment towards safe and healthy workplace.

5.2.2 Noise

Noise hazard is one of the physical hazards that can affect the health of employees. The impact of this noise hazard will cause a person to experience temporary or permanent hearing loss. In addition to hearing loss, noise hazard can cause psychological stress and reduced productivity. Additionally, hearing loss can cause the quality of daily communication and a person's focus to be affected. Lack of communication due to hearing loss may also be the cause of accident at workplace.

In the First Schedule of Regulation 5 (1) Factory and Machineries (Noise Exposure) Regulation 1989 stated that Permissible Exposure Limit (PEL) for 8 hours of work is 90db (A). This regulation also imposed that no employee shall be exposed to noise level exceeding 115 dB (A) at any time as per Regulation 5 (2) of the same regulation. For impulsive noise, no employee shall be exposed to noise exceeding a peak sound pressure level of 140 dB as stated in Regulation 6 of the same regulation.

5.2.2.1 Existing Risk Control and Recommendations

Based on the report, there are TWO (2) identified sources of noise which are pipe beveling activity and operation of generator sets. The control measures that can be taken to reduce the risk of exposure of workers to noise at work are as follows:

1) Substitution - the portable generator sets in the work area are rented thus the substitution or replacement of less-noise generator sets that may involve a high cost. Also, conversion of existing PFM machines to other technologies may become costly.
2) Engineering control by treating sound at source or in transmission route for example. using sound dampener or silencer, sound barrier and isolation. The position of generator sets installation can be relocated to isolated locations within the workshop to reduce exposure. For pipe beveling Pipe Facing Machine (PFM), installation of portable sound dampener may be an option to reduce the noise at workplace.
3) Introducing administrative noise control measures for example. training and education, job rotation, job redesign or planning rosters to reduce the number of employees exposed to noise. Company also should conduct noise monitoring in the work area and conduct audiometric test for the workers involved as part of hearing conservation programs.
4) Provides Personal Protection Equipment (PPE) such as earmuffs, earplugs to all workers.

5.2.3 Electrical Hazard

Electric shock is one of the findings and recorded during workplace assessment. At the welding workshop, a number of portable generator sets are the main power source to supply electricity for welding machines. Electric shock may occur if someone touch a wire with electric current and hold another wire with another hand, the electric current will pass through the body causing an electric shock.

Dented, overdue cables and improper connection of electrical installation may result an electrical short circuit or electrocution. Someone may get contact with these cables while working or walking around the workshop. Besides that, use of substandard hand tools such as welding torch or angle grinder may cause workers to get electric shock.

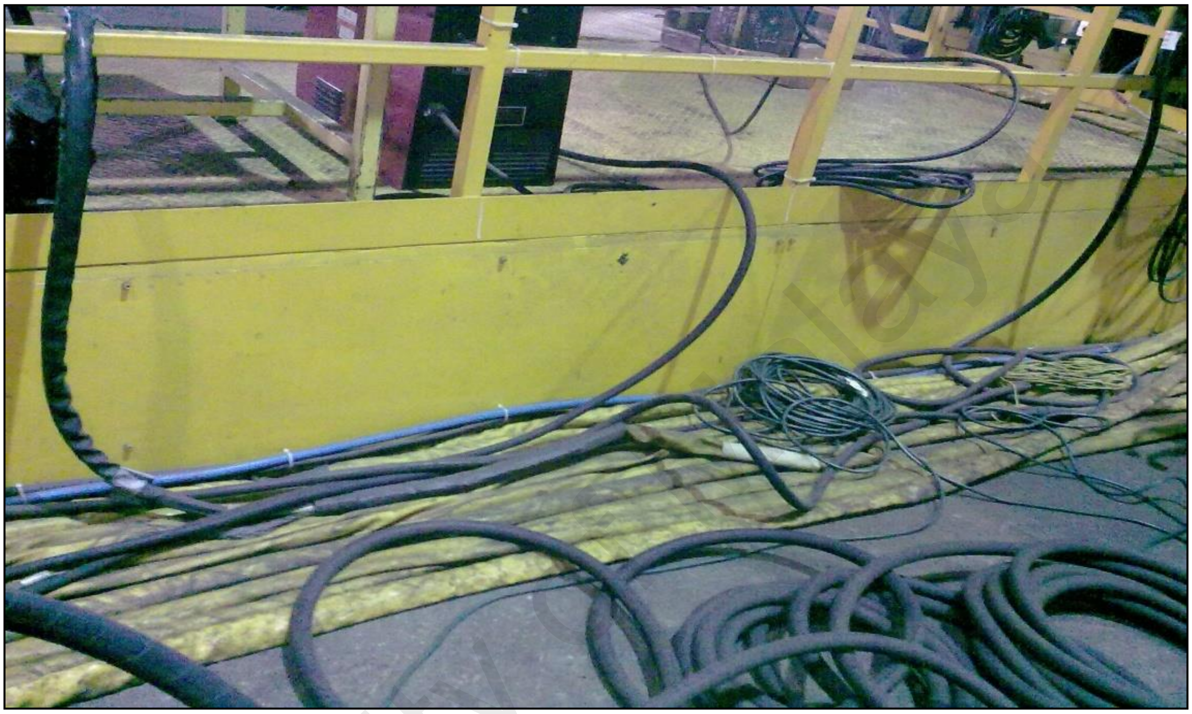

Figure 5.2 Bad wires and cables arrangement at welding workshop station

5.2.3.1 Existing Risk Control and Recommendations

As current practices, all wires and cables for welding machines are installed with electrical trunking at above head height. All current welding station are equipped with wire trunks with cables connected to generator sets as part of engineering control by the company. This can avoid tripping hazard and contact with water on the workshop floor. It also good for housekeeping at workplace. The generator sets are also installed with grounding cable as a mandatory installation practice.

Besides that, generator sets installation must be endorsed by competent charge man prior to use. An inspection checklist must be filled and checked by Person-In-Charge (PIC) and competent charge man to ensure all requirements are complied. Use of industrial type plug and socket connection also been implemented to ensure quality and better protection from rough work environment.

Generator sets also been well maintained and serviced as per schedule by the rental company. A service report shall be produced for record keeping.

Figure 5.3 Wires and cables are fixed at above head level

5.2.4 Mechanical Lifting

Lifting activity is a routine task at the welding workshop. Pipes, work materials and equipment are transferred to another location by using forklift or overhead cranes. There are many hazards associated with mechanical lifting activity such as crushing due to impact of moving objects or loads falling from vehicles because they are not slung properly or the wrong type of slings were used. Worn out sling and overload lifting capacity may also contributed to incident at workplace.

5.2.4.1 Existing Risk Control and Recommendations

Only trained and approved operators are allowed to handle any lifting equipment. For example, a competent forklift operator should have the required skills and techniques to transfer pipe coupon or an ILUC during welding preparation. A trained rigger should know the suitable and proper web sling to be used for lifting the load.

Besides that, lifting activity may need to be barricaded to ensure the safety of workers and to avoid other people from entering the lifting area. All lifting and rigging equipment are also inspected as per schedule and been colour coded for easy identifications.

Lastly, proper Personal Protective Equipment (PPE) such as impact resistant gloves must be worn by workers involved with lifting activity to protect themselves in case of unwanted event occurs.

Figure 5.4 Competent forklift operator transferring a pipe joint

5.2.5 Fire and Explosion

Highly flammable gases are used in welding workshop such as propane and oxy-acetylene gas. Propane is used to heat up pipe coupon to a desired welding temperature while oxy-acetylene gas are used as cutting gas for metal plates and pipe coupon. Besides that, welding activity also produce heat and spark, which may cause fire or explosion if caught by any combustible or flammable material nearby.

Figure 5.5 A pipe fitter cutting a pipe coupon using oxy-acetylene gas cutter

5.2.5.1 Existing Risk Control and Recommendations

In order to control this hazard, all propane and oxy-acetylene cylinder are installed with Non-Return Valve (NRV) or flashback arrestor on both hose connection to prevent any gas return back to the cylinder. Besides that, oxygen cylinder and acetylene gas cylinder must be placed in separated rack and keep a distance from source of heat.

Permit-To-Work (PTW) system is also implemented for any hot work activity for any non-routine job. At least ONE (1) unit of fire extinguisher must be made available nearby hot work activity to put out any small fire. A fire watcher will check the work area and will continuously monitor for at least 30 minutes after job completion.

5.2.6 Moving Vehicle

Study area consist of two warehouses building which separated by a main road. Therefore, many type of moving vehicle will use this road such as lorry, cars and motorcycles. Within the workshops, forklift is used to transfer material to both workshops.

Figure 5.6 Main road between two warehouses

5.2.6.1 Existing Risk Control and Recommendations

For movement of employees between these workshops, a zebra crossing was provided by local authority to guide the pedestrians and forklift to cross the road. This zebra cross is clearly visible and easy to catch drivers’ attention if someone or forklift crossing the road. Portable safety signage with hazard lamp was made available to notify and alert drivers for any lifting activity nearby main road. Forklift operator must be trained and approved before handle any lifting activity within workshops.

Figure 5.7 Zebra crossing for pedestrian

5.2.7 Ground Condition

Uneven ground may cause unbalance movement for forklift. This condition may also pose a threat and can cause a crane to topple during lifting activity. Uneven ground may also become dangerous to worker surrounding, if the load or pipe slip from the forklift during lifting.

Figure 5.8 Potholes spotted at forklift route

5.2.7.1 Existing Risk Control and Recommendations

To overcome this issue, ground condition within workshops must be in good condition. Any uneven ground or potholes must be reported to management immediately for further action. Again, competent forklift operator is a mandatory requirement and anybody without forklift handling competency shall not be allowed to operate the forklift at any time.

CHAPTER 6

CONCLUSION

6.1 Conclusion

Based on the results of the study, a total number of 45 hazards have been identified for the pipe welding process. No hazards are classified as high risk hazards. For Medium Risk Rating hazard, there are 37 hazards identified with 2 significant hazards with recommendations to improve current control measure and accident prevention. The hazards are welding fume from the welding activity and the noise generated from the pipe beveling activity. Both hazards gave a relatively high risk rating with risk rating 12 compared to other Medium risk hazards. For the low risk rating, there are 8 hazards that have been identified and most of these risks can be lowered by perform housekeeping in everyday work.

The proposed follow-up action is to provide welding station with LEV to reduce the exposure of welding fumes either permanent or portable type of LEV. For pipe beveling Pipe Facing Machine (PFM), installation of portable sound dampener may be an option to reduce the noise at workplace.

Support and commitment from the company's management is vital ensure the health and safety of their worker are in good hands. For improvement, it is recommended to all workers to apply and cultivate safety culture and safety intervention towards a better health and safety performance.

6.2 Future Recommendations

Future research should focus on industrial hygiene assessment with specific work such as assessment on body positioning during automatic welding, or noise exposure monitoring at pipe beveling station.

Future research should also to be conducted at project worksite such as at offshore pipe-laying barges or onshore pipeline projects, whereby the intensity and commitment towards safety and health can be determined.

REFERENCES

1. Agwu, M. O. (2012). The Effects of Risk Assessment (Hirarc) on Organisational Performance in Selected Construction Companies in Nigeria. *Economics, Management & Trade*, 2, 212- 224.

2. Allavudeen, S. S., & Sankar, S. P. (2015). Hazard Identification, Risk Assessment and Risk Control in Foundry. *Industrial Engineering*, 2 (3).

3. Bailey, L.A., Kerper, L.E. & Goodman, J.E. (2017) Derivation of an occupational exposure level for manganese in welding fumes. *NeuroToxicology* https://doi.org/10.1016/j.neuro.2017.06.009

4. Department of Occupational Safety and Health. (2008). Guidelines for Hazard Identification, Risk Assessment and Risk Control. Ministry of Human Resources Malaysia.

5. Department of Occupational Safety and Health. (2008). Guidelines on Occupational Safety and Health Management Systems. Ministry of Human Resources Malaysia.

6. Department of Occupational Safety and Health. (1994). Occupational Safety and Health Act 1994. Ministry of Human Resources Malaysia.

7. Department of Occupational Safety and Health (1967). Factories and Machinery Act 1967. Ministry of Human Resources.

8. Gholami, R., Rabiei, M., Rasouli, V., Aadnoy, B. & Fakhari, N. (2015). Application of quantitative risk assessment in wellbore stability. *Jurnal of petroleum science and engineering*, 135, 135-200.

9. Marhavilas, P. K., & Koulouriotis, D. E. (2008). A risk-estimation methodological framework using quantitative assessment techniques and real accidents' data: Application in an aluminium extrusion industry. *Jurnal of Loss Prevention in the Process Industries*, 21(6), 596-603.

10. NIOSH, US. (2017). Retrive from https://www.cdc.gov/niosh/topics/riskassessment/how.html

11. Radu, L. (2009). *Qualitative, semi-qualitative and quantitative methods for risk assessment: case of the financial audit* (Doctoral dissertation, University of Iasi). Retrieved from: http://anale.feaa.uaic.ro/anale/resurse/50_I02_Radu.pdf.

12. Raftery, J. (1994). Risk Analysis in Project Management. New York, NY 10001.

13. Saedi, A. M., Thambirajah, J. J., & Pariatamby, A. (2014). *A HIRARC model for safety and risk evaluation at a hydroelectric power generation plant*. Safety Science, 70, 308-315. http://dx.doi.org/10.1016/j.ssci.2014.05.013

14. Spellman, F. R., & Whiting, N. E. (2005). *Safety engineering: Principles and practices* (2nd ed.). Lanham, Maryland: Government Institutes.

15. Wang R., & Ruijie G. (2011). Developments of automatic girth welding technology in pipelines. *Electr Weld Mach* 2011;41(9):53-5.

16. Zeng H., Wang C., Yang X., Wang X., & Liu R. (2014) Automatic welding technologies for long-distance pipelines by use of all-position self-shielded flux cored wires. *Natural Gas Industry B 1*, 113-118. http://dx.doi.org/10.1016/j.ngib.2014.10.015