HIRARC STUDY FOR OCCUPATIONAL SAFETY AND HEALTH EVALUATION OF CLINICAL WASTE HANDLERS AT A HOSPITAL AND AN INCINERATION PLANT

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DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF TECHNOLOGY (ENVIRONMENTAL MANAGEMENT)

INSTITUTE OF BIOLOGICAL SCIENCES

FACULTY OF SCIENCE

UNIVERSITY OF MALAYA

KUALA LUMPUR

2015

UNIVERSITI MALAYA

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ABSTRACT

Clinical waste poses serious threats and hazards to human health. Clinical waste, which is categorized as a scheduled waste in Malaysia, has been increasing over the years. Thus, proper clinical waste management is important as improper clinical waste handling has led to many incidents involving handlers over the years (Arab et al., 2008). However, research on hazard and risk assessment for clinical waste management has been very limited, and there is a serious dearth of information for risk control planning. This project seeks to document the hazards found during clinical waste collection and disposal practices in a healthcare establishment and hazards involving the operators at a clinical waste treatment incinerator. Along with hazard identification, a quantitative risk assessment has been done to prioritize the risk control management.

Hospital Raja Permaisuri Bainun, Ipoh was selected for this study to evaluate the safety and health hazards associated with daily clinical waste collection and disposal activities. The clinical waste management in this hospital is handled by a private concessionary company appointed by Ministry of Health, Malaysia. The study reveals that the clinical waste handlers were exposed to some hazards during handling of clinical waste. This includes biological, chemical, physical, mechanical and ergonomic hazards. Out of 10 identified hazards, 40% posed high level risk and another 60% posed medium level risk. The major hazard found was biological hazard which contributes to 100% of high level risk. Accident records show needle prick injuries often involves the clinical waste handlers. Usage of PPE and administrative control are main mitigation measures implemented at the hospital.

The study shows no frequent training courses were organized by the management to create awareness among the employees. The risk assessment by the safety committee was also not done quantitatively to prioritize the risk management.

Secondly, an incineration plant treating clinical waste was selected for this study to evaluate the occupational safety and health risk management at the plant. A total of 82 safety and health hazards identified at the plant were then classified as physical, mechanical, electrical, chemical, biological, ergonomic and psychological. 19% of the hazards posed high risk followed by 49% of medium risk hazards and another 32% of low risk hazards. Existing risk control measures includes engineering control measures such as installation of machine guards, usage of PPE and some administrative controls are implemented at the plant.

The hazard and risk management at this plant is in accordance with Malaysian Occupational Safety and Health Act. However, some deficiencies observed could be improved through better risk control implementation. Internal air quality inspection and detailed comparative analysis on medical records of workers was suggested for better control of the risk. It was noticed that some small accidents were not recorded and analysed accordingly.

Unless there are strong measures put in place as recommended in this study, the rise in safety and health risk due to mismanagement of clinical waste will increase and may become a serious problem in future.

ABSTRAK

Sisa klinikal boleh menimbulkan ancaman yang serius dan berbahaya kepada kesihatan manusia. Di Malaysia, sisa klinikal dikategorikan sebagai sisa berjadual dan penghasilannya semakin meningkat setiap tahun. Oleh itu, pengurusan sisa klinikal yang betul adalah penting kerana pengendalian yang tidak betul dibeberapa negara pernah menjurus kepada banyak insiden yang melibatkan keselamatan dan kesihatan para pekerja. Walau bagaimanapun, penyelidikan yang teliti mengenai bahaya dan penilaian risiko dalam pengurusan sisa klinikal serta maklumat perancangan kawalan risiko adalah amat terhad.

Projek ini bertujuan untuk mengenalpasti bahaya yang dihadapi semasa aktiviti pengumpulan sisa klinikal di sebuah hospital dan bahaya yang melibatkatkan para pekerja di insinerator merawat sisa klinikal. Kemudian penilaian risiko secara kuantitatif dilakukan untuk menetapkan keutamaan bagi pengurusan kawalan risiko.

Hospital Raja Permaisuri Bainun, Ipoh telah dipilih untuk kajian ini bagi menilai bahaya yang berkaitan dengan aktiviti pengumpulan sisa klinikal. Pengurusan sisa klinikal di hospital ini dikendalikan oleh sebuah syarikat konsesi swasta yang dilantik oleh Kementerian Kesihatan Malaysia. Analisis kajian ini mendedahkan bahawa para pengendali sisa klinikal di hospital itu terdedah kepada beberapa bahaya melibatkan keselamatan dan kesihatan pekerja. Ini termasuklah bahaya biologikal, kimia, fizikal, mekanikal dan ergonomik. 60% daripada bahaya tersebut berisiko tinggi dan 40% lagi menjurus kepada risiko tahap sederhana. Bahaya biologikal dikenalpasti sebagai bahaya yang utama kerana 100% berisiko tinggi.

Analisa kemalangan menunjukkan kemalangan tercucuk jarum sering berlaku dikalangan para pengendali sisa klnikal. Kelengkapan perlindungan diri digunakan sebagai langkah kawalan risiko yang utama semasa pengendalian sisa klinikal. Kajian ini menunjukkan bahawa kursus-kursus kesedaran mengenai risiko dalam pengendalian sisa klinikal dan amalan pengurusan sisa klinikal yang terbaik tidak kerap dianjurkan oleh pihak pengurusan. Penilaian risiko juga tidak dilakukan secara kuantitatif.

Dalam kajian ini, sebuah insinerator merawat sisa klinikal telah dipilih untuk mengkaji bahaya keselamatan dan kesihatan pekerjaan diikuti dengan penilaian risiko secara kuantitatif. Sebanyak 82 jenis bahaya telah dikenal pasti di loji tersebut. Bahaya-bahaya tersebut diklasifikasikan sebagai bahaya fizikal, mekanikal, elektrikal, kimia, biologi, ergonomik dan psikologi. 19% daripada bahaya tersebut berisiko tinggi, 49% berisiko sederhana dan 32% berisiko rendah. Penilaian risiko secara kuantitatif telah dilakukan bagi menyenaraikan bahaya mengikut tahap risiko dan langkah-langkah kawalan risiko yang diamalkan juga telah dianalisa. Beberapa langkah kawalan risiko kejuruteraan, penggunaan “PPE” dan kawalan pengurusan merupakan langkah kawalan risiko yang diutamakan di insinerator tersebut.

Pengurusan risiko di loji ini adalah komprehensif dan mengikut Akta Keselamatan dan Kesihatan Pekerjaan. Walau bagaimanapun, beberapa kekurangan yang dikenalpasti boleh diperbaiki untuk pelaksanaan kawalan risiko yang lebih baik. Pemeriksaan kualiti udara dalaman telah dicadangkan untuk memastikan persekitaran bekerja yang selamat. Analisis perbandingan rekod perubatan pekerja yang terperinci dan berterusan boleh membantu dalam pengesanan awal masalah kesihatan.

Adalah dikenalpasti bahawa kemalangan kecil seperti kecederaan tercucuk jarum semasa pengendalian sisa klinikal dan abu tidak direkodkan dan dianalisis dengan sewajarnya. Ini perlu dilakukan bagi mengenal pasti punca kemalangan dan mengurangkannya melalui langkah-langkah pencegahan yang sesuai.

Secara ringkasnya, jika langkah–langkah yang sewajarnya tidak diambil seperti yang disyorkan dalam kajian ini, peningkatan dalam risiko keselamatan dan kesihatan pekerjaan akibat pengurusan yang salah boleh menjadi satu kebimbangan yang besar pada masa depan. Hasil kajian ini boleh digunakan sebagai data asas untuk mewujudkan satu garis panduan bagi pengurusan bahaya dan risiko dalam pengendalian sisa klinikal.

ACKNOWLEDGEMENTS

The study was carried out at two locations, Hospital Raja Permaisuri Bainun, Ipoh and an incineration plant located in southern region of Malaysia. I wish to express my sincere gratitude to Dr.John Thambirajah and Dr A. Sasekumar for their help, commitment, guidance and encouragement in accomplishing this project paper. They have been the sources guidance and inspiration that have helped me to complete this project successfully. I am very grateful for your both constructive comments and criticism during the preparation of this thesis.

I also would like to thank all the employees and management staffs from both my studied areas who have participated in this project. My sincere thanks goes to the plant manager and safety officer from AAA incineration plant for all the guidance cooperation and willingness to share. I also would like thank the top management of AAA incineration plant for providing me the opportunity to carry out this study in their good establishment. Not forgotten the clinical waste handlers and the supervisors from XXX Sdn Bhd who have helped and guided me during the data collection at Hospital Raja Permaisuri Bainun, Ipoh.

This thesis is dedicated with love and gratitude to my late beloved mother Mrs. Mirabai Permal for her lifetime of love, encouragement and unflinching faith in me. Not forgotten my father Mr. Muniandy and my siblings for their continuous support during my study period. Finally, my sincere appreciation to all individuals who have helped me in making this study come true by lending hand directly and indirectly.

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LIST OF ABBREVIATIONS

HIRARC – Hazard identification, risk assessment & risk control

OSHA - Occupational Safety & Health

SMS – Safety management system

EQA – Environmental Quality Act

DOSH – Department of Occupational, Safety & Health

KA – Kualiti Alam Sdn Bhd

SW – Scheduled waste

CAP – Consumer Association of Penang

MOH – Ministry of Health

WHO – World Health Organization

DOE – Department of Environment

HIV – Human Immunodeficiency Virus

HBV – Hepatitis B Virus

NIOSH – National Institute of Occupational Safety & Health

PPE – Personal Protective Equipment

PVC – Polyvinyl Chloride

SHE – Safety, Health & Environment

CHRA – Chemical Health Risk Assessment

dBA – Decibel

NIL – Nothing / zero

JHA – Job Hazard Analysis

MSDS – Material Safety Data Sheet

CSDS – Chemical Safety Data Sheet

NADOPOD – Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease

1.0 INTRODUCTION

Clinical waste management is becoming a vital part in the developing healthcare industry. Clinical waste poses high risk and the most hazardous and dangerous of all the waste (H.T.N., 2001). A well planned clinical waste handling and management is essential to reduce the hazards and minimize the risk to humans. Clinical waste is categorized as scheduled waste in Malaysia. It is regulated under Environmental Quality (Scheduled Waste) Regulations 1989 of Environmental Quality Act 1974 (Act 127).

1.1 Clinical waste management in Malaysia

There was no proper handling and management of clinical waste in Malaysia until 1980's (Shahidatul & Bakri, 2010). The emergence of HIV made the Ministry of Health to take initiative in revising the guidelines and policies related to management of clinical waste in Malaysia. In collaboration with Department of Environment, The Guidelines for Handling and Management of Clinical Waste in Malaysia was introduced in 2009. However, no detailed studies have been conducted on safety and health risk posed by clinical waste handlers. Incineration of clinical waste followed by disposal of ash into landfill is the common method adopted in Malaysia for clinical waste treatment (Shafii, 1998). As a concern towards clinical waste management, few regulations are in place to ensure protection, safety and health during handling and management of clinical waste (Zaimastura, 2005). The collection rate for biomedical waste was reported as 90% with highly standardized mechanized collection vehicles, compactors and containers. The collection services include most urban and even rural medical areas (Malaysia's CAP Country Report, 2010).

1.1.1 Clinical waste Incineration in Malaysia

In order to reduce Government's financial and administrative burden, the privatization of clinical waste management in Malaysia commenced in 1997. The rationale behind privatisation of biomedical waste management was mainly economic. Privatisation was considered as an effective and efficient way to improve the quality of biomedical waste management in Malaysia. The Ministry of Health appointed three concessionaires; Radicare (M) Sdn Bhd, Faber Mediserve (M) Sdn Bhd and Pantai Medivest Sdn Bhd. They were appointed to manage the public health care services including waste collection, transportation and disposal system (Ministry of Health Malaysia, 1993). They managed almost 16,000 tonnes of biomedical waste in the year of 2009 and generated a profit of RM200 millions (Malaysia Environmental Industry Report, 2010).

Bukit Nanas integrated waste treatment facility is Malaysia's first comprehensive waste treatment plant and comprise of high temperature incinerators, chemical and physical treatment systems. Few regional and onsite clinical waste incinerators were developed after privatisation took place in 1997. There are five regional medical waste incinerators that have a capacity to burn 200Kg per hour located in Taiping, Perak (2 units); Bukit Minyak, Melaka (2 units); and Teluk Panglima Garang, Selangor (1 unit). Another seven small on-site medical waste incinerators located in Sarawak with capacity 20 - 50kg/hour (Malaysia Country Report, 2001).

Waste incineration technology is used to reduce waste, destroying contaminated hospital disposals as well as hazardous waste to produce energy.

The existing frameworks evaluate human exposure and health effects from incinerator plants on the incident populations without sufficient regard to risk posed by clinical waste handlers (Bakoglu et al., 2004).

Experimental data and research reveals that health hazards at incineration plants was evaluated mainly on engineering standards. However, it is well known that incinerator releases toxic gases and substances that humans are inevitably exposed to. Such studies had dwelt on concerns regarding to possible health impacts from incinerators. There are strong indicators showing that discharges from incinerators are potentially damaging to human health (Allsopp et al., 2001). However, locally such studies are very limited. Without a comprehensive and integrated study on the overall safety of clinical waste handlers, it appears that level of safety and risk associated with hazards may never be known or evaluated.

1.2 Introduction to hazard identification, risk assessment and risk control.

Hazards are common around workplace and consist of risk to safety and health of employees. Hazards could lead to accidents but this is preventable if risk assessment and risk controls are implemented accordingly.

According to safety management system (SMS), “identification and evaluation of major hazards” attends to the “adoption and implementation of procedures for systematically identifying major hazards arising from normal and abnormal operation followed by selection of risk analysis method which is solely depend on the frequency of occurrence (likelihood) and consequence magnitude (severity) (Demichela et al., 2004).

Hazard : a situation at the workplace capable of causing harm such as personal injury, occupational related disease or death. Hazard identification is a process used to identify all possible situations where people may be exposed to injury, illness or disease, the type of injury or illness that may result from these and the way in which work is organized and managed. It is the first part of a risk management system. Hazard can be divided into three main groups; health hazard, safety hazard and environmental hazards (Department of Occupational Safety and Health Malaysia, 2008).

Risk : The chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard. It may also apply to situations with property or equipment loss. It is measured in terms of consequences or likelihood to happen. Risk can be presented in qualitative way based on result analysis of likelihood and severity.

Risk can be calculated using the following formula:

L x S = relative risk

L = Likelihood

S = Severity

Risk assessment is an important element in the decision making process of an organization and the decision need to be rationally implemented. (Nippon Kaiji Kyokai, 2009). This involves the process of identifying the hazards, determining the likelihood to happen and the severity level. Also estimate and access the risk posed and propose risk control options based on assess results. Generally the risk assessment procedure can be illustrated in the following way (Figure 1.1)

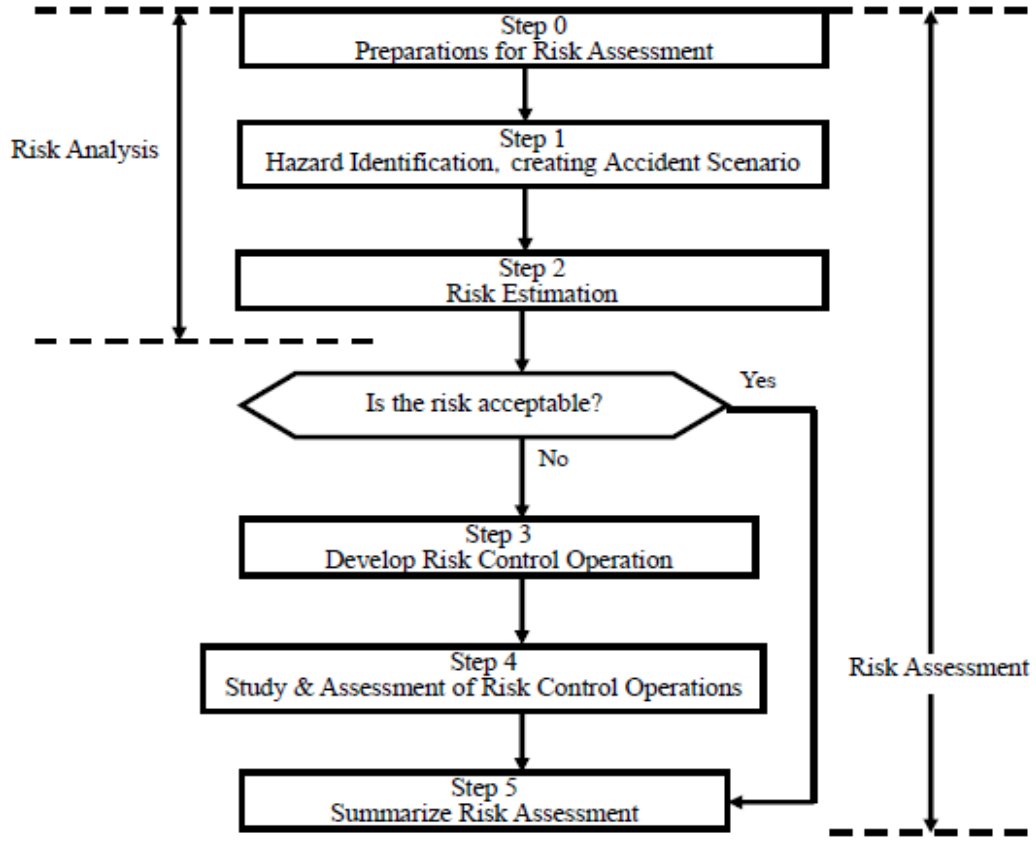


Figure 1.1: General flow of risk assessment (Nippon Kaiji Kyokai, 2009)

Control : is the elimination, reduction or inactivation of a hazard to a manner such that the hazard would not pose any risk to workers in a particular area of work. Hazards should be controlled at the source where the problem is created. It is best to have control measures at the point of source in order to create a preventive environment. Risk control implies the implementation of measures to prevent harm from happening (Department of Occupational Safety and Health Malaysia, 2008).

The 'Guidelines' for hazard identification, risk assessment and risk control may be found at:

(http://www.dosh.gov.my/doshV2/index.php?option=com_phocadownload&view=category&id=1&Itemid=97&lang=en&limitstart=40.,accessed on 1st February 2013)

In Malaysia, clinical waste management is handled by three private concessionary companies that operate at central region, northern region, east coast region and southern region. The operations of all these clinical waste management companies are monitored by Ministry of Health and Department of Environment. The transportation and disposal of clinical waste in Malaysia is regulated under Environmental Quality (scheduled waste) regulations 2005. The operation of clinical waste management companies follows the Guidelines for Handling and Management of Clinical Waste in Malaysia prepared by Department of Environment, Malaysia (2009).

1.3 Scope of study

Most of the previous studies conducted were on health hazards to public and workers associated with clinical waste in hospitals. A huge group of people involved in clinical waste handling including doctors, nurses, medical assistants, hospital attendants, clinical waste collectors, clinical waste transporters and workers at clinical waste treating incineration plants. This study particularly focus on clinical waste handlers directly involved in clinical waste collection and disposal activities in a hospital and an incineration plant treating clinical waste. The scope of this study will focus on identification of the existing and potential hazards for clinical waste handlers in a selected hospital and an incinerator plant treating clinical waste followed by a quantitative risk assessment to prioritize the risk control initiatives at the workplace. Recommendations will be made to improve the existing risk control management.

1.3.1 Hospital Raja Permainsuri Bainun (Ipoh)

Hospital Raja Permaisuri Bainun, Ipoh is the third largest hospital under Malaysia's Ministry of Health after Hospital Kuala Lumpur and Hospital Pulau Pinang. The hospital comprise of an eight level main building, specialist clinic complex and a daily care complex. The hospital has a capacity of 990 beds, 16 operation halls, 16 beds at adult intensive care unit, 8 beds at heart treatment unit, 17 beds at children intensive care unit (PICU) and 20 beds of neonatal treatment unit.

The clinical waste in this hospital is managed by "*XXX Sdn Bhd*", a concessionary company appointed by the Ministry of Health. "*XXX Sdn Bhd*" started its operation in 1997 with a 15 years contract that ended in 2011. The contract was extended further for another 10 years. A total of three staff is appointed as clinical waste collectors who work from 7:00 am till 5:00pm every day.

1.3.2 The AAA incineration plant treating clinical waste

The project site of clinical waste incineration plant is located at Southern region of Malaysia. The incineration plant incinerates clinical wastes, which consists of a heterogeneous mixture of general refuse, laboratory and pharmaceutical chemicals, pathological and cytotoxic wastes all of which are potentially infectious.

The plant started its operation in 1997 with two units of incinerator and two units of air pollution control system. It also contains other related facilities including a cold room, bin washing facilities, ash and residual waste storage areas. The type of incinerator used is starved air incinerator which is also known as static hearth incinerator.

The plant operates 24 hours, 7 days a week. The clinical waste is generally incinerated within 6 to 8 hours upon arrival at the plant.

The incineration process can reduce the volume of the waste by 90% of its original volume. However, waste that cannot be incinerated within 24 hours is stored temporarily in a cold room prior to incineration.

Each incinerator unit at the plant is equipped with the following units:-

- Loader and Bin Tippler;
- Primary combustion chamber;
- Ash discharge system;
- Secondary combustion chamber;
- By-pass stack; and
- Air pollution control system

Flue gas from the incineration units are treated with the use of an air pollution control system comprising of the following units:-

- Heat exchanger;
- Rotary contactor mixer;
- Fabric filter & cyclone separator;
- Stack.

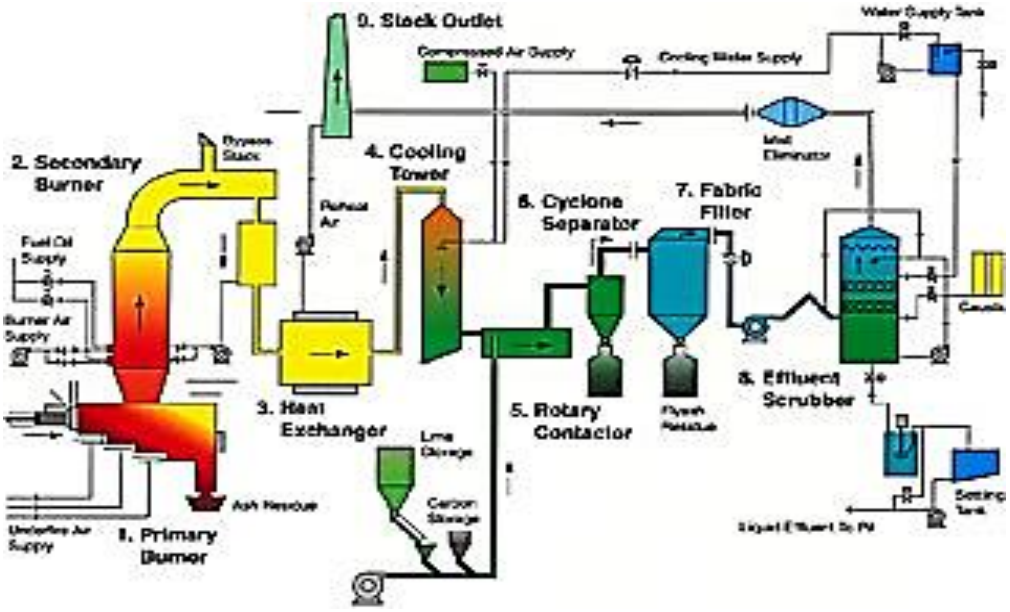


Figure 1.2 : The incineration process

The waste is incinerated at the primary chamber for 6-8 hours to produce the bottom ash. The secondary burner burns the gas released at 1000°C.

Then, ash will pass through the heat exchanger to reduce the heat followed by cooling tower to reduce the temperature to 600°C. As the next step, acidic gases from rotary contactor are neutralized by injecting lime and carbon is added to remove the smell. This also helps to trap the furan and dioxin. Then, fabric filters are used to filter fine particulate matters contaminated with lime and carbon followed by collection of the bottom ash. The draft fan sucks all gases into the air pollution control system which consist two units of burner chamber.

Flue gas of 20,939 Nm3/hr is discharged from the stack of air pollution control system. The 5.5 m3/day of wastewater from the bin washing activities, general wash down and truck washing activities are collected in various tanks and pumped for storage to reuse in the incineration process. Thus, no wastewaters are discharged from the clinical waste disposal process.

The air pollution control system is fixed with a continuous monitoring system that records the parameters need to be monitored. This system is connected directly to Department of Environment, Melaka.

Ashes generated from the primary chamber of the incinerator units are collected into jumbo bags. It is then inventoried and stored as scheduled waste coded SW406 according to Environmental Quality (Scheduled Wastes) Regulations 2005. Finally, the ashes are disposed at the Central Waste Management and Disposal Facility operated by "*Kualiti Alam Sdn Bhd"* located at Bukit Nanas, Negeri Sembilan. Presently 86.4 Kg/hr of residual wastes are generated from the incineration process (Environmental Impact Assessment, 2000).

1.4 Problem statement

The current research aimed to study the Hazard Identification, Risk Assessment and Risk Control for clinical waste collectors at Hospital Raja Permaisuri Bainun and employees at an incineration plant treating clinical waste. The generation of clinical waste is gradually increasing in Malaysia and the establishment of incineration plants to treat waste is emerging as a major industry in Malaysia.

The growing concern over the need for a proper management of clinical waste in Malaysia has prompted the government to establish a comprehensive clinical waste management system for all the government hospitals through a privatisation program. One of the programmes is incinerator for clinical waste treatment and disposal.

There are some important hazards involved in handling of clinical waste and operations of incineration system. If the organization unaware and fail to identify the relevant hazards, it could lead to fatality when engaged with clinical waste collection, disposal and treatment activities. This may harm the employees, employers as well as economic crisis could occur due to damaging the facilities and environment.

Unfortunately, some of the hazards are left unidentified or no mitigation measures being implemented at the moment. This could lead to serious health and safety problems involving clinical waste handlers in future.

One of the main aspects in safety management system is hazard identification and risk assessment. Clinical waste collection at hospital and operation of incineration plant has various hazards with significant effects.

The current study was on identification of existing and potential hazards followed by quantitative risk assessment to prioritize the hazards. It recommends applicable method to reduce the risks and control the residual impact to increase the safety for clinical waste handlers.

For this case study, one of the biggest general hospital and an incineration plant treating clinical waste was selected. Studies were conducted on identifying the hazards and evaluate the risk posed by clinical waste collectors and incineration plant operators.

1.5 Objectives

- To identify the current and potential hazards for clinical waste handlers at a hospital and incineration plant based on observation using standard checklist, interviews with the employees and review of previous accident records
- Perform job hazard analysis to classify the hazards and the causes followed by evaluation of associated risk using a standard scales for risk assessment
- To assess the current risk control measures used for mitigation and make recommendations for improvement to minimize the associated risk.

With the above objectives, Hazard Identification, Risk Assessment and Risk Control (HIRARC) study for occupational safety and health evaluation on clinical waste handlers at a hospital and an incineration plant will help to increase the awareness of the management and safety officer on the existing hazards.

The results attained from the study can be used as a guideline to minimize the associated risk and increase the safety of clinical waste handlers.

2.0 LITERATURE REVIEW

2.1 Clinical waste

According to the Ministry of Health (2009), clinical waste is defined as any waste which consists partly or wholly of human or animal tissue, excretions, blood or body fluids, drugs and pharmaceutical products. Other waste arising from veterinary, medical, dental, nursing, treatment, medical related teaching and research, collection and transfusion of blood are classified as medical waste. Medical waste including human and anatomical waste, fluids and secretions from patients, contaminated syringes and other sharps , contaminated laboratory , surgical and nursing supplies which have potential of spreading infectious diseases. Most of the biomedical waste is considered as hazardous due to likely infectious consequences (Ambali et al., 2013). However, waste from hospitals, clinics and medical research laboratories are assumed as bio-hazardous due to its origin even potential infectious microorganisms or toxins are not present in it (Agamuthu, 1997, p.5). According to World Health Organization (2004), only 20% of the healthcare waste is considered as infectious to human while balance 80% is naturally non-infectious.

Table 2:1 Percentage of waste type in health care centres

Type of waste	Quantity
Pathological and infectious waste	15%
Sharp waste	1%
Pharmaceutical and chemical waste	3%
Broken thermometers and pressurized cylinders	< 1%
Non-infectious waste	80%

Source: WHO 2005, Management of Solid Healthcare Waste at Primary Healthcare Centres – A Decision Making Guide, Geneva.

Dzakula and Pavic (2008) reported that the generation of clinical waste is increasing tremendously over the decade in line with population growth and urbanization process particularly in developing countries.

2.1.1 Clinical waste in Malaysia

Clinical waste is categorized under scheduled waste by the Environmental Quality (Scheduled waste) Regulations, 2005. The categories are as below:

I. SW403 - Discarded drugs containing psychotropic substances or containing substances that are toxic, harmful, carcinogenic, mutagenic or teratogenic.
II. SW 404 - Pathogenic and clinical waste and quarantined materials
III. SW421 - A mixture of scheduled waste
IV. SW422 - A mixture of scheduled and non-scheduled waste

(Source: Guidelines on the Handling and Management of Clinical Waste in Malaysia, Department of Environment, 2009)

According to the data obtained from the Ministry of Health (2009), waste from hospitals comprise of general waste, clinical waste, pharmaceutical waste ,hazardous chemicals and radioactive waste material whereby clinical waste is reported together with pharmaceutical waste. Based on the Malaysian Environmental Quality Report (2011), 44,674.52 metric tonnes of clinical waste was generated in 2011. The generation of clinical waste has increased year by year. Figure below shows the generation of clinical waste in Malaysia from 2004 until 2011.

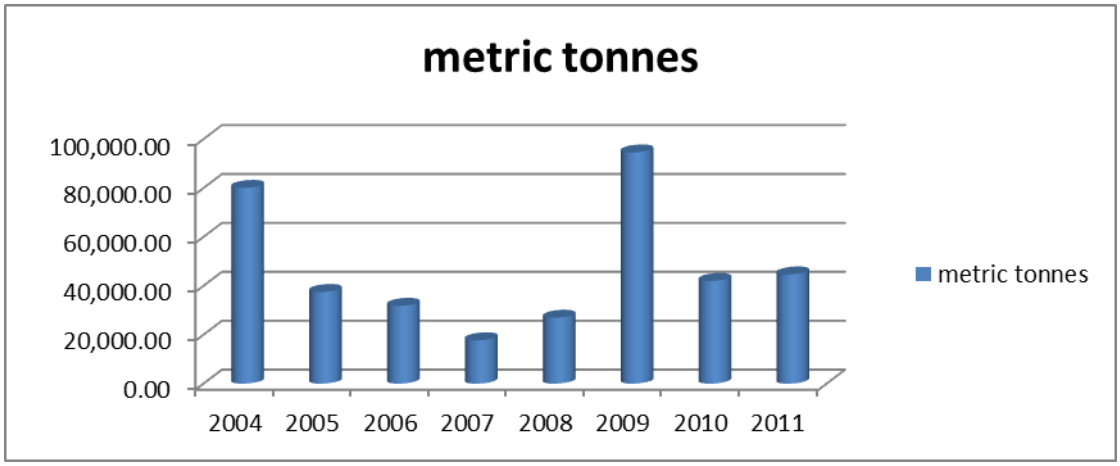


Figure 2.1 : Generation of clinical waste in Malaysia from 2004- 2011

The Ministry of Health (2011) stated that, out of 44,672.52 metric tonnes of clinical waste generated, only 17,795.47 metric tonnes were incinerated by licensed off site facilities. Improper clinical waste management can lead to many problems especially threats to health, safety and environment (Ali and Kuroiwa, 2009). The Private Healthcare Facilities and Services Act 1998 and Private Healthcare Facilities and Services (Private Medical Clinics and Private Dental Clinics) regulations 2006 established to regulate infectious waste from clinics. According to this regulation, hazardous waste includes both infectious and non-infectious waste.

Under this context, human, animal and biological waste contaminated sharps and any items contaminated with pathogens are considered as infectious waste. While, toxic chemicals, cytotoxic drugs, radioactive, flammable and explosive waste is non-infectious waste.

Table 2:2 Major classification of clinical waste and its recommended management guidance in Malaysia

Description	Waste Management guidance
1. Blood and body fluid waste I. Surgical cotton, wool, gloves & swabs II. All waste in treatment area which have come into contact with blood or wounds III. Cloths and wiping material use to clear spillage of blood and body fluids IV. Material other than reusable linen, from cases of infectious diseases V. Pathological waste including all human tissues	Must be incinerated completely
2. Waste posing risk to injury (sharps) (needles, scalpel, saw, blades and other instruments that can cause injury)	• Collected separately in leak tight puncture resistant container. • Should be incinerated completely
3. Infectious wastes Clinical waste from laboratories (blood bank, haematology, pathology, microbiology & histology) and post mortem department rooms other than materials in category 1	Should be incinerated completely

Source: Guidelines on The Handling and Management of Clinical Waste in Malaysia, 3rd edition 2009.

2.1.2 Clinical waste management in Malaysia

Malaysia did not have proper clinical waste management facilities until 1980s (Razali and Ishak, 2010). It is estimated that the generation rate of clinical waste varies from 0.3 to 0.8 kg per occupied bed per day. There is no separate annual reporting on generation of clinical waste by the biomedical research activities as all hazardous waste is combined in the reports. These make it difficult to estimate the total amount of clinical waste generation accurately (Tarmudi et al., 2009). The biomedical waste generated by research activities are heterogeneous, make the selection of treatment method a complicated and problematic task in Malaysia (Lim M., 2011). According to the Department of Environment (2011), clinical waste consists of only 40% out of total solid waste from hospitals, but it takes more than 60% of the disposal cost (Blenkharn, 2005). In Malaysia, the preliminary guideline for the management of clinical waste was introduced back in 1998. In addition, "Hospital Waste Management Manual" was drafted by Ministry of Health for management and safe disposal of hospital waste (Saw C.B., 1994). However, parallel and overlapping responsibilities in waste management remain diffused in many countries including Malaysia (Tiong et al., 2012). Colour coding standard was adopted to classify biomedical waste in line with Environmental Quality (Scheduled Wastes) Regulations 1989. Waste is disposed in different colour bags or containers (Zaimastura, 2005). Waste to be autoclaved is disposed in blue plastic bags, black plastic bags for general household waste and yellow plastic bags for waste to be incinerated (Department of Environment, 2009). The clinical waste in Malaysia is managed by three different organizations. The impacts from clinical waste towards humans are serious but only minor attention has been given on the proper handling and legal aspects (Dasimah Omar et al., 2012).

2.1.3 Storage and transportation of clinical waste

Hospitals are generally equipped with temporary clinical waste storage areas. According to the guidelines set by the Ministry of Health (1993), clinical wastes are stored at these facilities from twelve to twenty four hours and not more than forty eight hours. The transportation of clinical waste from hospital storage area to incinerator is carried out using authorized trucks only. Hospital personnel are involved in the verification process during collection as required by the Ministry of Health.

Based on the Guidelines for Handling and Management of Clinical waste in Malaysia (2009), effective clinical waste management should be given consideration to: generation and minimization, source separation and segregation, identification and labelling, handling and storage, safe transportation and treatment.

The collection and disposal of clinical waste involve high possibilities for direct contact and this increase the risk for infection among waste handlers (Bdour et al., 2007). Proper clinical waste management is important to prevent health risk and damage to flora, fauna and environment (Yong et al., 2009).

2.2 Incineration

Incineration is a waste treatment process which involves combustion of organic materials contained in the waste. It is a thermal treatment that converts waste into ash, flue gas and heat (Wikipedia, 2013). There are 15 types of incinerators as listed below:

- Rotary kiln
- Liquid injection
- Cement and lime kiln
- Fluidized bed
- Boiler system
- Oxygen enriched
- Infrared
- Fume
- Multiple chamber
- Multiple hearth
- Cyclonic
- Auger combustor
- Two stage (starved air)
- Catalytic
- Molten salt

2.2.1 Incineration of clinical waste

Incineration has been regarded as a "gold standard" method for sterilization (Kanemitsu et al., 2005). It is used widely as a method of choice for hazardous health care waste treatment (Katoch, 2007).

The high temperature of incinerator capable to destroy all kinds of viruses and bacteria present in the medical waste. Thus, incineration is the most common treatment method used for medical/clinical waste. Commonly, there are three generic types of incineration technology used to treat health-care waste.

- Starved air incinerator with dual chamber which operates at below stoichiometric conditions in the primary chamber

- Multiple chamber incinerator, which operates above stoichiometric conditions for pathological waste
- Rotary kiln incinerator, with high temperature that is capable of breaking down heat resistant chemicals

Starved air incinerator is also known as controlled air incineration, pyrolytic incineration, two stage incineration or static hearth incineration. The combustion uses less oxygen compare to ideal amount needed for burning of carbon and hydrogen. The starved air incinerator comprise of a primary and secondary chamber. Waste is thermally decomposed in the primary chamber with oxygen deficient and medium combustion temperature of 800-900°C, which releases the final product of solid ashes and gases. The gases from primary chamber is burned with high temperature of 1100°C-1600°C in the secondary burner using excess air to minimize the odour and smoke. (Guidelines on Safe Management of Waste from Health Care Activities, WHO 2013)

Previously, multiple chamber incinerators were used widely for pathological waste treatment and still being used in some countries. There are two types of multiple chamber incinerators known as inline incinerator and retort incinerators. The inline incinerator is rectangular shape in design with large primary chamber attached with moving grate and a secondary chamber to decompose the organic compounds in the flue gas. There is also an additional chamber to force the gas direction to remove the ash residues. The retort type primary and secondary chambers are in 'U' shape. The flue gas from primary chamber is used to add heat to the secondary chamber. Both designs are not used much because of the high volume airborne emission due to its operation involving excess air mode. (Guidelines on Safe Management of Waste from Health Care Activities, WHO 2013)

The rotary kiln incinerator comes with a rotating oven and a post-combustion chamber. It is designed specifically to treat chemical waste or large scale clinical waste with suitable temperature and scrubbing system installed. The gases from klin are heated up to high temperature. Then it is used to burn organic compound in gases at the post combustion chamber. It is also suitable to treat toxic waste. (Guidelines on Safe Management of Waste from Health Care Activities, WHO 2013)

The incineration process is the most accepted proper disposal method for clinical waste (Wahid, 2013). Even though incineration have been adopted as an effective method, the emission of toxic by-products such as dioxins, furans and plastics made of PVC which is burned carries potential threat to environment. The long term exposure could lead to various health complications (World Health Organization, 2011). Although, several other disinfection technologies are available, incineration is preferred for clinical waste because it does not only kill the pathogens, but also destroys the material it relies on (Wahid, 2013).

2.2.2 Acts and legislation

The first guideline for safe management of healthcare waste was established in 1999 by World Health Organization. It contains regulatory frameworks, planning issues, waste minimization, recycling, handling, storage, transportation, treatment, disposal options and training guidelines.

In United Kingdom, clinical waste handling is closely regulated by Environmental Protection Act 1990, Waste Management Licencing regulations 1994, Hazardous Waste Regulations (England &Wales) 2005 and Special Waste Regulations in Scotland.

While in United States, the Medical Waste Tracking Act initiated in 1988 was then repealed in 1991. All the states were given responsibility to regulate laws concerning to disposal of medical waste.

Few regulations are observed in Malaysia to ensure safety and protection as far as clinical waste is concerned (Zaimastura, 2005). The Malaysian law consists of acts related to clinical waste. It is empowered by the Department of Environment under the Environmental Quality Act 1974. Regulations dealing with hazardous waste were set in May 1989 which comprises of:

- Environmental Quality (Scheduled Waste) Regulations 1989
- Environmental Quality(Prescribed Premises)(Scheduled Waste Treatment and Disposal Facility) Regulations 1989
- Environmental Quality (Prescribed Premises) (Scheduled Waste Treatment and Disposal Facility) Order 1989

The environmental quality scheduled waste regulations (1989) contains 107 categories of hazardous waste known as scheduled waste which is classified into specific and non-specific sources. Clinical waste is categorized under non-specific source. The categories of scheduled waste related to clinical waste are as follows:

I. SW 403 - Discarded drugs containing psychotropic substances or containing substances that are toxic, harmful, carcinogenic, mutagenic or teratogenic
II. SW 404 - Pathogenic wastes, clinical wastes or quarantined materials
III. SW 405 - Waste arising from the preparation and production of pharmaceutical product

(Source: First schedule environmental quality (scheduled waste) regulations 2005)

The following requirements are included in the regulations:

- Schedule wastes shall as far as practicable, before disposal be rendered innocuous
- Generation of scheduled waste shall be reduced using the best practicable means;
- Waste generators should notify DOE of any scheduled waste generated , and keep inventory of scheduled waste generated, disposed ad treated;
- Scheduled waste can be stored, recovered and treated within the premises of a waste generators;
- Land farming, incineration, disposal, off-site recovery, off-site storage and off-site treatment shall be carried out at prescribed premises licensed by DOE;
- Use of durable waste containers with clear labels. Storage of wastes shall be proper and adequate
- Waste generators shall conform to the requirements of consignment note system when transporting waste to ensure it reaches the approved destination and are carried out by licences transporter
- Waste generators shall provide information to the transporter about nature of waste transported and action to be taken in case of accidents.

This regulations are meant to control the waste generators, waste contractors and waste disposal site operators. There are 6 types of premises prescribed under Environmental Quality (Prescribed Premises) (Scheduled Waste Treatment and Disposal Facilities) Order 1989.

The premises are:

a. Land treatment facilities such as sludge farming of oily wastes or sludge;

b. Off-site recovery facilities such as solvent recycling plant;

c. Off-site treatment facilities such as centralised physical/chemical wastewater treatment plant;

d. Scheduled wastes incinerators;

e. Off-site storage facilities including the premises of waste transport contractors;

f. Secure landfills designated for the disposal of scheduled wastes.

(Source: Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Order 1989)

Ministry of Health have appointed three clinical waste management concessionary companies which holds off site incinerator and transportation license issued by Department of Environment. These companies are:

- Faber Medi-Serve Sdn Bhd
- Radicare (M) Sdn Bhd
- Pantai Medivest Sdn Bhd

(Source: List of scheduled waste facility/transporter, Department of Environment, 2013)

2.3 History of HIRARC study for occupational safety and health

2.3.1 Study on occupational safety and health evaluation on clinical waste handlers at hospital

Very few studies have been conducted on hazards and health impacts on clinical waste handlers especially in developing countries. In Malaysia, about 46000 metric tonnes of clinical waste have been generated on 2012 with the generation rate varying from 0.3 to 0.8 kg per occupied bed per day. Medical/ non-medical staff and waste handlers at hospitals are mostly exposed to hazards due to improper clinical waste management (Arab et al., 2008). Thus, proper clinical waste handling and management has become an area of concern. The mishandling and improper management of infectious clinical waste could lead to direct and indirect health impact on community and environment. Waste from hospitals, clinics and biomedical research laboratories are often claimed as bio-hazardous even if infectious microorganisms and toxins were not encountered in it (Agamuthu, 1997).

Contaminated waste poses various risks to clinical waste handlers (World Health Organization, 2011). Studies by WHO also shows 20% of those handling sharps at hospitals experienced sharp injury.

Ministry of Health Malaysia (1993) has formulate “hospital waste management manual” for the management and safe disposal of hospital wastes. This manual includes guidelines for handling and disposal of clinical waste. Disposal of hazardous clinical waste is intensively regulated by Department of Environment under Environmental Quality Act, 1974 and Scheduled Waste Regulations, 2005. This includes identification, labelling, on-site storage and management, transportation, treatment and disposal.

Private clinics in Malaysia are regulated under Facilities and Services (private medical clinics or private dental clinics) regulations 2006 to protect both environment and person involved (Tiong et al., 2012).

According to clinical waste handling guidelines set by Ministry Of Health (1993), all clinical waste bags should be handled at the neck only. All waste from initial storage areas shall be removed regularly. Clinical waste from high risk area like operation theatres shall use double layer yellow bags and syringes with needles shall be discarded into sharp bins only. Wheel containers, trolleys and carts used to transfer waste must be reserved for transporting clinical waste only. In case of any spillage, it must be cleaned and disinfected immediately. Clinical waste at central storage areas should be removed daily while refrigerated storage area shall not keep the waste for more than 48 hours.

However, enforcement of proper clinical waste handling to minimize the associated hazards is lacking. Previous studies show good clinical waste management practices in Malaysia government hospitals. However, there are no extensive studies on effectiveness in managing clinical waste to prevent infectious diseases.

Surveys and previous studies show healthcare waste handlers are more prevalent for contracting diseases. The hazards from small sources of health care waste are usually overlooked.

Infection may occur during waste handling through punctures, cuts, inhalation or dermal contact. Sharp waste poses high risk for waste handlers due to highly hazardous. Transmission of viral pathogens such as hepatitis C virus, HIV and HBV had happened due to unsafe handling of contaminated sharps. Syringe needles contaminated with human blood transmit the viruses.

Hepatitis B virus can survive on a surface for several weeks as it is very persistent to dry air (Paintsil et al., 2009). The studies by Japanese Association for Research on Medical Waste shows that hepatitis B and hepatitis C virus can survive up to seven days in a blood droplet trapped inside a hypodermic needle (World Health Organization, 2013). Sharp waste and concentrated cultures of pathogens poses most acute potential hazards to human health. Instead of causing cuts and punctures, sharp waste also cause infection to the wounds if they are contaminated with pathogens (World Health Organization, 2013).The presence of various microorganisms in clinical waste, highly hazardous to clinical waste handlers. For example, *Pseudomonas aeruginosa* is a hospital acquired pathogen which could resist under various environmental distress and could survive in the environment without host for more than 40 days (Hoiby et al., 1995). *Staphylococcus aureus* which is also found in the clinical waste could cause infections such as pneumonia, meningitis, osteomyelitis bacteria and sepsis (Park et al., 2009).

Chemicals and pharmaceutical waste are considered hazardous due to its toxicity. This waste can cause intoxication to the clinical waste handlers. Absorption of chemicals through skin or mucous membrane or through inhalation and ingestion could results in intoxication. Contact with flammable, corrosive or reactive chemicals can cause injuries to skin, eyes and mucous membrane (World Health Organization, 2013).

Extensive studies on clinical waste handling at hospitals and better risk assessment on the hazards would permit for improvement in healthcare waste management. This also helps in planning for appropriate control measures to reduce risk to clinical waste handlers.

2.3.2 Study on occupational safety and health evaluation at incineration plant treating clinical waste

Previous studies focusing on the HIRARC evaluation for incineration facilities treating clinical waste is lacking. Most studies take a macro view of such projects and mainly involve municipal waste incinerators. Allsopp et al., (2001) for example examined the human health risk in a multi criteria decision making process for incineration. Labib et al., (2005) who evaluated medical waste incinerators at Alexandria focused on the emission of pollutants and its impacts on the health of the public. Sahidatul et al., (2010) has written on clinical waste handling and obstacles in Malaysia but it only focus on the impact to health care workers at hospitals. Roberts et al., (2006) wrote on health risks factors which rely on waste incineration technology focusing on public health of residents staying in near incineration areas.

Previous studies stated, there were limited number of morbidity and mortality cases among incinerator workers have been reported. Gustavsson (1989) reported in his studies that 176 mortality cases have been recorded in Sweden among those who have worked for more than a year in an incineration plant between 1920's to 1985. However, the study mentioned that less contamination is expected in modern incinerator compare to old version plants.

The biomedical waste incineration in Malaysia currently has the capacity to treat 18,000 tonnes per year (Frost and Sullivan, 2010). However, it is estimated to increase up to 30,000 tonnes by the year 2020.

2.4 Hazard identification, risk assessment and risk control

To achieve and implement Occupational Safety and Health aspects at work place, we need to look into HIRARC which helps to identify and overcome the hazards. HIRARC involves three consecutive activities: Hazard Identification, Risk Assessment and Risk Control. Hazard identification involves identifying activities that may cause injury or harm. Risk assessment refers to determining the likelihood for a harm to happen on an individual subjected to severity. Risk control is introducing or suggesting control measures which will eliminate or reduce the risk of a person being exposed to a hazard.

In Malaysia, the Department of Occupational Safety and Health (2008) had published the HIRARC guidelines. The guidelines explain a systematic approach to identify hazards and assess their related risks to provide objective measures to control the hazards. According to Occupational Safety and Health Act 1994 (Act 514), it is the duty of an employer to provide a safe workplace for employees.

HIRARC guidelines are aimed to:-

a. Identify all the factors that may harm workers and others (the hazards);

b. Consider the chances of that harm affecting anyone under circumstances (probability) and the possible extend of severity that could happen (the risks); and

c. Guide employers to plan, introduce and monitor preventive measures to ensure implementation of risk control measures at all times.

HIRARC activities shall be planned and carried out when:

a. There are cases where hazards pose significant threat;

b. Uncertain about the adequacy of existing controls;

c. Before instituting corrective or preventive measures.

d. There are changes in the system/process

e. Organization intending to enhance its OSH Management System.

Employers are responsible in assigning trained, qualified, experienced personnel to lead a team associated with particular system/process to conduct HIRARC.

The HIRARC process

The process of conducting HIRARC involves 4 simple steps:

(a) Identify and categorize work activities;

(b) Identify the hazard;

(c) Conduct risk assessment (estimate the risk from each hazard), by estimating likelihood for the hazard to occur and the severity;

(d) Determine either risk can be tolerated and implement control measures if required.

Hazard identification and assessment methodology should be established by employer taking into account the following data:

i. Any accident occurrence investigation reports;

ii. First aid records and minor injury records;

iii. Work place health protection programs;

iv. Work place inspections results;

v. Employee complaints and comments record;

vi. Any report from government or employer, studies and tests concerning employee's health and safety;

vii. Reports made under the Occupational Safety and Health Act, 1994 regulations

viii. The material safety data sheet of hazardous substances; and

ix. Any other pertinent information. (Guidelines for Hazard Identification, Risk Assessment and Risk Control (HIRARC), DOSH 2008)

According to the Ministry of Health Malaysia, before starting the identification of hazards, knowledge on categorization and definition of hazard, risk and danger is important and necessary.

- Hazard – whatever may result in harm
- Risk – outcome from likelihood and severity of harm occurring.
- Danger – relative exposure to a particular hazard.

(Ministry of Health Malaysia. http:// ppg.moh.gov.my/thewe/?_page=2, August 2011).

Hazards comprise health and safety hazards.

Health hazards include:

- Chemical - gases, vapours, acids, alkali, poisons, aerosols, irritants
- Biological - pathogens, fungi, other microorganisms
- Psychosocial - stress, social problems, accidents, fear of failure, retrenchment
- Ergonomic - workplace design, layout of workstation, excessive manual handling, and design of tools

The biological hazards mainly results in infection during handling of clinical waste due to exposure of pathogens, fungi and all kind of microorganisms. The incineration process does not inactivate heat resistance pathogenic bacteria and these are released to environment through stack gas and bottom ash (Blenkharn, 2005).

Apart from exposure to chemicals used at the plant, the exposure to various chemicals in clinical waste such as glutaraldehyde, formaldehyde, common disinfectants and cleansing agents could pose acute and chronic effects ranging from burns, respiratory distress, dermatitis and carcinomas. Previous studies show that incidents on diseases are more prevalent among healthcare waste handlers compare to healthcare staff (Coker et al., 2009). Generally, waste handlers posed higher risk for infection through cuts and punctures due to exposure during occupational job functions (Hossain et al., 2011).

The major imminent physical hazard that involves healthcare workers is the needle prick injury. Needles are broadly used in medical industry poses high risk to transmit dangerous and deadly infections such as HIV, Hepatitis B and Hepatitis C. Thus, needle pricks also categorized as biological hazard.

The US NIOSH Alert Preventing Needle Stick Injuries in health care setting estimated 600 000 to 800000 needle stick injuries happen every year among healthcare workers. The OSHA estimates 2% out of sharp injuries reported annually in US were contaminated with HIV.

Ergonomic hazard results in various musculoskeletal disorders such as low backache, neck pain, shoulder pain due to extra postural burden, awkward postures, force and repetition of works. While the psychosocial hazard due to shift work and continuous routine work are usually not obvious as it is difficult to link with work-relatedness (MFL Occupational Health Centre, 2014).

Safety hazards include:

- Physical - noise, heat, radiation, vibration, pressure, machinery, electricity;
- Mechanical - cuts, entanglement ... etc
- Electrical - shock, burns
- Fire/Explosion - burns, injury, death ... etc
- Confined space - poisoning ... etc

Various safety hazards occur at hazardous waste sites. Some safety hazards derived from the function of work itself. For example, some hazards occur during operational works while some additional hazards occur due to working environment and lack of carefulness during working.

Mechanical hazards usually occur due to lack of concentration during working or mishandling of equipment. These hazards could be avoided by proper handling and usage of appropriate personal protective equipment to minimize the impact of hazards.

Electrical hazards potential to happen at any part of the incineration plant in case of improper maintenance (Jayakumar & Retneswari, 2008). Electrical hazards happen from overhead power lines, electrical wires and cables. OSHA guidelines include explanation on appropriate clothing and equipment for protection against electrical hazards.

Incinerators poses high risk for fire hazards as the process itself involves fire. The fire or explosion may occur due to chemical reactions, ignition of materials due to oxygen enrichment, agitation of shock or friction sensitive compounds or sudden release of materials under pressure. The protection against fire hazards starts from safe practices while performing any job task. All potential ignition sources shall be kept away from explosive atmospheres

2.4.1 Hazard Identification

It is employer's responsibility to provide a safe working environment by eliminating and minimizing hazards. Adequate knowledge through training, instructions and appropriate supervision shall be provided to employees to ensure safety and health at workplace. Primary focus is given for employer's responsibility in Malaysian Occupational Safety & Health Act to ensure safety and health aspects at workplace.

Walk through survey is extremely useful for identification and evaluation of hazards. It also gives a better understanding about the job nature and potential hazards could be identified. Apart from identifying key hazards, it also helps to obtain an overview of the activities where the effectiveness of control methods could be seen (Jeyakumar, 2008).

Hazards can be identified by:

- Observations
- Workplace inspection by walk through survey
- Hazard identification checklist
- Job hazard analysis
- Feedback from workers
- Advice from specialists
- Accident records
- MSDS/CSDS

Job hazard analysis

The Department of Occupational Safety and Health Malaysia (2008), recommend that Job Hazard Analysis (JHA) shall be done to identify the hazards through HIRARC.

Job Hazard Analysis (JHA) requires breaking down of jobs or tasks into specific steps, identify the hazards and potential accidents, evaluate the hazards and develop solutions through safe work procedures. This helps to eliminate or decrease the hazards by integrating safe work procedures into safety and health programs.

JHAs should be done for each job task and SHOs should collaborate with workers to complete the JHA together.

Accident investigation

Provision in notification of accidents has been recognized as an important element in the Malaysian regulations. Initially it was outlined in Factory & Machinery Act 1967.

These provision was then included in the Occupational Safety and Health act 1994 under Occupational safety and Health Act (Notification of Accident, Dangerous Occurrence (Occupational Poisoning and Occupational disease) Regulations 2004 [NADOPOD 2004]. NADOPOD 2004 include new features such as standard forms to notify work related accidents in accordance with OSHA regulations, 1994 to empower employers to manage risks at the workplace.

The forms to be completed are:

- JKKP 6 Notification of Occupational Accident/Dangerous Occurrence. Occupational Safety & Health (Notification of Accident, Dangerous Occurrence ,Occupational Poisoning and Occupational Disease) Regulations 2004
- JKKP 7 Notification of Occupational Poisoning/Disease. Occupational Safety & Health (Notification of Accident, Dangerous Occurrence ,Occupational Poisoning and Occupational Disease) Regulations 2004
- JKKP 8 Register of Accident , Dangerous Occurrence, Occupational Poisoning and Occupational Disease

The JKKP 6 and JKKP 7 forms shall be sent to the nearest Department of Safety & Health (DOSH) within 7 days. While the JKKP 8 form shall be submitted to the DOSH headquarters before 31st January of every year compiling summary of all incidents happen within a year.

It is important for healthcare workers to understand the provisions under OSHA Act so that appropriate mitigation measures could be taken to manage the risk arise at workplace (Jeyakumar, 2008).

2.4.2 Risk assessment

Risk assessment is carried out by collecting data on each identified hazard; then using the collected data to determine the likelihood and severity of each hazard. A qualitative or quantitative risk table is created using these data.

Risk assessment is done based on likelihood and severity of the accident/event sequences. Numerical value is given to likelihood and severity in order to assess the risk value through quantitative analysis. This is used to gauge the risk magnitude and prioritize the identified hazards. Previous data is used as modelling outcomes of past incidents to determine the severity. The values of severity, likelihood and their combination give the risk level (Department of Occupational Safety and Health, 2008).

Likelihood of an occurrence

Likelihood of an event to happen determine through workers experience from past incidents or near missed occurrences which happened before. Likelihood levels ranged from “most likely” to “inconceivable”. Table below elaborates different ranges of likelihood with their rating.

Table 2:3 Likelihood values

LIKELIHOOD(L)	EXAMPLE	RATING
Most likely	The most likely result of the hazard / event being realized	5
Possible	Has a good chance of occurring and is not unusual	4
Conceivable	Might be occur at sometimes in future	3
Remote	Has not been known to occur after many years	2
Inconceivable	Is practically impossible and has never occurred	1

Source: Department of Occupational Safety and Health Malaysia, 2008.

Severity of hazard

Severity of a hazard is determined based on increasing level of severity to an individual's health, safety, environment or property damages. Table 2.4 shows the rating of severities by giving an example.

Table 2:4 Indications of severity

SEVERITY (S)	EXAMPLE	RATING
Catastrophic	Numerous fatalities, irrecoverable property damage and productivity	5
Fatal	Approximately one single fatality major property damage if hazard is realized	4
Serious	Non-fatal injury, permanent disability	3
Minor	Disabling but not permanent injury	2
Negligible	Minor abrasions, bruises, cuts, first aid type injury	1

Source: Department of Occupational Safety and Health Malaysia, 2008.

Risk rating

Risk elaborated in different ways based on the analysis done and results obtained used to make decisions on risk control implementation. Risk matrix used to present the results of quantitative analysis which is done based on likelihood and severity. Table 2.5 shows an example of risk matrix to identify the risk value.

Risk calculated using the following formula:

L x S = Relative Risk

L = Likelihood

S = Severity

Table 2:5 Risk matrix values

	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

High Medium Low

Source. Department of Occupational Safety and Health Malaysia, 2008.

Severity column best describes the outcome of risk. The likelihood row is used to find the description that best suits the likelihood that the severity occurs. The risk level is where the row and column intersect. The risk level is where the row and column intersect.

The relative risk value is use as guide to prioritize the hazards and implement effective risk control measures. Table below shows the level of the risk with particular values.

Table 2:6 Risk descriptions

RISK	DESCRIPTION	ACTION
15-25	High	A HIGH risk requires immediate action to control the hazard as detailed in the hierarchy of control. Actions taken must be documented on the risk assessment form including date for completion.
5-12	Medium	A MEDIUM risk requires a planned approach to controlling the hazard and applies temporary measure if required. Actions taken must be documented on the risk assessment form including date for completion.
1-4	Low	A risk identified as LOW may be considered as acceptable and further reduction may not be necessary. However, if the risk can be resolved quickly and efficiently, control measures should be implemented and recorded.

Source: Department of Occupational Safety and Health Malaysia, 2008.

Evaluation on risk caused by clinical waste and incinerators treating clinical waste

According to the guidelines on handling and management of clinical waste in Malaysia, the proper management of clinical waste is important for community and environmental health. Irrespective of technologies used for treatment and disposal, the standard requirements for the safety and health is uniform across all countries. The government has established a comprehensive system for clinical waste collection, transportation and disposal for all government hospitals through a privatisation program.

Clinical waste comprise of 20-40% of the total waste generated by the hospitals. It is estimated that the generation rate for clinical wastes varies from 0.3 to 0.8 kg per occupied bed per day. (Ministry of Health, 2011)

The incinerator combustion process reduces the waste mass and the volume more than 90% and makes the infectious medical waste become harmless. Proper incineration process capable to convert waste into relatively harmless gases, ashes and incombustible solid residue (World Health Organization,2011).

A survey by Batterman in 2004 on four small scale incinerators treating clinical waste showed widespread deficiencies in the design, placement, construction, operation, and management of the incinerator units. A well operated incinerator should have zero visible emission and no solid particulate matter should be emitted from the stack.

Emission of thick black smoke indicates either the incinerator is not well maintained or not being operated properly. Healthcare workers including incinerator operators are exposed to high risk of disease transmission from clinical waste particularly sharp infectious waste.

Proper personal protective equipment (PPE) is necessary to protect against risk especially for clinical waste handlers. The ultimate purpose of using personal protective equipment (PPE) is to reduce risk for accident or exposure and the consequences (Sharma et al., 2006). The major risks encountered by clinical waste collectors and incinerator operators will be either direct contact with clinical waste or when exposed to heat and fumes emitted during its operation. Direct contact with clinical waste may results in risk for HIV and hepatitis B infection through needle stick injuries (International Committee of Red Cross, 2011)

Clinical waste contains sharps, human tissues, body parts, and other infectious materials highly potential for health and environmental risk (Baveja et al., 2000). Infectious waste is highly potential to contain pathogenic microorganisms. Mishandling of infectious clinical waste may allow pathogens to enter human body through inhalation, ingestion, through membranes or through puncture, abrasion or cut in the skin. (World Health Organization, 2013) Healthcare workers who have direct contact with clinical waste posed great risk for infection.

Sharps such as syringes and needles pose physical hazards through cuts and punctures. The threat is greater when the waste is from infectious waste category. Needle prick injury while handling clinical waste could lead to HIV or hepatitis B and C infection and these infections may result in fatality (Johannessen, 2000).

The hepatitis B virus could survive up to one week under optimal conditions and persistent to dry air. It had been detected in discarded needles as well (Paintsil et al., 2010).

HIV is less resistant and survived only from three up to seven days under ambient temperature. It could be inactivated at 56°C or survive for not more than 15 minutes when exposed to 70% ethanol (World Health Organization, 2013).

Large quantity of chemical and pharmaceutical waste are considered hazardous as it may be toxic, corrosive, flammable, reactive or explosive. It can damage or burn the skin through inhalation and direct contact (Johannessen, 2000). Improper disposal of clinical waste pose greater threat compare to initial disease themselves as various risk present in concentrated form including pathogenic and antibiotic resistant microorganisms (Sharma et al., 2010).

In some cases, particularly low temperature (less than 800°C) incineration or incineration of plastics containing polyvinyl chloride (PVC), dioxins, furans, hydrochloric acid (which causes acid rain) and many other toxic air-borne pollutants are formed. They are found not only in emission but also in the air-borne ashes as residues and in effluent gases released through incinerator chimneys. Exposure to dioxins, furans and coplanar polychlorinated biphenyls can have harmful effects on public health (Pruss et al., 2010). Dioxin is non bio-degradable and considered as highly potent to cause cancer. It accumulates with higher concentration as it moves up in the food chain

(World Health Organization, 1999). Apart from release of dioxin and furan, medical waste incinerators also contain heavy metal which is emitted through fumes, particles and ash (Fritsky et al., 2001; Yuhas et al., 1994). Toxic discharged also contain many types of metals such as lead, mercury and arsenic (Singh & Prakash, 2007).

Exposure of healthcare workers to these toxic metals could lead to kidney failure, respiratory tract infection and cancer on lungs and prostate as well (United Nations Environment Programme, 2007).

Ash which is the final product of clinical waste incineration also posed some risk to the incinerator operators. Physical injury is still potential while handling the ash as burnt out needles and glass may be present in it after the incineration process. Elevated concentration of heavy metals and other toxic items also may present in the incinerator ash. As ash exposed to high temperature range between 200-450°C for long time, it provide an ideal condition for the synthesis of dioxin and furan. The inhalation and ingestion of ash during handling may results in accumulation of chemical in our body. This may cause severe health problems after a long term of exposure (World Health Organization, 2013).

2.5 Hierarchy of risk control

The hierarchy of risk control comprise of six aspects. These include:

1. Elimination

   Remove the hazard or hazardous work practice from the workplace.

2. Substitution

   Substituting or replacing the hazard or hazardous work practice with less hazardous one

3. Isolation

   Isolating the hazard or hazardous work practice from workers or general work area

4. Engineering control

   Modifying the tools and equipment using enclosures, guarding, mechanical ventilation or automated process

5. Administrative control

   Introduce policies or changes in work practices and procedures that could reduce the risk. This includes reducing the time employees exposed to the hazard, reducing the number of employees exposed, job rotation, log out or tag out procedures, and prohibiting eating or drinking at contaminated area.

6. Personal protective equipment

   PPE as risk control measure should be considered only when other control measures are not are not practicable, used together with other measures to provide greater measure, when specified by legislation as a basic requirement

   (Risk Management Training Material, NIOSH, 2004)

Under Malaysia's Occupational Safety and Health Act (1994) Act 514, the employer's duty towards employees are :

- Ensure the safety, health and welfare of all employees at workplace is practicable and maintains a safe workplace condition free from any risk to safety and health of workers.
- Ensure the provision and maintenance of plant or system is practicable and safe without any risk to health and safety of workers

- Ensure proper management of operation, handling, storage and transport of plant and substances is practicable and safe with absence of risk to health and safety of workers.
- Proper instruction, information, training and supervision is needed to ensure safety and health at workplace
- Establish safety and health policy: revise appropriately with written statement and all employees should be updated any stamen or revision of it
- Appoint a certified, competent Safety and Health Officer at the workplace to ensure due observance of the OSHA and its regulations and to promote safe the workplace.
- Establish a Safety and Health Committee if there are more than 40 employees which could provide mean of communication between management and employees to promote better and safer workplace environment.
- Required to notify the nearest Occupational Safety and Health Office of any accident, dangerous occurrence, occupational poisoning or occupational disease which has happened or is likely to happen at the workplace. (Laws of Malaysia, Act 514, 2013)

In turn employees need to take care of their own safety and health. Employees need to co-operate with employers in performing duties or requirement imposed by employers.

Usage of appropriate personal protective equipment provided by employers at all times could minimize and prevent safety and health risks; and abide all safety and health instruction mandated by their employer under the OSHA (Laws of Malaysia, Act 514, 2013).

3.0 METHODOLOGY

This chapter describes the methodology that was used to identify the hazards followed by risk assessments to improve the safety of clinical waste handlers at hospital and incineration plant treating clinical waste. Same methodology was used for both area of research (hospital & incineration plant). The methodology was divided into three sections: hazard identification, risk assessment and recommendation for risk control measures. In general, the common HIRARC form from Department of Safety & Health (Appendix A) was used to identify, collect and analyse all the above parameters. The research includes primary and secondary data collection. Primary data collection was done by interviewing the clinical waste handlers and staff from one of the hospital and at the incineration plant. Archived documents were used to collect secondary data to identify hazards, risk matrix ranking applied to evaluate and assess risks along with control measures. Some steps were designed in order to carry out the research. Several site visits were conducted to achieve data collection.

The hazards during clinical waste handling at the hospital and hazards generated at the plant have direct relation with implementation of safety measures. It depends on different factors such as types and severity of work, number of accidents, monitoring by relevant authorities, cost, and etc. Therefore the aim of HIRARC is to find out every parameter that is considered as a hazard to reduce the level of risk and increase the safety. The framework of process is provided in Figure 3.1.

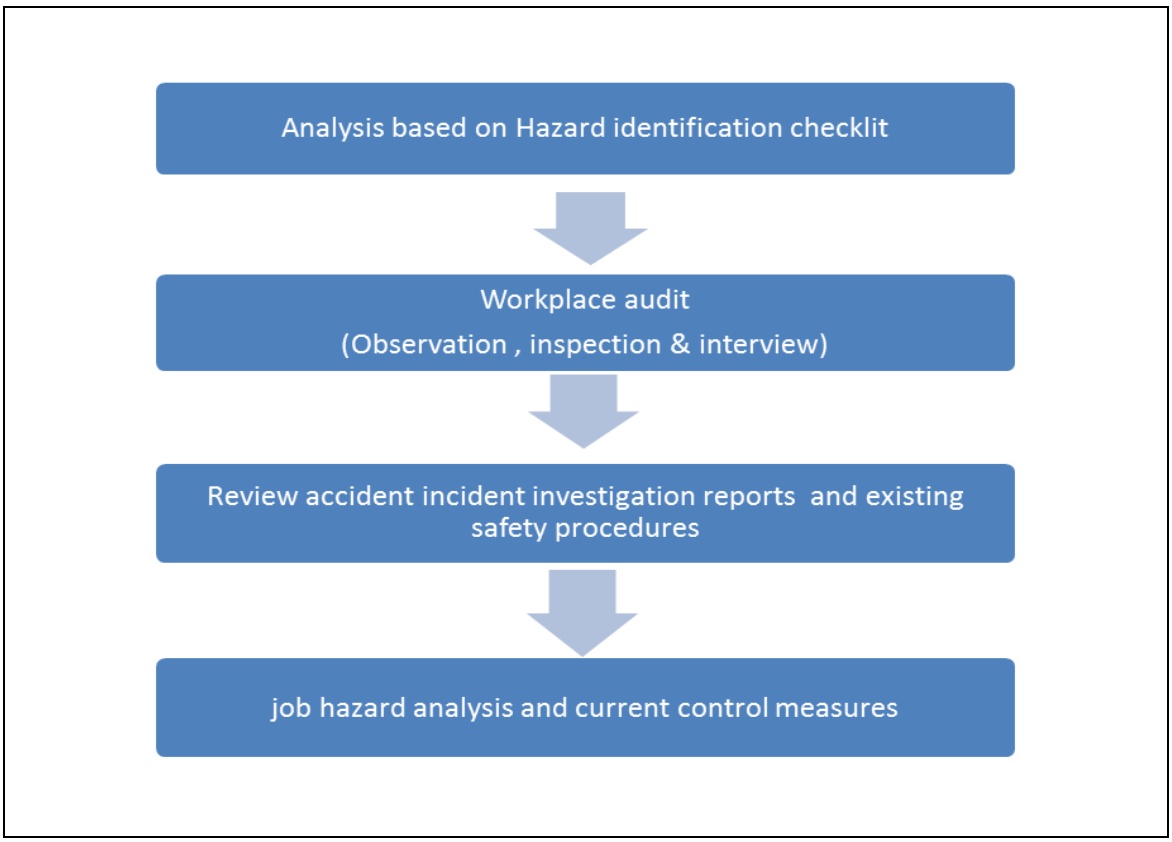


Figure 3.1 : Method of hazard identification

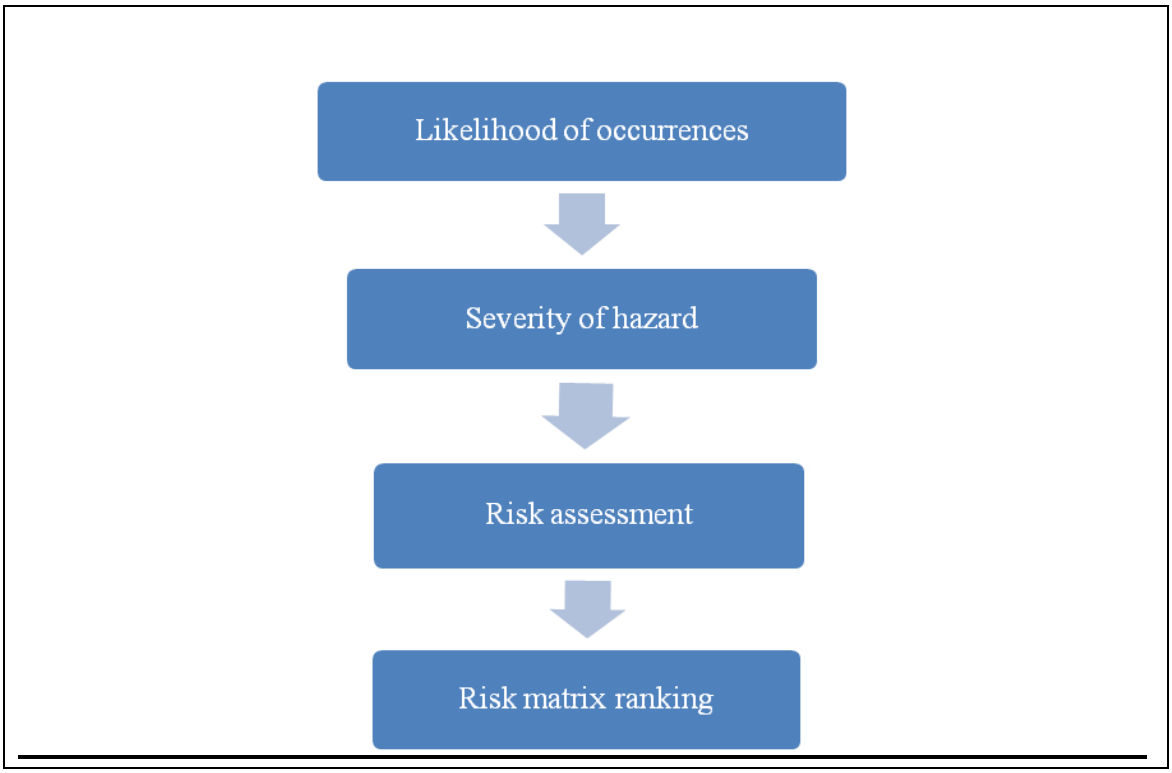


Figure 3.2 : Method of risk assessment

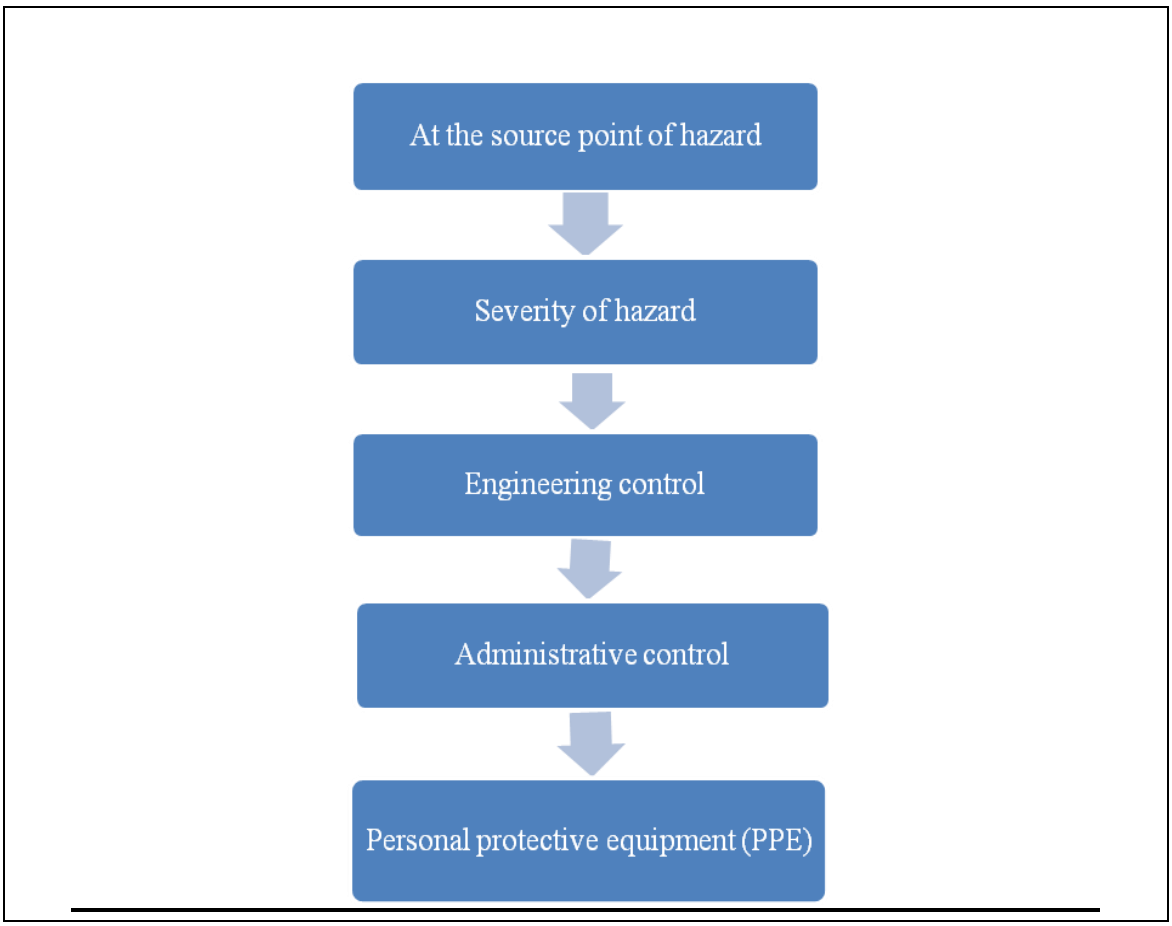


Figure 3.3 : Risk control measures implementation

3.1 Method of hazard identification

In this study, hazard identification referred to identification of undesired events leading to hazard occurrence. Several techniques were used to complete the hazard identification at the study area. In fact, the identification methods were depends on the type of job task. The following methods were used to ascertain the hazards associated with each job task at the studied areas.

3.1.1 Hazard identification checklist

The hazard identification checklists consist of all potential and known hazards including causes of hazards drawn from each job task. This technique involved systematic use of an appropriate checklist and considering whether each identified hazard on the checklist could possibly cause any risk or not.

In this study, the hazard identification checklist was not used at hospital because the scope of work being analysed is small. However, it was used for three main activities at the incineration plant include plant preparation before the process, the incineration process and maintenance of the plant. The hazard identification checklist (refer to Table 4.1 to 4.7) comprise seven sections that include: Biological/Health, Chemical, Electrical, Mechanical, Ergonomic, first-aid & fire-fighting equipment and methods of control. The checklists were distributed among the workers and safety officer at the plant to identify the existing and potential hazards at workplace.

3.1.2 Workplace inspection (observation and interview for job hazard analysis)

Visits were conducted to the incineration plant and the hospital. Inspections were used as tools for assessing workplace hazard. In this study "inspection" was a general walk-around inspection at the clinical waste handling place in the hospital. The incinerator worksite was inspected following the process flow of the plant to identify non-compliances based Malaysian safety standards. At times the term "audit" is referred to "inspection." Audits usually involve locating ineffective or missing safety programs. Audits are similar evaluation tool that involve assigning numerical ratings on audited items. Inspections, on the other hand, involve locating hazardous conditions.

In this study, worksite observation was crucial because it is the most effective tool used to identify behaviours that account for workplace injuries. It takes into account how these behaviours interact with the hazardous environment.

Furthermore, an interview was conducted in private with the relevant authority of the incineration plant and clinical waste handling staffs at the studied hospital. This allowed to collect more information from the plant in different dimension (Identifying and Controlling Hazards). The workplace inspection checklist (refer to table and interview questionnaire used during the inspection is attached in chapter 4.

3.1.3 Accident and incident investigations

Accidents happen when hazards are undetected during job or process safety analysis. Some hazards are not obvious and incidents occur from combination of unforeseen factors. In the studied area, the accident investigation formerly overlooked. Physical or process hazards, unsafe work practices and lack of awareness on risk factors were among the need for more extensive safety training. The main reason for accident investigation is to determine the facts surrounding them and the lessons to be learned to prevent future similar occurrences. Investigation should never be focused on placing blame; instead, it must be seen as a chance for enhancing safety. In general, investigation was carried out for:

a. All injuries (even the very minor ones)

b. All accidents with potential for injury (recorded and non-recorded)

c. All “Near Misses” where there was potential for serious injury

Incident reporting and investigation enable hazard identification and allows implementing controls before hazards lead to even worse incidents. Accident investigations enable detecting hazards missed earlier or hazards involving failed controls. Investigation is only useful when aimed at identifying root causes.

All incident contributing factors should be exposed and suggestions given to avoid recurrence (Colorado State University Occupational Health and Safety Section, 2001). Appendix B shows an example of a preliminary accident report form and appendix C shows an example of accident investigation report used at studied plant. Appendix D to F shows the NADOPOD forms which is used to report accidents to Department of Safety & Health.

The methodology for hazard identification and risk assessment shall include:

a. Steps for identifying and assessing the hazards.

Steps must be defined for identifying hazard identification. Information documented should include:

i. Who will be held responsible for identification, whether it should be the workplace health and safety committee, or an individual/individuals appointed by the committee;

ii. How the identification reports are processed: for example, compiled and processed by the committee, or by individuals appointed by the committee;

b. The keeping of a record of the hazards.

After identifying the hazards, an identification record must be established and maintained in print or electronic form.

c. A time frame for reviewing and revising the methodology.

The date for identification reviewing: for example, identification method review shall be carried out every three years (Department of Occupational Safety and Health Malaysia, 2008).

3.2 Hazard classification and risk assessment

Hazard classification is done through job hazard analysis. The identified hazards were categorized as either safety or health hazard followed by classification into biological, chemical, ergonomic, physical, mechanical, physiological and electrical hazards.

3.2.1 Job Hazard analysis (JHA)

The job hazard analysis aid in identifying hazards associated with each particular job task. In this study, JHA was done for clinical waste collection and disposal activities at the hospital and by breaking down the activities at the incineration plant according to job tasks followed by identifying the potential hazards related to each job task. This provides a way to eliminate or control the related hazards and reduce the risks. It aid in avoiding the injuries to employees (NPS Risk Management Division, 2005). A job hazard analysis checklist (refer to Table 4.26 to 4.29) was used in this study to evaluate the safety and health aspects during clinical waste handling at Hospital Raja Permaisuri Bainun and AAA incineration plant.

3.2.2 Method of risk assessment

Risk assessment is done to determine the likelihood and severity of the accident/event sequences in order to gauge the magnitude and prioritize identified hazards. Risk assessment can be done by quantitative, qualitative, or semi quantitative approaches. This study is done quantitatively for better results.

Quantitative analysis gives value to risk in numerical terms and not the descriptive scales used in qualitative and semi-quantitative analysis. Both severity and likelihood are given values, using data from sources such as previous accidents and near missed occurring and results of scientific studies.

We can determine severity by modelling outcomes of events or sets of events, or by extrapolating from experimental research or previous data. Severity may be denoted by monetary, technical or human impact terms, or some other criteria. Expression of severity and likelihood combination express the risk levels.

Risk matrix ranking

Likelihood of an occurrence

In this study area, the value depended on the likelihood of an event happening. Assessing likelihood in the plant was based on worker experience, analysis or measurement. Likelihood levels ranged from “most likely” to “inconceivable”. Refer to table Table 2.3 that elaborates different ranges of likelihood with their rating.

Severity of hazard

Severity could be divided into five categories. Severity was based upon an increasing level of severity to an individual’s health, the environment, or to property. Refer to table 2.4 that show the rating of severities by giving an example.

Risk assessment

Risk could be presented in different ways based on results of analysis and facilitate decision-making for risk control. For risk analysis that used likelihood and severity in the quantitative method, presenting results in a risk matrix is an effective way to show the risk in a workplace. Refer to table 2.5 that show an example of risk matrix to identify the risk value.

Risk is calculated using the following formula:

L x S = Relative Risk

L = Likelihood

S = Severity

The relative risk value can be used as a guide for prioritizing needed actions in effective risk management of workplace. Refer to table 2.6 that express the level of the risk in particular values.

Hazards evaluated as “High Risk” require immediate actions to resolve or reduce the risk to life safety and/or the environment. Personnel responsible for taking required action should do the follow-up inspections to ensure the effectiveness of the implemented control measures.

3.3 Risk control methods

In this study, four major categories of risk control methods are applied includes the elimination or substitution at source of hazard, engineering control, administrative control and usage of personal protective equipment to regulate, reduce or prevent the hazards. The details of control methods are as bellow:

At the source of the hazard

Implementation of elimination and substitution parameters at the source of the hazard is one of the control methods to control hazards by in the plant.

a. **Elimination** - Getting rid of a hazardous job, tool, process, machine or substance is perhaps the best way of worker protection.

b. **Substitution** -Controls must protect workers from repetitive and any newly created hazard.

Engineering controls

Engineering controls prevent and reduce the discharge of hazards into the working atmosphere through mechanical modification of machinery or processes. This is solely dependent on the type of hazards as different factors of engineering control can be applied at the plant. Table 3.1 shows some different types of engineering controls.

Table 3:1 Engineering Control Parameters

Parameters	Remark
Redesign	Jobs and processes can be reworked for better safety. For example, containers can be made easier to hold and lift.
Isolation	If elimination or replacement is impossible, the hazard can sometimes be isolated, contained or otherwise kept away from workers.
Automation	Dangerous processes can be automated or mechanized.
Barriers	A hazard can be blocked before it reaches workers.
Absorption	Baffles can block or absorb noise. Lockout systems can isolate energy sources during repair and maintenance. Usually, the further a control keeps a hazard away from workers, the more effective it is.
Dilution	Some hazards can be diluted or dissipated.

Administrative controls

Administrative controls include various policies and requirements that are recognized at an administrative level. Administrative controls implemented by the authority (Management, Safety department, safety committee or safety officer). The following parameters can be implemented as an administrative control to minimise and control risks in working area (Table 3.2).

Table 3:2 Administrative Control Parameters

Parameters	Remark
Safe work procedures	Workers can be required to use standardized safety practices. The employer is expected to ensure that workers follow these practices. Work procedures must be periodically reviewed with workers and updated.
Supervision and training	Initial training on safe work procedures and refresher training should be offered. Appropriate supervision will assist workers in identifying possible hazards and evaluating work procedures.
Job rotations	Can reduce worker exposure to a hazard. For example, workers can be rotated through jobs requiring repetitive tendon and muscle movements to prevent cumulative trauma injuries. Noisy processes can be scheduled when no one is in the workplace.
Housekeeping, repair and maintenance programs	Housekeeping includes cleaning, waste disposal and spill cleanup. Well maintained tools, equipment and machinery are less likely to cause injury.
Hygiene	Hygiene practices can reduce the risk of toxic materials absorption by workers or risk of carrying toxins home. Street clothing should be kept in separate lockers to avoid contamination by work clothing. Eating areas must be isolated from toxic hazards. Eating should be banned in toxic work areas. Where applicable, workers should be required to shower and change clothes at the end of the shift.

Personal protective equipment

Usage of personal protective equipment (PPE) is determined according to hazards identified. PPE should be the last resort, after exhausting all other controls or when more significant hazard controls are not feasible. However, PPE usage should be mandatory for employees based on their job task. In this study personal protective equipment control focus on employee safety by preparing all protection equipment such as Eye and Face, Head, Foot and Leg, Hand and Arm, Hearing and Body Protection (Department of Occupational Safety and Health Malaysia, 2008) .

4.0 RESULTS

4.1 Hazard identification

Hazard identification is the first step done in the study. Hazards were identified through hazard identification checklist, workplace inspection, interviews and accident report reviews.

4.1.1 Hazard Identification checklist

There are several approaches used in hazard identification. Hazardous element and component checklist based on previous experience and analysis is one of the approaches used to identify hazards (Ericson, 2005). The hazard identification checklist was used in this study to identify and understand all the expected and unexpected hazards at the incineration plant involving the waste handlers. The hazard identification checklist was used to assess every parameter involved in the process, review the effectiveness of current safety measures and introduce better control measures to achieve a tolerable level of risk.

In this study, the hazard identification checklist was prepared with assistance of an occupational safety and health expert. The checklist was distributed among the workers and safety officer at the incineration plant to identify hazards. The results obtained through the checklist shows, the incineration plant comply with OSH regulations under Occupational Safety & Health Act 1994(Act 514) and guidelines set by Department of Environment, Malaysia on handling and management of clinical waste.

Based on the study using hazard identification checklist, biological hazards have been identified as one of the main hazard in incineration plant treating clinical waste. The detail results of the analysis are shown below.

Table 4:1: Biological hazard checklist

Biological / Health	Y	N	Comment
1. Are workers exposed to clinical waste extensively during transferring of waste into cold room or into incinerator?	√		
2. Is there chances for inhalation and ingestion of virus and bacteria during handling of clinical waste	√		PPE is provided as preventive measure
3. Are there any falling of clinical waste and injury hazard during bin lifting or storage of waste in cold room?	√		
4. Do any parts of incinerator discharge heated air during and after the process and make heat hazard for workers? If yes, which part and how this hazard is overcome?	√		APC Stack: Designed 20 meters height from the ground
5. Are there any physiological and psychosocial stresses on workers due to their working position or working schedule?	√		
6. Is health of workers at plant being monitored? How?	√		Workers are sent for regular medical check-up every six months once
7. Are there frequently indoor air quality and industrial hygiene to check and control the air quality and worker health in incineration plant and cold room area?		√	
8. Is cleanliness of cold room is taken care to avoid microorganisms growth? How growth of microorganisms is prevented at cold room area?	√		Frequent cleansing and maintain temperature less than 6 degree Celsius
9. Are workers exposed to presence of maggots at cold room area? How it is prevented or overcome?	√		PPE

Table 4.1, continued

10. Are there chances for inhalation of contaminated air during handling of waste?	√		PPE
11. Is there any direct contact with waste and does it cause any skin/eye irritation?	√		Only if handle without appropriate PPE
12. Do any parts of incinerator discharge heated air during and after the process and make heat hazard for workers? If yes, which part and how this hazard is overcome?	√		APC Stack: Designed 20 meters height from the ground
13. Are there any physiological and psychosocial stresses on workers due to their working position or working schedule?	√		
14. Is health of workers at plant being monitored? How?	√		Workers are sent for regular medical check-up every six months once
15. Are there frequently indoor air quality and industrial hygiene to check and control the air quality and worker health in incineration plant and cold room area?		√	
16. Is cleanliness of cold room is taken care to avoid microorganisms growth? How growth of microorganisms is prevented at cold room area?	√		Frequent cleansing and maintain temperature less than 6 degree Celsius
17. Is workers exposed to presence of maggots at cold room area? How it is prevented or overcome?	√		PPE
18. Are there chances for inhalation of contaminated air during handling of waste?	√		PPE
19. Is there any direct contact with waste and does it cause any skin/eye irritation?	√		Only if handle without appropriate PPE

In this study, chemical hazard was generally found to be under control. However employees are mainly exposed to chemicals during plant preparation stage and ash collection after incineration. Table 4.2 shows the checklist of hazardous chemical exposures at the incineration plant.

Table 4.2 : Hazardous chemical checklist

Hazardous chemical exposure	Y	N	Comment
1. Are employees aware of the potential hazards involving various chemicals component?	√		
2. Is employee exposure to chemicals kept within acceptable levels?	√		
3. Are all employees required to use personal protective clothing and equipment when contact chemicals (i.e. gloves)?	√		
4. Where needed for emergency use, are respirators stored in a convenient, clean and sanitary location?	√		
5. Are respirators intended for emergency use adequate for the various uses for which they may be needed?	√		
6. Are employees prohibited from eating in areas where hazardous chemicals are present?	√		
7. Is personal protective equipment provided, used and maintained whenever necessary?	√		
8. Are there written standard operating procedures for the selection and use of respirators where needed?	√		
9. If you have a respirator protection program, are your employees instructed on the correct usage and limitations of the respirators?	√		
10. Are the respirators DOSH approved for this particular application?	√		Approved by JKKP

Table 4.2, continued

11. Are they regularly inspected and cleaned sanitized and maintained?	√		
12. If hazardous substances are used in your processes, do you have a medical or biological monitoring system in operation?	√		We have annual medical surveillance with licensed OHD conducted to all operation staff.
13. Are you familiar with the Threshold Limits and Permissible Exposure Limits of airborne contaminants in your workplace?	√		
14. Are control procedures been instituted for hazardous materials, where appropriate, such as respirators, ventilation systems, handling practices, and the like?	√		.
15. Do you use local exhaust ventilation systems to control dusts, vapours, gases, fumes, smoke, solvents or mists which may be generated in your workplace?		√	Our facilities are in open area. No ventilation system required. However we still have trained staff on guidelines of PPE requirement for works involving dust or fumes.
16. Is ventilation equipment provided for removal of contaminants from such operations, and is it operating properly?		√	No special ventilation equipment as the facilities are in open area
17. Do employees complain about dizziness, headaches, nausea, irritation, or other factors of discomfort when they contact and working with chemical component?		√	
18. Is there a dermatitis problem--do employees complain about skin dryness, irritation, or sensitization?		√	
19. Have you considered the use of an industrial hygienist or environmental health specialist to evaluate your operation?	√		We do have conducted (based on requirement) SHE monitoring such as CHRA, Chemical Exposure Monitoring, noise exposure & Ambient Air Monitoring by accredited lab or licensed Hygiene Officer.

Table 4.2, continued

20. If internal combustion engines are used, is carbon monoxide kept within acceptable levels?	√		
21. Is vacuuming used, rather than blowing or sweeping dusts whenever possible for clean up at ash collection area?		√	For incinerator ash, we just sweep a floor and put it in bulky bag. Vacuum is not possible because of its size.
22. Have you faced with any explosion products during the process?	√		Explode during burning process. Inside the combustion chamber.
23. Does ash collection and packing make hazard (e.g., sharp items, dust)?	√		Sharp edge, heavy load, ash vapour, hot ashes and hazard from forklift handling.
24. Is there any gas emission in any parts of the process or electrical equipment(Scrubber, sump tank, etc)?	√		During abnormal operation. During normal operation, gas just emitted by through stack.
25. Do disturbances of lubrication and diesel oil supply to incinerator can rapidly lead to water and cause hazard?		√	

The hazard identification checklist shows, risk for electrocution occur during maintenance works only. Maintenance of fan system, hydraulic system, air dryer and secondary burner is highly prone for electrocution risk. The management has made the work permit application as a mandatory requirement prior to any work at thermal radiation prone area.to Appropriate signage are available at all high voltage electricity areas. Some areas were guarded with locked steel gates to prohibit unauthorized entry. There are high chances for fire hazard due to nonstop running of the incineration process, however continues monitoring is carried out throughout the process to avoid any unintended fire incident.

Table 4.3 : Electrical hazard checklist

Electrical hazard	Y	N	Comment
1. Do you specify compliance with OSHA as a requirement for all aspects of the electrical related work?	√		
2. Is there any simple access to high voltage switchyards or control areas?		√	Locked and only authorized person hold the key.
3. Are all electrical power tools, systems and electrical equipment tagged and inspected follow the • Electricity Supply Act 1990 - Act 447 • Licensee Supply Regulations 1990 • Electricity Regulations, 1994 • Malaysian Standard MS IEC 60364 Electrical Installation of Buildings	√		
4. Do the employees have knowledge of the electrical device and their function?	√		
5. Is there any hazard due to direct contact of workers with live parts?	√		
6. Does contact of workers with parts which have become live under faulty conditions (indirect contact) may cause hazard?	√		
7. Is there a hazard due to proximity to live parts under high voltage?	√		
8. Does electrostatic charge pose any hazards?	√		
9. Is there a hazard due to thermal radiation (heat) if yes, what is the steps taken to overcome it?	√		1. Signage 2. Full body protection uniform 3. Work Permit before start any work there

Table 4.3, continued

10.	Is there any Electrical Safety Training for employee and all people who engaged with process?	√		
11.	Are tight fitting covers provided for electrical enclosures such as switches, receptacles, junction boxes, etc.?	√		
12.	Are all flexible cords and cables free of splices and taps?	√		
13.	Are initial inspections and/or appropriate tests done to determine what conditions exist before starting work on electrical equipment or control rooms?		√	Inspection is done during weekly maintenance works and workers are trained to ensure safety first before using any tools or start any works.
14.	Are lockout-tagged out being practiced when electrical equipment or control rooms are to be serviced, maintained, or adjusted?	√		
15.	Are portable electrical tools and equipment grounded or have double insulation?	√		
16.	To permit safe operations and maintenance, is sufficient access and working space provided and maintained around all electrical equipment?	√		
17.	Are electrical tools and equipment appropriate for the use at wet or damp locations or otherwise protected?	√		
18.	Are metal ropes, handlines or similar devices with metallic thread prohibited at places where it can come into contact with energized parts of the incinerators?	√		
19.	Does circuit breaker not cutting off the power supply in the event of thunderstorm, lighting or any other emergency situations could lead to any hazard?	√		

Table 4.3, continued

20. Does firing hazard possible by nonstop running of the operation?	√		Hazard exists but never happened.
21. Does heat due to high temperature during process have cause any accident before?		√	

Some mechanical hazards are found at various areas of job task including plant preparation, process and maintenance work. Study shows all equipment and machineries are placed securely and anchored. All new employees were briefed on the safety aspects of the system prior to start work.

Table 4:4 : Mechanical hazard checklist

Mechanical hazard	Y	N	Comment
1. Is there a training program to instruct employee's on safe methods of incinerator operation?	√		New employees are briefed on safety aspects of the system.
2. Is equipment and machinery securely placed and anchored to prevent tipping or other movement to avoid any unintended personal injury?	√		
3. Is an incinerator preventive maintenance program established?	√		
4. Does audible warning device mounted on each incinerator?	√		
5. Does sufficient illumination provided during operation and maintenance to ensure safe working environment?	√		
6. Are bin lifter of such design, that the boom could fall over backward, equipped with boom stops?		√	

Table 4.4, continued

7. Does certificate of fitness available for each mechanical part ?Indicate the parts involve and frequency of inspection done for certification?	√		Air compressor system such as tank to be inspected annually by DOSH
8. Are usage of kinked or twisted chains and rope slings prohibited from usage?	√		
9. Are employees instructed to avoid carrying loads over people?	√		
10. Are all hooks equipped with spring-loaded safety clips to prevent accidental load release?		√	We have a special lock system on the bin lifter
11. Are only employees who have been trained in the proper use of bin lifter allowed to use them?	√		
12. Can electric power to each burner be locked-out for maintenance, repair, or security?	√		
13. Are rotating or moving parts of equipment properly guarded to prevent physical contact (e.g., ash conveyer, burner, bin lifter)?	√		
14. Are machinery guards secure and arranged to avoid any hazard when in use?	√		
15. Is there suitable ventilation system to gather the dusts, vapors, or gases at whole incinerator to be controlled, and convey them to a suitable point of disposal?		√	Open area plant or workplace
16. Do disturbances of lubrication or diesel supply can rapidly lead to damage the burner due to the huge exposure?		√	
17. Is there any mechanical failure for burner due to low maintenance and overloading?	√		
18. Do damaging and fails to run in ducts and fans in ventilation system can cause hazard in confine space?	√		

Heavy lifting and other manual handling of containers by the waste handlers increase the risk of musculoskeletal problems (Poulsen et al., 1994). Some physiological stresses on employees were identified at the study area due to repeated exposure on same job task and working schedule. Exposure to vibration during usage of jet spray for bin washing is one of the ergonomic hazards found at the plant. Table below shows the checklist of ergonomic hazards at the incineration plant.

Table 4:5 : Ergonomic hazard checklist

Ergonomic hazard	Y	N	Comment
1. Do externally paced tasks perform by the incinerator operators?	√		
2. Are incinerator operators required to exert force with their hands (e.g., gripping, pulling of bins, pushing of waste into cold room)?	√		
3. Are any hand tools used by the workers? When?	√		During maintenance activities
4. Do workers stand continuously for long period of time?		√	
5. Do workers sit for a long time without the opportunity to stand or move around freely?		√	
6. Do workers use any devices to check temperature, pH and so on for continuous periods of time?		√	
7. Do plant operators kneel for any job task (one or both knees)?		√	
8. Does any work require the workers to raise their hands above shoulder height?		√	
9. Is there any activities perform by the workers while bending or twisting at the waist?		√	
10. Are workers exposed to vibration? When?	/ √		During washing of waste bins using pressurized water pipes

Table 4.5, continued

11. Do workers lift or lower objects between floor and waist height or above shoulder height?		√	
12. Do workers lift, lower, or carry large objects or objects that cannot be held close to the body?		√	
13. Does any activity require the neck and shoulders to be stooped to view the task?		√	
14. Does sufficient rest breaks given in addition to the regular rest breaks, to relieve stress from repetitive-motion tasks?	√		

Fire is one of the main hazard at the incineration plant. Fire at hazardous waste site could occur due to moving of drums, accidently mixing of incompatible chemical, ignition of material due to oxygen enrichment, sudden release of material under pressure or spark from equipment into explosive flammable environment (NIOSH, United States, 1985).

The incineration plant present high safety issues because the process itself involve extremely high temperature and burning fire which is prone to cause fire breakouts. The structure is designed in such a way to avoid trapping of workers at any part of the plant. Adequate emergency exits available at the plant. These exits are always ensured to be kept free from any obstruction for movement of workers during emergency situations. There is no fire alarm panel or smoke detectors installed at the plant area due to its high sensitivity. However there is a specific system incorporated into the incinerator to trigger and send notification to the control room when fire is detected at any parts other than burner. Adequate lighting is provided during night operations to ensure clear visibility for employees. Table below shows the first aid and fire prevention actions implemented at the plant.

Table 4.6 : First aid and fire-fighting equipment checklist

First-aid and fire-fighting equipment	Y	N	Comment
1. Do you have adequate first aid at the plant to be used in emergency situations?	√		
2. Are first aid kits kept at easy access area for every one?	√		
3. Does fire drills conducted regularly to train the staffs how to react in emergency situations?	√		
4. Are first-aid supplies checked and replenished regularly?	√		
5. Is the local fire department acquainted with the facility and its specific hazards?	√		
6. Are adequate numbers of portable fire extinguishers provided?	√		
7. Is an emergency response plan established at the plant?	√		
8. Does your plan describe the type of fire protection equipment and/or systems?	√		
9. Are there any established practices and procedures to control potential fire hazards and ignition sources?	√		
10. Is your local fire department well acquainted with your facilities, location, and specific hazards?	√		
11. Does your fire alarm system tested on regular basis?		√	No fire alarm system at the incinerator plant. However, the management office equipped with in fire alarm system
12. If you have a fire alarm system, is it certified as required?	√		Certified by Fire and Rescue Department
13. If you have a fire alarm system, is it certified as required?		√	
14. If you have interior standpipes and valves, are they inspected regularly?	√		

Table 4.6, continued

15. Is there any automatic sprinkler system installed at the plant? Is maintenance of automatic sprinkler system assigned to responsible persons or to a sprinkler contractor?		√	
16. Are fire extinguishers mounted in readily accessible locations?	√		
17. Are fire extinguishers inspected and recharged regularly? Is there a notification tag on the extinguishers?	√		
18. Are employees instructed periodically on the proper usage of extinguishers and fire protection procedures?	√		

The study shows that appropriate control measures are implemented to manage and minimize the risk posed existing hazards. This also helps to reduce the chances for emergence of new hazards.

All the employees at the plant have been sufficiently informed about the hazards and associated risks. Table below shows the methods of control being implemented at the plant.

Table 4.7 : Methods of control checklist

Methods of control	Y	N	Comment
1. Is there a proper control on those hazards that have been identified or happened before?	√		
2. Are the control measures effective to overcome the hazards?	√		
3. Is the risk posed by the original hazard contained?	√		
4. Is there any new hazard have been identified recently?		√	
5. Are new hazards appropriately controlled?	√		
6. Are monitoring of hazards done adequately?	√		

Table 4.7, continued

7. Have workers been adequately informed about the hazards and the risks?	√		
8. Have orientation and training programs been modified to deal with any new changes in the process?	√		
9. Do method of controls allows workers to do their work in a safe condition without creating new hazard?	√		
10. Are workers protected with the appropriate controlling method when they are exposed to hazard?	√		
11. Do the control methods help to reduce or omit the hazard from the working environment?	√		
12. Is there a proper procedure for storage of excess waste and disposal of the ash?	√		
13. Are there any guidelines from ministry for storage of excess waste? (indicate which ministry and the guideline name)	√		Department of Environment : Guideline of Handling and Management of Clinical Waste in Malaysia
14. Are there any guidelines from ministry for handling of treated waste (ash)? (indicate which ministry and the guideline name)	√		Same as above

4.1.2 Workplace inspection (observation and interview)

Periodic workplace inspections are essential to ensure proper occupational safety and health management at workplace. Generally, waste handlers become victims of infection during waste handling through punctures, cuts, inhalation or dermal contact due to their occupational job functions (Coker et al., 2009). In this study, the observation was focusing on clinical waste collectors at the hospital.

Hospital Raja Permaisuri Bainun, Ipoh.

Based on the prepared checklist, a walkabout was done to see the clinical waste disposal and collection practices at Hospital Raja Permaisuri Bainun, Ipoh. The walkabout was assisted by one of the safety committee member from XXX Sdn Bhd. Few needle prick injuries have been recorded before in this hospital. The checklist comprised some main aspects as follows:

Table 4.8 : Worksite general inspection checklist

Worksite general inspection	Condition	Comments
1. The total number of workers in-charge for clinical waste collection at Hospital Raja Permaisuri Bainun , Ipoh.	3	
2. Number of working shift for clinical waste collectors.	1	
3. The frequency of clinical waste collection in a day. How the collection schedule is organized?	Usually once a day	If bins in ward overloaded, will collect accordingly
4. Where does the collected clinical waste stored prior to collection?	Temporary clinical waste storage cold room	
5. The temperature of temporary clinical waste storage cold room	3 °C	
6. The storage capacity of the temporary clinical waste storage cold room.	No specific maximum storage capacity	The container could accommodate waste from HRPB and all “klinik kesihatan” or Health Clinics in Ipoh
7. The frequency of clinical waste collection from temporary storage area to be sent to Kamunting incineration plant	2 days once	Depends on accumulation too

Table 4.8, continued

8.	The hygienic practice implemented at the clinical waste storage area	• Prohibited for entry of unauthorized person. • The door is closed all the time. • Temperature is maintained at 3°C • Cleaning is done every time after collection	
9.	Does blue, yellow and red bags stored in a same area?	Only yellow bags are collected as clinical waste	
10.	Does the sharp bins stored in a same area too? Or how is it segregated in storage area?	Sharp bins stored in the same area with other clinical waste ain yellow bags	
11.	The type of mask used by these clinical waste handlers	3 ply face mask	
12.	Problems encountered during transportation of clinical waste from wards to waste storage area.	Sometimes, the bins in wards are overflow and needles were found normal clinical waste bins instead of sharp bins.	Sometimes, clinical waste also found is normal waste bins
13.	Cleaning and washing of clinical waste collection bins.	‘ Presept ’ disinfectant tablet is used for cleaning of the bins	Bins are washed every day evening after stop the collection
14.	Cleaning of clinical waste yellow bins in wards	The yellow bins in wards were washed with disinfectant once a week by the cleaners or in between if there is any spillage	Daily washing is not done because the yellow bags are placed on the bins for collection
15.	Expired chemical collection and disposal	Expired chemical bottles are collected in sharp bins	Chemicals with explosive danger are not disposed in sharp bins
16.	How frequently, clinical waste temporary storage area is cleaned and disinfected?	Once a week on every Saturday	
17.	Does clinical waste collectors aware of the incident reporting procedures?	They are aware and the flow is pasted on the notice board	

There is 3 in-charge staff at Hospital Raja Permaisuri Bainun, Ipoh for clinical waste collection and disposal. They work from 7.30 am till 4.30 pm everyday including weekends and public holidays. The clinical waste is collected from respective wards and clinic once daily and sometimes according to accumulation of waste. The clinical waste is then transferred to temporary clinical waste storage cold room and stored under a temperature of 3 °C. The clinical waste is collected and transferred to temporary storage area using a trolley. Clinical waste from other '*Klinik Kesihatan'* is also sent to this temporary storage area prior to be collected by the clinical waste transporters. The clinical waste is collected two days once to be sent for incineration. A consignment note (Appendix G) is issued during collection to keep record on amount of waste generated and disposed. Only clinical waste in yellow bags and sharp bins were kept at the cold room to be sent for incineration. Expired chemical from wards and laboratories were disposed in sharp bins. The clinical waste collection bins in wards and clinics were washed once week or in-case of any spillages. The collection trolley and the cold room washed and disinfected once a week on every Saturday. The "Presept" disinfectant tablet is used for cleaning and disinfection works. The clinical waste collectors wear nitrile gloves, apron, safety boots and 3 ply face mask during collection of clinical waste.

Figure 4.1 : Clinical waste collection bins in wards

Figure 4.2 : Clinical waste collection bins in clinics

Figure 4.3: Clinical waste collection trolley

Figure 4.4 : Clinical waste collector with full PPE

Figure 4.5 : "Presept" disinfectant used for cleaning of yellow bins and the cold room

Figure 4.6 : "Presept" disinfectant tablet

Figure 4.7 : Clinical waste temporary storage cold room

After the walkabout, the supervisor who is also a safety committee member was interviewed to collect some information regarding the clinical waste management. 44 clinical waste collectors working under XXX Sdn Bhd at all hospitals and "*Klinik Kesihatan*" in Perak. First aid kind of needle prick injuries and bruises usually occur during collection of clinical waste from wards and clinics. Staff are equipped with personal protective equipment and training are given at the beginning of employment. Below are the response obtained from the interview.

Table 4.9 : Interview questionnaire for supervisor

Questions	Response	Remarks
1. What is the total number of clinical waste handlers are working under your company for Perak state?	44	
2. How many clinical waste handlers are allocated for each major hospital? Ex : HRPB	3 or 4	
3. What kind of accident/incident occurs among clinical waste handlers?	Needle prick injuries & bruises	Usually only first aid cases
4. Is there any inventory on waste quantity done prior to collection?	Yes	

Table 4.9, continued

5. What kind of clinical waste handling awareness programmes conducted for clinical waste collectors at hospital?	PPE training during induction	
6. How frequent the training are conducted and who conduct the training?	Only once during induction for new staffs	
7. How clinical waste from new disease outbreaks is handled?	Special briefing given prior to start collecting clinical waste at that particular wards	
8. How frequently needle prick injuries occur?	Seldom but occur sometimes	
9. How needle prick injuries are handled?	Immediately informed to superior and staff is sent to emergency department for cleaning and dressing on the injury. Blood test done to check if there is any infection. The blood test is done continuously once a month from 3 up to 6 months.	
10. How accident investigation is done	An accident investigation report is prepared by the supervisor attached with Doctor's checking verification and blood test results. All accident were reported to DOSH through NADOPOD on monthly basis.	

As for XXX Sdn Bhd staff, all clinical waste collectors are trained at the beginning of employment through induction training. The job hazards and importance of PPE usage is briefed during this induction. Often, special inductions are conducted for cleaners and clinical waste collectors on new disease outbreaks. Needle prick injuries are treated carefully through continuous blood test to ensure workers are free from any dangerous infections. Accident investigations are done by immediate supervisor with explanation from injured staffs. All accident reports were than analysed by the safety officer and reported to Department of Safety & Health through NADOPOD immediately and on yearly basis.

AAA Incineration Plant

During the survey at the incineration plant, a general observation has been conducted using workplace inspection checklist as an aid to collect actual data and independent information. Inspection was done by walking around the plant. Direct observation and interview with employees gave a better understanding of job tasks to determine the underlying causes of hazards. This helped to do better assessment of the risks to give effective recommendation for control measures. Generally, the inspection checklist covers potential workplace hazards missed during hazard identification at the plant.

The checklist contains sixteen parameters and the result of inspections is given as below. From the checklist, the site generally complies with occupational safety and health administration (OSHA) which requires safety signage and posters to be displayed at prominent locations of the worksite. The list of emergency contact numbers was also displayed at notice board for everyone's view.

Meanwhile, excess untreated clinical waste is stored at the cold room while treated waste ash is packed in jumbo bags and stored safely for disposal. However, summary of occupational illness were not displayed for employees information and employees are also not aware of heat cramp symptoms.

There were some faults discovered at the plant area. The emergency assembly point near the main access gate is considered not safe because it is too near to the plant. The chimney's height complies with regulations set by Department of Environment Malaysia. However, the dark smoke released through chimney can be noticed in the vicinity of the plant. Smoke is not dispersed far and accommodates the plant surroundings. This condition increased the risk of chemical hazard exposure to employees at the plant.

Table 4.10 : Worksite general inspection checklist (incineration plant)

Worksite general inspection	(X) Requires Action (O)Satisfactory			
	Y	N	Condition	Comments
1. Are posters on Occupational Safety and Health Administration (OSHA) displayed in a prominent location?	√		O	
2. Are appropriate safety signs/warnings posted at the prompt locations in plant?	√		O	
3. Does emergency contact numbers posted at the notice boards at the plant?	√		O	
4. Is a first aid kit available at the plant and been adequately stocked?	√		O	
5. Is the Summary of Occupational Illnesses posted on the notice board?		√	X	
6. Are emergency evacuation routes identified and informed to workers accordingly?	√		O	
7. Are the working areas clean and in order?	√		O	
8. Are combustible scrap, debris, and waste removed from work areas and stored promptly?	√		O	
9. Are toilets and washing facilities provided adequately?	√		O	
10. Are toilets and wash areas clean and sanitary?	√		O	
11. Are adequate illumination provided at work areas?	√		O	
12. Are resources provided to deal with very hot or cold conditions (drinking water, lined gloves, insulated boots)?	√		O	
13. Are work surfaces to assure the surfaces are slip resistant?	√		O	
14. Is ash from treated clinical waste prevented from entering or accumulation on or around electrical enclosures or equipment?	√		O	
15. Does wet work surfaces at washing area equipped with grips?	√		O	

Table 4.10, continued

16. Do workers aware of the symptoms of heat cramps, heatstroke and etc.?		√	X	Staff were not aware of the symptoms such as warm & dry skin, high fever, usually over 40° C), rapid heart rate, loss of appetite, nausea, Lethargy, Painful cramps especially in the legs, slushed moist skin

On job training is one of the main programmes conducted by the plant management. Every newly assigned staff is required to attend initial on job training which covers comprehensive review of the whole work process, hazards and risk associated with each job task, instructions to use PPE and emergency response guidance. However, employees are found to be not aware about 'right to refuse' procedures. The trainings are planned according to OSHA regulations. Employees are familiar with their job task and overall process of the plant. On job training is a good practice of safety management which helps to reduce accidents due to lack of knowledge and awareness among employees.

Table 4.11 : Training checklist

Training programmes	**(X) Requires Action (O)Satisfactory**			
	Y	**N**	**Condition**	**Comments**
1. Is training on job tasks and safety provided for new staffs on board?	√		O	
2. Does thorough review of hazards and accidents associated with the job included in the initial training?	√		O	
3. Is adequate training and instruction is given on the use of personal protective equipment?	√		O	
4. Is training for the use of emergency equipment provided? How frequent?	√		O	Annually
5. Are workers aware of the "Right to Refuse" procedures?		√	X	

Work process plays an important role to help in identifying potential hazards. There are three main parts of job task involved at the incineration plant: plant preparation stage, process stage and maintenance work.

These main stages of work are divided into specific job tasks. Various hazards are observed at each part of job tasks. Generally, the incineration plant is managed well with good safety practices. The hazards and associated risks are properly paced to keep at minimum level. All the process equipment is checked and maintenance is done frequently to ensure all machineries in good condition.

Table 4.12 : Work process checklist

Work process	**(X) Requires Action (O)Satisfactory**			
	Y	**N**	**Condition**	**Comments**
1. Are repetitive motion tasks properly paced and kept to a minimum?	√		O	
2. Do plant operators have the access to material safety data sheets?	√		O	
3. Are workers been informed with hazard signs and tags)?	√		O	
4. Have inspections and maintenance done on all trucks, forklifts and other equipment?	√		O	
5. Are lockout procedures available and been followed?	√		O	
6. Is ventilation equipment working effectively?	√		O	
7. Is fume and dust collection hood properly adjusted?	√		O	

Record keeping is well maintained at the incineration plant in accordance with OSHA requirements. The safety and health team are responsible to keep all relevant documents related to employee training, medical surveillance and accident records. The table below shows major record keeping items maintained at the study plant.

Table 4.13 : Record keeping checklist

Record keeping	(X) Requires Action (O)Satisfactory			
	Y	N	Condition	Comments
1. Are medical records of workers and the exposure records maintained as required?	√		O	
2. Are training records kept and maintained in accordance with OSHA requirements?	√		O	
3. Are employee records maintained for the required period of time?	√		O	
4. Are permits related to operations available and kept up-to-date?	√		O	
5. Is there any specific procedures and instructions to maintain records and logs? a. Safety inspections b. Safety meeting minutes c. Accident investigations d. Emergency response drills	√		O	

The incineration plant is prone for fire incidents due to its high temperature process. Thus, the plant management is aware of the high risk associated with fire occurrence. Therefore, fire emergency procedures are established at the plant in accordance to OSHA requirements. Fire drills are conducted on a regular basis to ensure all employees are familiar with established emergency response plans. However, it was noticed that fire response plan is kept only at the control room and not posted on notice boards for employee awareness. Suitable types of fire extinguishers are placed at all parts of the plant. All extinguishers are properly mounted and easily accessible by the employees.

Table 4.14 : Fire emergency procedures checklist

Fire emergency procedures	(X) Requires Action (O)Satisfactory			
	Y	N	Condition	Comments
1. Is the emergency response plan posted at each work area?		√	X	ERP kept in Control room
2. Do all workers know the plan?	√		O	
3. Are drills conducted on regular basis?	√		O	
4. Are fire extinguishers chosen based on type of fire most likely in that area?	√		O	
5. Are there enough extinguishers to use during emergencies?	√		O	
6. Are locations of extinguisher been marked conspicuously?	√		O	
7. Are extinguishers properly mounted and easily accessible?	√		O	
8. Are all extinguishers fully charged and operable?	√		O	

Emergency exit routes are important at the incineration plant. Both ground and first floor of the plant are equipped with enough exits to allow prompt escape during emergency situations. However, lack of emergency exit lights and signage were observed at the exit points. Emergency exit points are designed in accordance to OSHA regulations. During the inspection at site, it was noticed that some of the new employees are not aware of the emergency exit routes. The exits are not marked clearly and this can make the employees get trapped during emergency situations. Some emergency exits were also noticed to be not accessible without keys. Table below show details on means of exit identified at the study plant.

Table 4.15 : Means of exit checklist

Means of exit	(X) Requires Action (O)Satisfactory			
	Y	N	Condition	Comments
1. Are there appropriate exits to allow prompt escape?	√		O	
2. Do employees easily accessible to the exits?	√		O	
3. Are the exits unlocked to allow egress?		√	X	
4. Are all exits been marked clearly?		√	X	
5. Are exits and exit routes equipped with emergency lighting?		√	X	
6. Are doors that are required to serve as exits designed and constructed so that the way of exit travel is obvious and direct?	√		O	
7. Does exit doors could be open from the direction of exit travel without the use of key or any special knowledge or effort, if the building is occupied?		√	X	

OSHA Standards for Workplace Lighting indicates that poor workplace lighting may result in accidents. Poor lighting also has the potential to cause eye strain and severe headaches. Factors such as working environment, scope of work, day and night lighting requirements and reflection or glare of lights should be considered by the employers. The study area was evaluated for hazardous situation and associated risk to identify areas where extra lighting is required.

Emergency lighting is mandatory requirement stated in OSHA regulations which is inspected regularly to ensure the functionality. Emergency light assist to exit workplace during emergency situations. These lights will turn on during power outage. Emergency exits should have lighted exit signs to ensure clear visibility and provide to safe exit during emergency situations.

According to above mentioned requirements, the lighting facilities at the incineration plant was found to be sufficient and at satisfactory level for work performance. The emergency lights were adequate and regularly tested. The emergency lights will come on automatically by an external power source upon loss of electricity.

Table 4.16 : Lighting checklist

Lighting availability	**(X) Requires Action (O)Satisfactory**			
	Y	**N**	**Condition**	**Comments**
1. Does lighting produce glare on work surfaces?		√	O	
2. Is the lighting provided adequate for safe and comfortable to performance any work?	√		O	
3. Is emergency lighting adequate and been tested regularly?	√		O	
4. Does the emergency lighting activate automatically with an independent power source when normal lighting fails?	√		O	

Table below shows machine guards at the incineration plant are in proper condition and all dangerous machine parts were guarded accordingly. The machine guards are installed for fans, scrubbers and waste tipping lifter. Electronic safety devices, barrier guards and two-hand tripping devices are some examples of guarding methods.

Table 4.17 : Machine guards checklist

Machine guards	**(X) Requires Action (O)Satisfactory**			
	Y	**N**	**Condition**	**Comments**
1. Are all the dangerous machine parts guarded adequately?	√		O	
2. Does the machine guards meet required standards?	√		O	
3. Are lockout procedures practiced when performing maintenance without the guards?	√		O	

All tools and machineries at the incineration plant are designed and kept well maintained; any defective tools are removed and tagged for service as a part of maintenance programme. Most of the tools and machineries at the plant are used during maintenance works. All employees are familiar with these tools and machineries at the plant. The management shows satisfactory with guarding, tools and machinery usage through proper maintenance. No accident records from these sources as well. Table below shows result of tools and machinery checklist

Table 4.18 : Tools and machinery checklist

Tools and machinery	**(X) Requires Action (O)Satisfactory**			
	Y	**N**	**Condition**	**Comments**
1. Are manufacturers manuals for all tools and machinery kept at the plant for reference purposes?	√		O	
2. Do power tools comply with standards?	√		O	
3. Are tools properly designed for the use of employees?	√		O	
4. Are defective tools tagged and removed from the working area?	√		O	
5. Are tools and machineries used accordingly in proper manner to avoid electrical hazards?	√		O	
6. Is proper training on the safe use of tools and machinery been provided?		√	O	

In this study area, the confine spaces identified as the primary and secondary burner. Workers are required to enter these burners during maintenance work only. According to the survey done, adequate ventilation is available in the confined space. The air inside the burner is tested and repeatedly monitored during maintenance works. OSHA indoor air quality standard is followed to ensure confine space ventilation.

Table 4.19 : Confined space checklist

Confined spaces	(X) Requires Action (O)Satisfactory			
	Y	N	Condition	Comments
1. Are entry and exit guidelines adequately available?	√		O	
2. Are emergency response procedures in place?	√		O	
3. Is adequate ventilation is assured prior to and during confined space entry?	√		O	
4. Is atmosphere inside the confine space tested and monitored frequently during work? How?	√		O	Gas tester
5. Is adequate illumination is ensured in confined spaces?	√		O	
6. Is appropriate and approved respiratory equipment provided if the atmosphere inside the confined space not acceptable?	√		O	
7. Does an assigned safety standby employee available outside the confined space, who is solely responsible to watch the work in progress, sound emergency alarm if necessary, and render assistance?	√		O	
8. Is the confined space checked for possible untreated leftover of clinical waste, which could contain sharp properties? What is the precautionary action taken?		√	X	

Housekeeping at the incineration plant is adequate and within the acceptable level. The survey shows all work areas are clean and clear from any obstructions for movement.

Oil spills that occur occasionally are cleared immediately to avoid slippery surface. The housekeeping at the cold room is also maintained in good condition through daily cleaning. Sometimes, housekeeping works also creates slip and fall hazard, however no major injuries have been reported previously. Inadequate housekeeping is observed at the ash collection and packing area due to high debris and dust.

Table 4.20 : Housekeeping checklist

HOUSEKEEPING	(X) Requires Action (O)Satisfactory			
	Y	N	Condition	Comments
1. Does the work area clean and orderly?	√		O	
2. Are floors free from ash dust?	√		O	
3. Are aisles and passageways kept clear of obstructions?	√		O	
4. Are permanent aisles and passageways marked clearly?	√		O	
5. Are open pits, tanks and ditches placed with covers or guardrails?	√		O	
6. Are tools, raw materials, parts and products provided with appropriate and convenient storage racks?	√		O	
7. Are oil spills promptly cleaned up or removed to avoid any slips, trips and falls hazards	√		O	

Noise or sound level at the incineration plant is one of the important parameter to be monitored. The records show that employees are exposed to noise below 85dBA in compliance with OSHA standard requirements. Workers at particular areas where continuous noise level approximately reached 85dB or greater, are provided with hearing protective equipment. Annually, periodic audiometric testing is done for all the employees to ensure effective hearing protection.

Table 4.21 : Sound/ noise level checklist

Sound level / noise	(X) Requires Action (O)Satisfactory			
	Y	N	Condition	Comments
1. Are noise levels in the plant being measured using a sound level meter? Does the records being kept?	√		O	
2. Is noisy machinery isolated from the rest of the operation?	√		O	
3. Have engineering controls used to reduce excessive noise levels?	√		O	
4. Where engineering controls are determined not feasible, do administrative controls such as worker rotation been implemented to minimize individual employee exposure to noise?	√		O	
5. Is there a preventive health program to educate employees in safe levels of noise exposure, effects of noise to health and importance on usage of appropriate personal protective equipment?	√		O	
6. Are working areas with high noise level make the voice communication between employees difficult?		√	O	
7. Is approved hearing protective equipment (ex: ear plugs) available to every employee working in areas where continuous noise levels exceed 85 dBA?	√		O	
8. Does proper guidance given to the workers on the proper use and care of ear protectors?	√		O	
9. Is periodic audiometric testing conducted for employees exposed to continuous noise above 85 dBA to ensure an effective hearing protection system in place for the employees?	√		O	During annual medical surveillance
10. Is there any protection given against the effects of occupational noise exposure when sound levels exceed OSHA noise standard?	√		O	

From the observation at site, it was noticed that all employee facilities are kept clean and sanitary was in a good condition. Employees resting area is isolated from chemicals and any hazardous materials or tools.

Table 4.22 : Employee facilities checklist

Employee facilities	(X) Requires Action (O)Satisfactory			
	Y	N	Condition	Comments
1. Are cleaning and sanitary of facilities being maintained accordingly?	√		O	
2. Are facilities in good condition?	√		O	
3. Are cafeteria facilities provided away from toxic chemicals?		√	O	Not applicable

PPE (Personal Protection Equipmwnt) usage at the incineration plant had been made mandatory. Warning signs to remind the usage of PPE are displayed clearly. The utilization of PPE by the employees was monitored by the safety officer. However during observation, it was noticed that some lorry drivers who entered the plant site to deliver clinical waste or collect the ash for disposal were not wearing appropriate PPE.

Table 4.23 : Personal protective equipment checklist

Personal protective equipment	(X) Requires Action (O)Satisfactory			
	Y	N	Condition	Comments
1. Is required personal protective equipment provided, maintained and used accordingly?	√		O	
2. Does the equipment used reliable and meet the OSHA requirements?	√		O	
3. Are protective gloves, aprons, shields, or other means provided?	√		O	
4. Are safety helmets provided and being utilized where danger of falling objects exists	√		O	
5. Is appropriate foot protection provided to reduce the risk of foot injuries from hot, corrosive, poisonous substances, falling objects, crushing or penetrating of sharp objects?	√		O	Safety boots are wore by all the employees while at plant area
6. Are approved and appropriate respirators provided for regular or emergency use where needed?	√		O	

Table 4.23, continued

7. Is all protective equipment maintained in a sanitary condition and ready for use?	√		O	
8. Is the protective equipment checked regularly to ensure its usage and safety conditions? Is replace accordingly and frequently?	√		O	
9. Is the special equipment needed for those working in cold room available?	√		O	
10. When lunches are eaten on the premises, are they eaten in areas where there is no exposure to toxic materials or other health hazards?		√	O	Not allowed to eat in operation premise
11. Are hazardous areas equipped with appropriate warning signs?	√		O	
12. Is the overall used by the operators washed daily?	√		O	

Table 4.24 : PPE usage at site

Photos of PPE	Task	PPE
	Cleaning bins, cold room, wet zone and clearing major spillage	• Reinforced rubber type gloves • Safety helmet with visor • Mask with filter • Coverall • Wellington boots • Apron
	Working inside heat exchanger and incinerator	• Mask (filter cartridge) • Safety boots • Safety helmet • Coverall • Reinforced rubber type gloves
	• Working at dry zone • Cleaning rotary contractor • Cleaning quench spray nozzle • Working with bottom ash • Maintenance	• Mask (filter cartridge) • Safety boots • Safety helmet • Coverall • Reinforced rubber type gloves

Table 4.24, continued

	Loading bay and production area	• Coverall • Reinforced rubber type gloves • Mask • Safety boots
	Visitor during plant visit	• Safety helmet • Safety boots • Mask
	Forklift operator	• Safety boots • Safety helmets • Gloves(depends on activity to be done) • Mask (depend on area to be enter)

Table 4.24, continued

	• Charging lime and carbon. • Handling the ash	• Mask (filter cartridge) • Safety boots • Safety helmet • Coverall • Reinforced rubber type gloves • Apron • Google
	Working with caustic chemical	• Mask with filter • Wellington boots • Safety helmet • Coverall • Reinforced rubber type gloves(chemical resistance) • Apron & Google
	Inside ducting and confine space	• Safety helmet • Breathing apparatus • Coverall • Reinforced rubber type gloves • Safety boots • Protective suit with hood (barrier-man)

Table 4.24, continued

	Clinical waste spillage	• Safety helmet with visor • Mask with filter • Apron(barrier wet cloth) • Coverall • Wellington boots • Reinforced rubber type gloves

4.1.3 Accident investigation

Based on the review on accident records, few needle prick injuries have been registered from 2002 to 2013 at hospitals in Perak involving XXX Sdn Bhd staff .

Table 4.25 : Number of needle prick injuries in Perak 2002- September 2013

Hospital/state	Cleaner	Clinical waste collectors	Laundry workers	Transporter	Total
HRPB	13	3	0	0	15
Ulu Kinta	0	0	0	0	0
Kampar	2	0	0	0	2
Batu gajah	2	1	0	0	3
Sungai siput	2	1	0	0	3
Teluk intan	3	3	1	0	7
Changkat Melintang	1	0	0	0	1
Tapah	1	0	0	0	1
Slim river	1	2	0	0	3
Seri manjung	3	0	0	0	3
Taiping	7	3	1	0	11
Kuala Kangsar	4	1	0	0	5
Gerik	0	1	0	0	1
Parit buntar	1	0	0	0	1
Selama	1	0	0	0	1
Makmal Jelapang	0	0	0	0	0
Kamunting plant	0	0	1	1	2
Total	**41**	**15**	**3**	**1**	**60**

(Source: XXX Sdn Bhd , 2014)

The needle prick injuries involve the clinical waste collectors, cleaners, laundry workers and clinical waste transporters. The data shows a total of 15 needle prick injuries occurred at Hospital Raja Permaisuri Bainun, Ipoh.

This involved the cleaners and clinical waste collectors. In general, cleaners and clinical waste collectors are prone to be injured by needle pricks. Regarding the study conducted at the incineration plant, there were no accidents recorded. According to the interview with the plant manager and some employees at the plant, there were few minor accidents such as slip and fall and minor needle prick happened before in the plant. However, these accidents were not reported accordingly to the safety committee. This may be due to lack of awareness on seriousness and importance of reporting accidents among the employees as well as lack of management commitment to notice this.

4.2 Hazard classification and risk assessment

Hazard classification was done through job hazard analysis to identify the category and class of hazards. This was followed by quantitative risk assessment using a standard scale.

4.2.1 Job hazard analysis (JHA)

Job hazard analysis is one of the methods used for hazard identification at workplace.
In this study, JHA was conducted at a hospital on job task involving the clinical waste collectors and at the incineration plant by dividing the job task into three main parts as follows: Plant preparation, process and maintenance. These parts were then broken into specific job task to identify the hazards. Hazards were classified into two main groups as safety hazard and health hazard.

Those hazards were then classified into types of hazard as follows: physical, chemical, mechanical, biological, ergonomic, psychological and electrical.

Clinical waste collection from wards, clinics and operation theatres are carried out every day. The cleaning and washing of clinical waste collection trolley and cold room were done once a week on every Saturday.

The clinical waste collection bins at wards and clinics were not washed routinely unless if there is any spillage because it is always covered with yellow bags. However, the supervisors regularly check the clinical waste bins in wards and clinics to ensure the cleanliness.

Table 4.26 : Job hazard analysis for clinical waste collection and disposal activities

Clinical waste collection and disposal at hospital					
Job task	**Type of hazard**	**Hazard classification**	**Hazard cause**	**Consequence**	**Existing (E)/ Potential (P)**
Clinical waste collection from wards and clinics	Safety	Physical	Spillage of clinical waste	Bodily injury through needle pricks	P
	Health	Biological	Spillage of clinical waste	Infection through needle prick injury	E
		Chemical	Spillage of chemicals	Inhalation and direct contact	E
Waste movement to storage area	Health	Biological	Exposed to bacteria and virus	Inhalation and direct contact	E
		Ergonomic	Unnatural movement	Could result in musculoskeletal disorders	E
Load waste into lorry	Safety	Mechanical	Impact by bin	Bodily injury	P
		Biological	Expose to waste	Bacterial and viral infection	E
Cleaning and washing of cold room	Safety	Physical	Slip and fall	Bodily injury	P
	Health	Biological	Expose to bacteria and virus infection	Could lead to infectious disease	P

Table 4.26, continued

Cleaning and washing of waste collection trolley	Safety	Mechanical	Entanglement (pressure water)	Could result in musculoskeletal disorders	P

Plant preparation activities are carried out prior to incineration process. Incineration process at the study plant is operated 24 hours 7 days basis. The operation is stopped once a week for maintenance purpose. Plant preparation activities are done before every start up. However, activities such as waste tipping, waste movement to storage area, bin washing, jet spray usage and load bin in and out of lorry are routine plant preparation work carry out on daily basis.

Table 4.27 : Job hazard analysis for plant preparation activity

Plant preparation					
Job task	**Type of hazard**	**Hazard classification**	**Hazard cause**	**Consequences**	**Existing (E)/ Potential (P)**
Preparation of diesel, dettol pine, carbon, Clorox, hydraulic oil, fuel	Safety	Physical	Spillage cause floor become slippery	Slip and fall	P
	Health	Chemical	Expose to chemical extensively	Inhalation	E
		Physiological	Prepare continuously in large quantity	Ingestion	E
Hydraulic system preparation	Safety	Physical	Slip and fall	Slip and fall	P
	Health	Chemical	Expose to chemical extensively	Inhalation	E
		Ergonomic	Unnatural movement	Could result in musculoskeletal disorders	E

Table 4.27, continued

LPG gas preparation	Safety	Mechanical	Impact by cylinder	Bodily injury	P
		Ergonomic	Unnatural movement	Could result in musculoskeletal disorders	E
Lime preparation	Safety	Mechanical	Stabbing by forklift	Bodily injury	P
			Impact by lime bag	Bodily injury	P
	Health	Chemical	Exposure to lime during handling and preparation	Inhalation	E
		Ergonomic	Unnatural movement	Could result in musculoskeletal disorders	E
Bin washing	Safety	Physical	Slip and fall	Slip and fall	P
		Mechanical	Entanglement (pressure water)	Could result in musculoskeletal disorders	P
Jet spray usage	Safety	Mechanical	Entanglement and impact by nozzle	Could result in musculoskeletal disorders	P
		Physical	Vibration	Could result in musculoskeletal disorders	P
Load bin into and out of lorry	Safety	Physical	Slip and fall	Slip and fall	P
		Mechanical	Impact by bin	Bodily injury	P
	Health	Biological	Expose to waste	Bacterial and viral infection	P

After plant start-up, the incineration process involves waste burning followed by collection of ash through ash conveyer. The ash is then transfered into jumbo bags to be disposed to landfill. Monitoring is carried out throughout the process to ensure the process is on par with all the settings. Monitoring of the process is normally done by either by technicians or engineers at the plant.

Table 4.28 : Job hazard analysis for incineration process

Incineration process					
Job task	**Type of hazard**	**Hazard classification**	**Hazard cause**	**Consequence**	**Existing (E)/ Potential (P)**
Waste burning and incineration process	Safety	Physical	Expose to thermal (fire) with high temperature	Bodily injury	P
			Expose to noise	Could lead to reduction in hearing capacity	P
	Health	Chemical	Expose to extensive smoke	Inhalation and ingestion could results in lung infection	E
			Chances for occurrence of fire and explosion	Fatality and disability	P
Plant monitoring during process	Safety	Physical	Expose to thermal (fire)of high temperature	Bodily injury	P
	Health	Chemical	Expose to smoke	Could lead to lung infection	P
Ash conveyer	Safety	Biological	Expose to sharp item in the ash	Bodily injury	E

Table 4.28, continued

Ash conveyer	Health	Chemical	Contact, ingestion and inhalation of dust	Could lead to lung infection	P
House-keeping	Safety	Biological	Expose to bacteria and virus infection	Could lead to infectious disease	P

The below table shows the maintenance works which is carry out on a non-routine basis. Maintenance works were carried out on weekly, monthly, quarterly, half yearly or yearly basis. Trained maintenance technicians are appointed for these job tasks.

Table 4.29 : Job hazard analysis for maintenance works

Maintenance works					
Job task	**Type of hazard**	**Hazard classification**	**Hazard cause**	**Consequence**	**Existing(E)/ Potential(P)**
Compressor system	Safety	Physical	Thermal at confine space	Bodily injury	P
		Mechanical	Entanglement by belt	Bodily injury	P
	Health	Chemical	Contact with oil	Could lead to skin disease or irritation	P
Fan system	Safety	Physical	Noise and vibration	Could lead to reduction in hearing capacity	P
		Electrical	Electric static	Disability or death	P
	Health	Ergonomic	Vibration	Could lead to musculoskeletal disease	E
Hydraulic system	Safety	Physical	Slip or Shearing	Bodily injury	P
		Mechanical	Stabbing or impact by motor	Bodily injury	P
		Electrical	Electric static	Disability or death	P

Table 4.29, continued

	Health	Chemical	Ingestion	Could lead to lung infection	P
Water tank system	Safety	Physical	Thermal, Fall, Pressure	Heat could cause bodily injury or heat cramps	E
	Health	Ergonomic	Unnatural movement	Could lead to musculoskeletal disease	E
Air receiver	Safety	Physical	Noise	Could lead to reduction in hearing capacity	P
		Mechanical	Impact on body	Bodily injury	P
Air dryer unit	Safety	Physical	Noise	Could lead to reduction in hearing capacity	P
		Electric	Shock	Disability or death	P
	Health	Ergonomic	Unnatural movement	Could lead to musculoskeletal disease	E
Fire seal door	Safety	Physical	Slip and fall	Bodily injury	PP
		Mechanical	Shearing, impact or Ejection	Could lead to bodily injury	P
		Physical	Expose to heat	Could lead to bodily injury	E
Loader ram	Safety	Physical	Impact	Could lead to bodily injury	P
Bin tippler	Safety	Mechanical	Impact	Could lead to bodily injury	P
Ash pusher	Safety	Physical	Noise	Could lead to reduction in hearing capacity	P
			Slip and fall	Bodily injury	P
			Thermal pressure and heat	Could lead to heat injury or heat cramp	P
		Mechanical	Cutting (scratch)	Could lead to bodily injury	P
	Health	Biological	Expose to sharp needles	Bodily injury	E

Table 4.29, continued

Air holes	Safety	Physical	Thermal pressure	Could lead to heat injury	P
Rod of spike	Safety	Mechanical	Stabbing or cutting	Could lead to bodily injury	P
Isolation damper	Safety	Mechanical	Impact	Could lead to bodily injury	P
	Health	Ergonomic	Unnatural movement	Could lead to musculoskeletal disease	E
Bypass stack /damper	Safety	Physical	Noise	Could lead to bodily injury	P
	Health	Chemical	Contact with grease	Could lead to skin irritation	P
Secondary burner	Safety	Thermal	Expose to heat	Could lead to heat injury or heat cramp	P
		Electric	Electric static	Disability or fatality	P
Cutting using gas	Safety	Physical	Thermal flash on eyes and expose to high temperature	Could lead to heat injury or heat cramp	P
	Health	Chemical	Inhalation	Disability or fatality	P

4.2.2 Risk assessment

Safety committee plays a vital role to ensure safety and health of the employees and the safety of whole process in every aspect related to the working environment. The safety committee of XXX Sdn Bhd at Hopsital Raja Permaisuri Bainun, Ipoh comprise of representatives from all support service divisions including clinical waste collection division.

While the incineration plant, had established a safety committee consist of representatives from management, engineers and plant operators as well. Risk assessment is used as the main parameter to assess the risk associated with each part of the work process. Risk assessment helps to determine better control measures to reduce the associated risks and act as preventive measure to control the hazards.

Risk matrix ranking

Risk matrix ranking is one of the common tools used for risk assessment in various industries. It includes likelihood, consequences and severity axis. The combination of these parameters gives an estimate of risk or risk ranking. Based on previous studies, basic information of hazards and its consequences is needed to estimate the risk ranking. Therefore, after thorough observation, data collected and analysed through Hazard Identification, Risk Assessment and Risk Control (HIRARC) framework. Associated risks and mitigation measures were evaluated. Table below shows the result of HIRARC at the surveyed and studied hospital and an incineration plant. The highest level of risk rating found was 20.

Table 4.25 : Risk assessment on clinical waste collection and disposal at Hospital Raja Permaisuri Bainun,Ipoh

Process	Type of hazard	Hazard classification	Hazard	Consequences	Likelihood	Severity	Risk	Current Control measures
Clinical waste collection from wards and clinics	Safety	Physical	Spillage of clinical waste	Bodily injury through needle pricks	4	2	8 (M)	Nil
	Health	Biological	Spillage of clinical waste	Infection through needle prick injury	4	4	16 (H)	Nil
		Chemical	Spillage of chemicals	Inhalation and direct contact	3	2	6 (M)	• Mask with filter • Reinforced rubber type glove
Waste movement to storage area	Health	Biological	Exposed to bacteria and virus	Inhalation and direct contact	5	4	20 (H)	Mask with filter
		Ergonomic	Unnatural movement	Could result in musculoskeletal disorders	3	2	6 (M)	NIL
Load waste into lorry	Safety	Mechanical	Impact by bin	Bodily injury	3	2	6 (M)	NIL
	Health	Biological	Expose to waste	Bacterial and viral infection	5	4	20 (H)	PPE consist 3 ply face mask, rubber glove, apron

Table 4.30, continued

Cleaning and washing of cold room	Safety	Physical	Slip and fall	Bodily injury	3	2	6 (M)	• Wellington boots • Coverall with apron • Mask with filter • Reinforced rubber type glove
	Health	Biological	Expose to bacteria and virus infection	Could lead to infectious disease	5	4	20 (H)	PPE consist of 3 ply face mask, rubber glove and apron
Cleaning and washing of waste collection trolley	Safety	Mechanical	Entanglement (pressure water)	Could result in musculoskeletal disorders	3	2	6 (M)	NIL

Table 4.26 : Risk assessment at AAA incineration plant for plant preparation

Process	Type of hazard	Hazard classification	Hazard	Consequences	Likelihood	Severity	Risk	Current Control measures
Preparation of diesel, Dettol pine, carbon, Clorox, fuel	Safety	Physical	Spillage cause floor become slippery	Slip and fall	4	1	4 (L)	Continuous housekeeping to clear any spillage immediately
	Health	Chemical	Expose to chemical extensively	Inhalation	4	3	12 (M)	• Mask with filter
			Expose to chemical extensively	Contact	5	3	15 (H)	• Google • Reinforced rubber type gloves chemical resistance • Wellington boot • Safety helmet and coverall • Apron
		Physiological	Prepare continuously in large quantity	Stress	5	1	5 (M)	Nil

Table 4.31, continued

Hydraulic system preparation	Safety	Physical	Slip and fall	Bodily injury	4	1	4 (L)	Continuous house keeping
	Health	Chemical	Expose to chemical extensively	Inhalation	5	3	15 (H)	• Mask with filter
			Expose to chemical extensively	Ingestion	4	3	12 (M)	• Mask with filter
		Ergonomic	Unnatural movement	Could result in musculoskeletal disorders	4	1	4 (L)	Nil
LPG gas preparation	Safety	Mechanical	Impact by cylinder	Bodily injury	4	2	8 (M)	Nil
	Health	Ergonomic	Unnatural movement	Could result in musculoskeletal disorders	4	1	4 (L)	Nil

Table 4.31, continued

Lime preparation	Safety	Mechanical	Stabbing by forklift Or impact by lime bag	Bodily injury	3	2	6 (M)	Nil
	Health	Chemical	Exposure to lime during handling and preparation	Contact	4	1	4 (L)	• Google • Reinforced rubber type gloves chemical resistance • Wellington boots • Safety helmet and coverall • Apron
			Exposure to lime during handling and preparation	Inhalation	4	3	12 (M)	• Mask with filter
		Ergonomic	Unnatural movement	Could result in musculoskeletal disorders	3	1	3 (L)	Nil

Table 4.27 : Risk assessment at AAA incineration plant for incineration process

Process	Type of hazard	Hazard classification	Hazard	Consequences	Likelihood	Severity	Risk	Current Control measures
Waste tipping	Safety	Mechanical	Impact by bin and impact through friction	Bodily injury	3	2	6 (M)	• Reinforced rubber type glove • Mask • Safety boots
	Health	Ergonomic	Repeated exposure	Could result in musculoskeletal disorders	4	1	4 (L)	Nil
Waste movement to cold room	Health	Biological	Exposed to bacteria and virus	Infection of dangerous bacteria and virus	5	3	15 (H)	• Reinforced rubber type glove • Mask with filter • Coverall & apron • Wellington boots

Table 4.32, continued

Bin washing	Safety	Physical	Slip and fall	Bodily injury	4	1	4 (L)	• Safety helmet with visor • Wellington boots • Coverall with apron • Mask with filter • Reinforced rubber type glove
Jet spray usage	Safety	Physical	Vibration	Could result in musculoskeletal disorders	3	1	3 (L)	Nil
		Mechanical	Entanglement (pressure water)	Could result in musculoskeletal disorders	4	1	4 (L)	Nil
			Impact by bin	Bodily injury	3	2	6 (M)	Nil
Load bin into and out of lorry	Safety	Physical	Slip and fall	Bodily injury	3	1	3 (L)	Safety boots
		Mechanical	Impact by bin	Bodily injury	3	2	6 (M)	Nil

Table 4.32, continued

Load bin into and out of lorry	Health	Biological	Expose to waste	Bacterial and viral infection	5	3	15 (H)	• Reinforced rubber type glove • Mask with filter • coverall
Waste burning and incineration process	Safety	Physical	Expose to thermal (fire)with high temperature	Bodily injury	3	2	6 (M)	• Coverall
			Expose to noise	Could lead to reduction in hearing capacity	3	3	9 (M)	Nil
			Chances for occurrence of fire and explosion	Fatality and disability	3	5	15 (H)	• Fire extinguishers • Fire hydrant
	Health	Chemical	Expose to extensive smoke	Inhalation and ingestion could results in lung infection	5	3	15 (H)	• Mask with filter cartridge

Table 4.32,continued

Plant monitoring during process	Safety	Physical	Expose to thermal (fire) of high temperature	Bodily injury	3	2	6 (M)	• Coverall
	Health	Chemical	Expose to smoke	Could lead to lung infection	5	3	15 (H)	• Mask with filter
Housekeeping	Health	Biological	Expose to bacteria and virus infection	Could lead to infectious disease	5	3	15 (H)	• Reinforced rubber type glove • Mask with filter • Coverall

Table 4.28 : Risk assessment at AAA incineration plant for maintenance activity

Process	Type of hazard	Hazard classification	Hazard	Consequences	Likelihood	Severity	Risk	Current Control measures
Compressor system	Safety	Physical	Thermal at confine space	Bodily injury	3	2	6 (M)	• Breathing apparatus • Protective suit with hood (barrier man)
		Mechanical	Entanglement by belt	Bodily injury	3	2	6 (M)	• Safety helmet • Safety boot
	Health	Chemical	Contact with oil	Could lead to skin disease or irritation	4	2	8 (M)	• Coverall • Reinforced rubber type glove
Fan system	Safety	Physical	Noise and vibration	Could lead to reduction in hearing capacity	3	3	9 (M)	Nil
		Electrical	Electric static	Disability or death	4	5	20 (H)	• Machine guards install
	Health	Ergonomic	Vibration	Could lead to musculoskeletal disease	3	1	3 (L)	Nil

Table 4.33, continued

Hydraulic system	Safety	Physical	Slip or shearing	Bodily injury	3	1	3 (L)	• Safety helmet
		Mechanical	Stabbing or Impact by motor	Bodily injury	3	2	6 (M)	Nil
		Electrical	Electric static	Disability or death	3	5	15 (H)	Nil
	Health	Chemical	Ingestion	Could lead to lung infection	3	3	9 (M)	• Mask with filter
Water tank system	Safety	Physical	Thermal pressure	Heat could cause bodily injury or heat cramps	4	2	8 (M)	• Cover all
	Health	Ergonomic	Unnatural movement	Could lead to musculoskeletal disease	3	1	3 (L)	Nil
Air receiver	Safety	Physical	Noise	Could lead to reduction in hearing capacity	3	3	9 (M)	Nil
		Mechanical	Impact on body	Bodily injury	3	2	6 (M)	Nil
Air dryer unit	Safety	Physical	Noise Slip	Could lead to reduction in hearing capacity	3	3	9 (M)	Nil
		Electrical	Shock	Disability or death	3	5	15 (H)	Nil

Table 4.33 continued

Air dryer unit	Health	Ergonomic	Unnatural movement	Could lead to musculoskeletal disease	3	1	3 (L)	Nil
Grease trap	Safety	Physical	Slip and fall	Bodily injury	4	1	4 (M)	• Safety boots • Continuous housekeeping upon spillage
		Mechanical	Impact crush or entanglement due to pump	Bodily injury or could lead to musculoskeletal disease	3	2	6 (M)	
	Health	Chemical	Contact with grease	Skin irritation or skin disease	5	2	10 (M)	• Coverall • Reinforced rubber type gloves
Sump tank	Safety	Physical	Slip and fall	Could lead to bodily injury	4	1	4 (L)	• Safety boots
Primary zone	Safety	Physical	Thermal and Pressure at confine space	Could lead to bodily injury	3	2	6 (M)	• Breathing apparatus • Protective suit with hood (barrier man)
			Slip and fall	Could lead to bodily injury	4	1	4 (L)	• Safety boots

Table 4.33, continued

Primary zone	Health	Chemical	Contact and inhalation of dust	Could lead to lung infection	5	3	15 (H)	• Mask with filter cartridge
Ash conveyer	Health	Biological	Exposed to sharp items in the ash	Bodily injury or could cause infectious disease	4	2	8 (M)	• Coverall • Reinforced rubber type glove • Apron
		Chemical	Contact, ingestion and inhalation of dust	Could lead to lung infection or skin related diseases	5	3	15 (H)	• Mask with filter • Reinforced rubber type glove • Mask with filter • Google
Fire seal door	Safety	Physical	Slip and fall	Could lead to bodily injury	4	1	4 (L)	• Safety boots
			Expose to heat	Could lead to bodily injury or heat cramp	4	2	8 (M)	• Coverall • Reinforced rubber type glove

Table 4.33, continued

Fire seal door	Safety	Mechanical	Shearing, impact or Ejection	Could lead to bodily injury	3	2	6 (M)	• Safety boots • Safety helmet
Ash pusher	Safety	Physical	Noise	Could lead to reduction in hearing capacity	3	3	9 (M)	Nil
			Slip and fall	Bodily injury	4	1	4 (L)	• Safety boots
			Thermal Pressure and heat	Could lead to heat injury or heat cramp	4	2	8 (M)	• Coverall • reinforced rubber type glove
		Mechanical	Cutting (scratch)	Could lead to bodily injury	5	2	10 (M)	• reinforced rubber type glove
	Health	Biological	Expose to sharp needles	Bodily injury	5	1	5 (M)	• Coverall and apron • Reinforced rubber type glove
Loader ram	Safety	Physical	Impact	Could lead to bodily injury	3	2	6 (M)	• safety boots

Table 4.33, continued

Bin tippler	Safety	Mechanical	Impact	Could lead to bodily injury	3	2	6 (M)	• safety boots
Air holes	Safety	Physical	Thermal Pressure	Could lead to heat injury	4	1	4 (L)	• coverall • reinforced rubber type glove • goggle
Rod of spike	Safety	Mechanical	Stabbing or cutting	Could lead to bodily injury	3	2	6 (M)	• Safety helmet
Isolation damper	Safety	Mechanical	Impact	Could lead to bodily injury	3	2	6 (M)	• Safety boots
	Health	Ergonomic	Unnatural movement	Could lead to musculoskeletal disease	3	1	3 (L)	Nil
Hopper lid	Safety	Physical	Slip and fall	Could lead to bodily injury	4	1	4 (L)	• Safety boots
	Health	Ergonomic	Unnatural movement	Could lead to musculoskeletal disease	3	1	3 (L)	Nil
Secondary zone	Safety	Physical	Thermal and Pressure at confine space	Could lead to bodily injury	4	2	8 (M)	• Breathing apparatus • Protective suit with hood (barrier man)

Table 4.33, continued

Secondary zone	Safety	Physical	Slip and fall	Could lead to bodily injury	4	1	4 (L)	• Safety boots
	Health	Chemical	Contact and inhalation of dust	Could lead to lung infection	5	3	15 (H)	• Breathing apparatus
Bypass stack /damper	Safety	Physical	Noise	Could lead to reduction in hearing capacity	3	3	9 (M)	Nil
	Health	Chemical	Contact with grease	Could lead to skin irritation	4	1	4 (L)	• Coverall • Reinforced rubber type glove
Secondary burner	Safety	Physical	Expose to heat	Could lead to heat injury or heat cramp	4	2	8 (M)	• Protective suit with hood (barrier man) • Reinforced rubber type glove • Safety helmet • Google • Breathing apparatus

Table 4.33, continued

Secondary burner	Safety	Electrical	Electric static	Disability or fatality	3	5	15 (H)	• Safety boots • Safety helmet
Cutting using gas	Safety	Physical	Thermal flash on eyes and expose to high temperature	Bodily injury or disability	3	2	6 (M)	• Safety boots • Safety helmet • Goggle
	Health	Chemical	Inhalation	Could lead to lung diseases	5	3	15 (H)	• Mask with filter • Google

Risk assessment on clinical waste collection and disposal at Hospital Raja Permaisuri Bainun, Ipoh

A total of Ten (10) hazards focusing on clinical waste collectors exist during clinical waste collection and disposal activities at the hospital. The hazards were identified through observations, inspections, interviews, job hazard analysis and accident analysis. Risk assessment methodology was used to classify the hazards into three categories as low, medium and high. The risk assessment results are shown in the figure below.

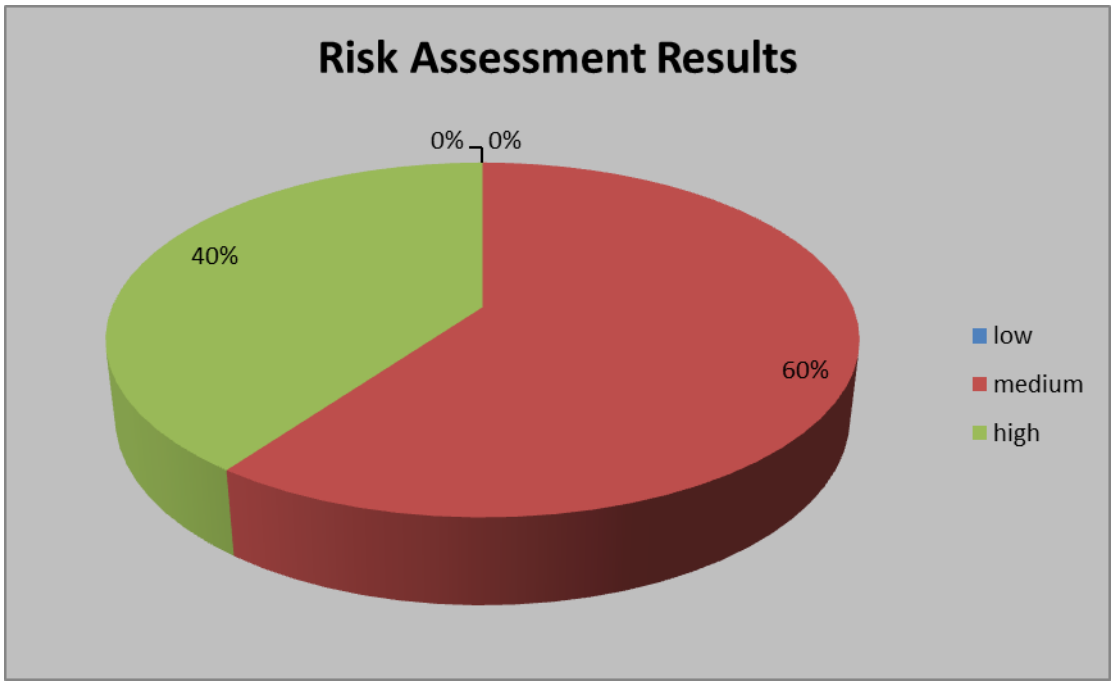


Figure 4.8 : Risk assessment results for Hospital Raja Permaisuri Bainun, Ipoh

Out of 10 hazards identified during the clinical waste collection and disposal work activity, two was existing hazard and another 8 was potential hazards. These hazards were categorized into safety and health hazard comprise of biological, chemical, physical, mechanical and ergonomic hazards.

There are 4 biological hazards, 2 mechanical hazards, 2 physical hazards, 1 ergonomic hazard and 1 chemical hazard. The hazard classification results are shown below in percentage of number items.

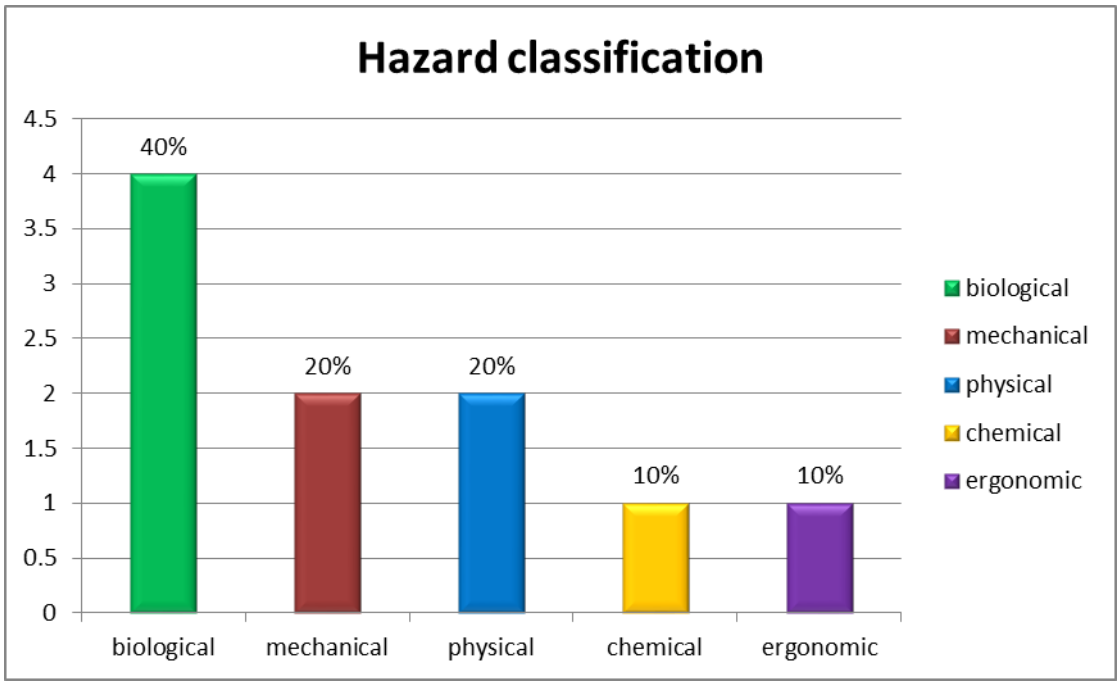


Figure 4.9 : Hazard classification at Hospital Raja Permaisuri Bainun ,Ipoh

From the analysis done, 40% of the hazards are biological hazard followed by 20% of mechanical and physical hazard each. Only one chemical and ergonomic hazard were found during waste collection and disposal at Hospital Raja Permaisuri Bainun, Ipoh.

The previous figure shows that 40 % of the hazards found posed high risk and another 60% posed medium risk. None of the hazards found were low risk. Thus, appropriate control measures are essential to mitigate the hazards found. The figure below shows the percentage of risk level according to category of hazards.

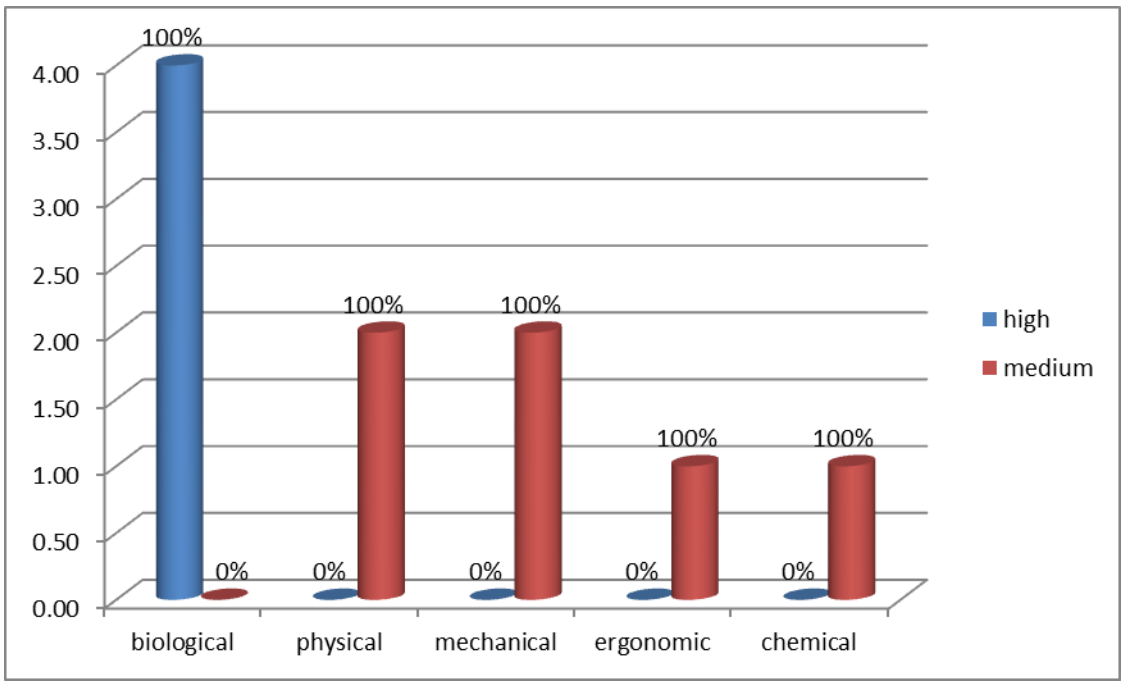


Figure 4.10: Percentage of risk level according to hazards at Hospital Raja Permaisuri Bainun, Ipoh

Based on the analysis results, the four biological hazards found during clinical waste collection and disposal activity posed 100% of high risk. Meanwhile, all the other physical, mechanical, ergonomic and chemical hazards found are poses medium risk.

Risk assessment at AAA incineration plant

A total of 82 hazardous job tasks were observed at the AAA incineration plant focusing on plant operators and management staff. The hazards have been identified through observation and walking at the plant, hazard identification checklist, interviews, job hazard analysis and accident analysis.

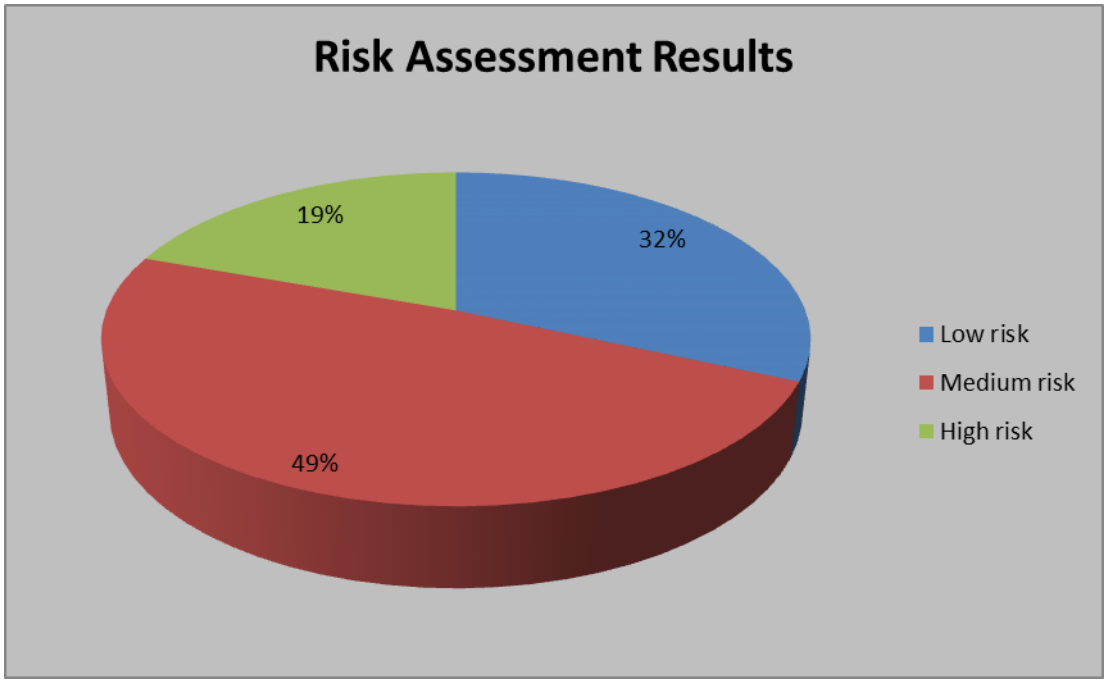


Figure 4.11: Risk assessment results for AAA incineration plant

Out of total 82 hazards identified at the plant, 64 were potential hazards another 18 wer existing hazards. It was grouped as safety hazards and health hazards and then classified as physical, mechanical, electrical, chemical, biological, ergonomic and psychological. There are 50 safety related hazards and 32 health related hazards identified. From the 82 hazards identified, there are 32 physical hazards, 16 chemical hazards, 15 mechanical hazards, 9 ergonomic hazards, 5 biological hazards, 4 electrical hazards and 1 physiological hazard.

This helps to set the priority of hazard and implementation of control measures. The hazard classification results are shown below in percentage of number items.

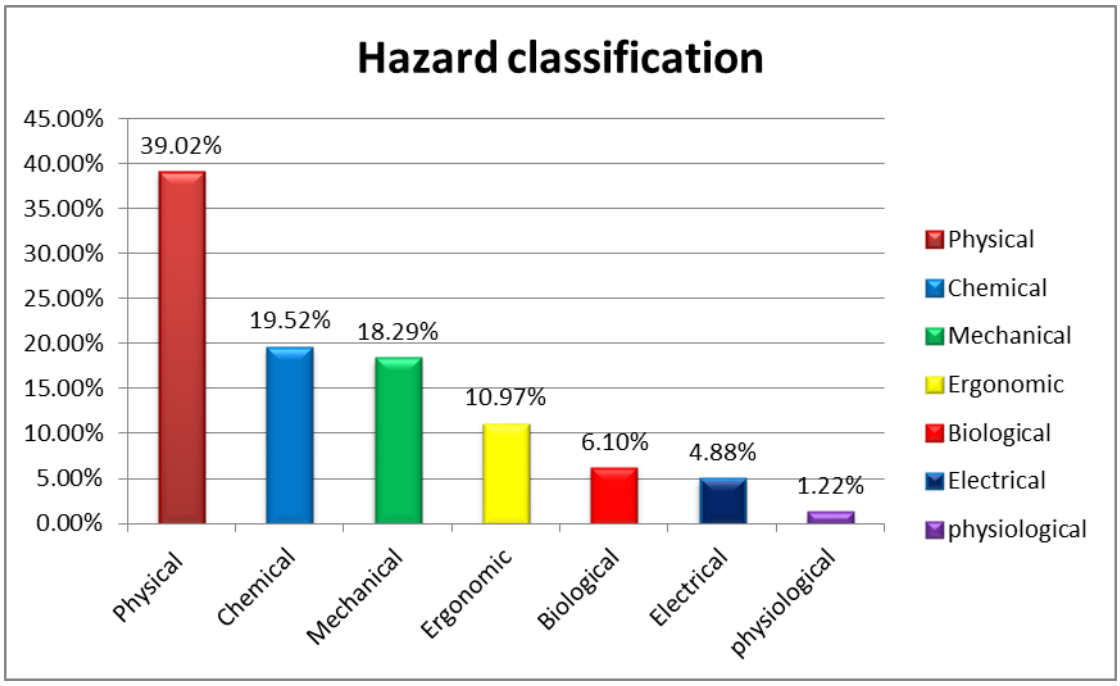


Figure 4.12 : Hazard classification at AAA incineration plant

From the results above, findings shows physical hazard is the main hazard found with highest percentage where the safety committee and the management should focus to implement appropriate control measures; following is the chemical hazard with 19.52%, mechanical hazard 18.29%, ergonomic hazard 10.97%, biological hazard 6.10% and electrical hazard 4.88%. Lastly physiological hazard that contributed only 1.22% from the total percentage shows that physiological hazard is the minimum hazard at the study area.

The previous figure shows from the total of 82 hazards identified, the risk matrix ranking shows, 49% of the hazards are with medium risk level followed by 32% with low risk level and 19% with high risk level. Overall, only a minimum number of hazards give high risk rating.

As for electrical hazard, even it is only 4.88% from total hazard percentage, but the whole 100% of it leads to high risk level. Generally, above figure shows all class of hazards with specific risk level at the studied incineration plant.

Based on the results collected at the incineration plant shown in HIRARC table and table 4.3 : Risk matrix values, figure below illustrates the risk level rating specifically for each class of hazards.

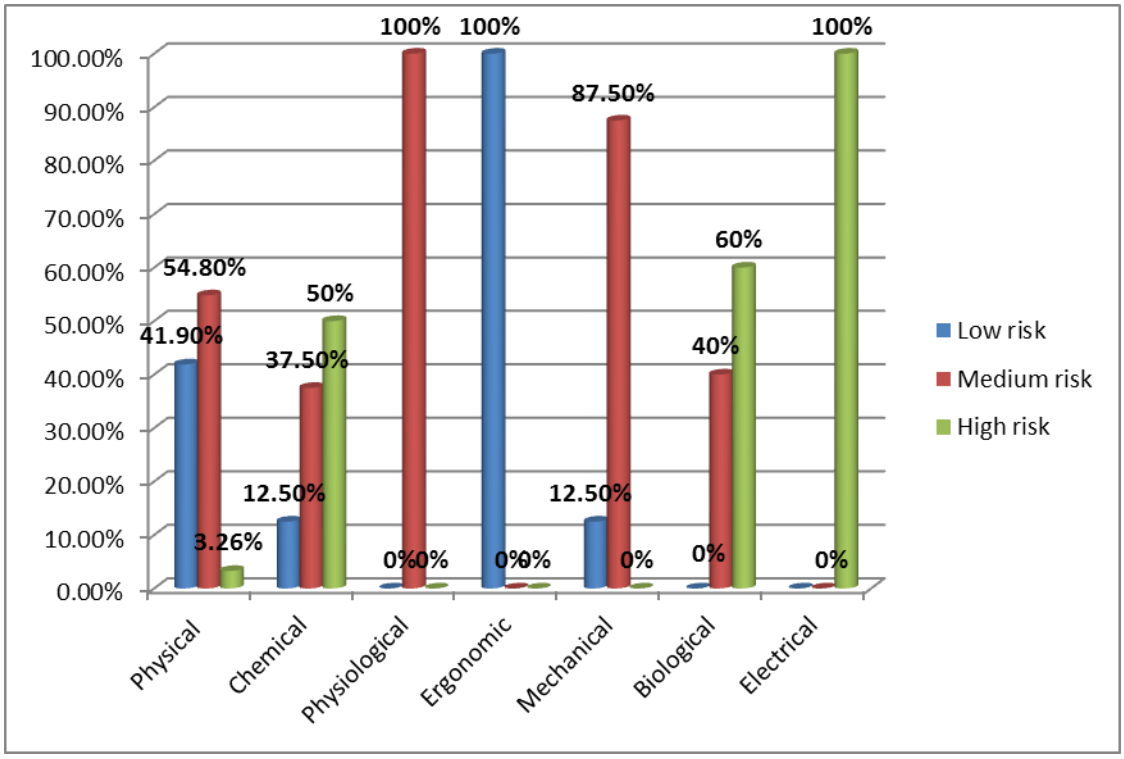


Figure 4.13 : Percentage of risk level according to hazards at Hospital Raja Permaisuri Bainun, Ipoh

Based on the results for each type of hazard class at the incineration plant, 39.02% was physical hazard with 41.90% of low risk, 54.80% of medium risk and 3.26% of high risk. As for chemical hazard which is 19.52% from total percentage of hazard, 12.50% shows low risk, 37.50% of medium risk and 50% of it gives high risk.

Out of total risk for physiological, 100% shows medium risk while 100% of ergonomic hazard gives low risk. Mechanical hazard which is the third highest with 18.29% out of total percentage including 87.5% of medium risk and 12.5% of low risk without any high risk stated.

One of the hazards that should be given important consideration at clinical waste incineration plant is the biological hazard which is 6.10% from overall hazards includes 40% of medium risk, 60% of high risk and 0% of low risk. As for electrical hazard, even it is only 4.88% from total hazard percentage, but the whole 100% of it leads to high risk level. Generally, above figure shows all class of hazards with specific risk level at the studied incineration plant.

Waste types with related hazards and risks at AAA incineration plant

Based on the study conducted through surveys, observations and interviews, two types of hazardous waste were identified at the incineration plant. Those waste are clinical waste which is received from authorized clinical waste transporters and industrial waste which is the ash produced from incineration process. The clinical wastes are collected by AAA waste collection Lorries from government hospitals, private hospitals, medical laboratories and clinics.

Both types of waste identified were considered to have negative impact on the environment and human health at the AAA incineration plant. The result in Table below shows the main waste and their hazards identified at the AAA incineration plant.

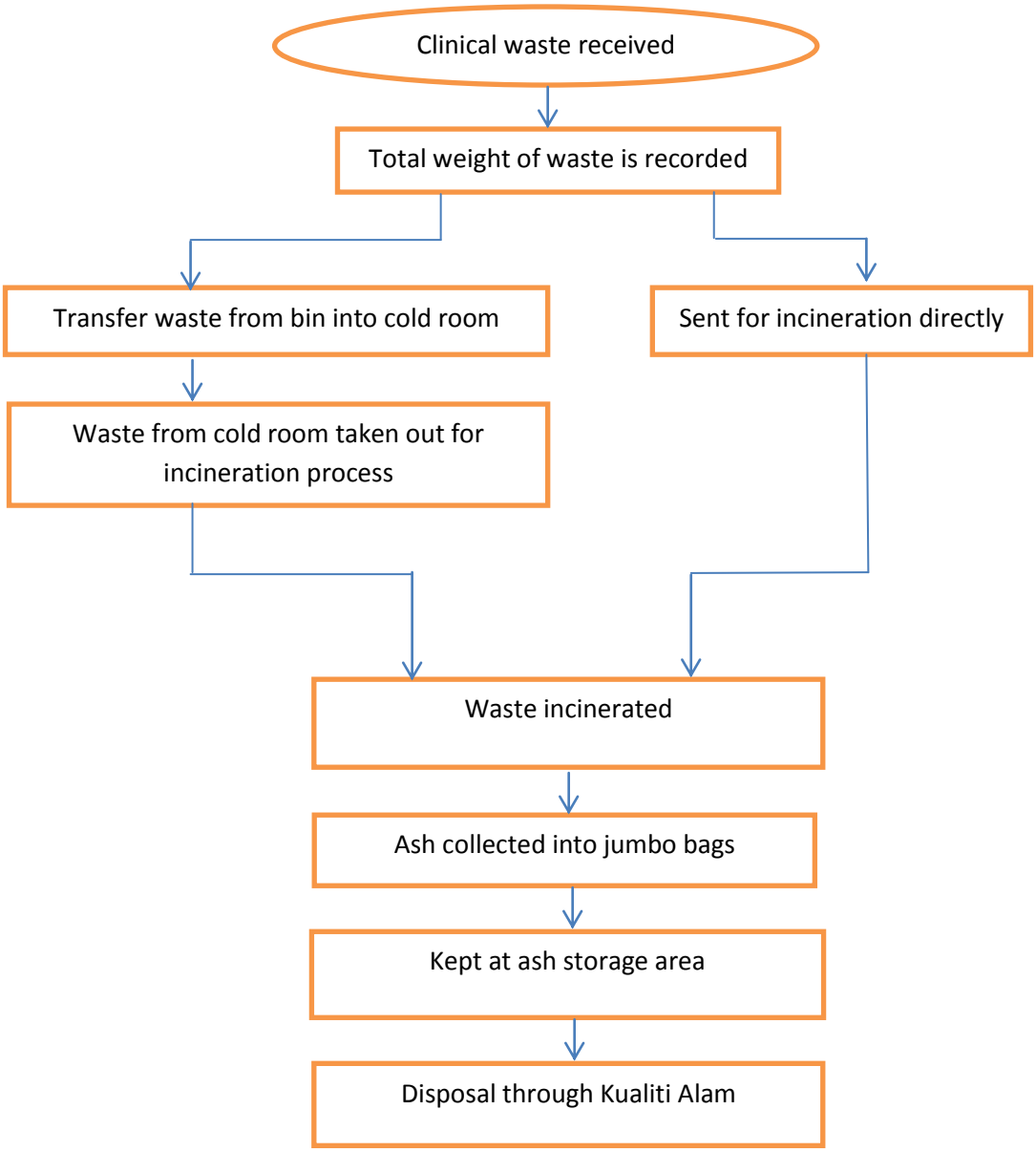
Table 4.29 : Wastes related hazards at AAA incineration plant

Waste	Activities	Hazards
Clinical waste	Waste received to be treated contain partly or wholly of human or tissue, excretions, blood or body fluids, medical treatment related materials, collection and transfusion bloods, drugs and pharmaceutical products.	• Biological hazards
Incineration ash	Ash produced after incineration of clinical waste	• Biological hazard • Chemical hazard
Grease and oil lubricants	Mostly used in bypass dampers, forklift, fan system and reclamation or repairing of different parts of machinery.	• Physical hazard • Chemical hazard
Saw dust	Used as a control measure for oil spillage	• Chemical hazard
Non-hazardous	Scrap produced from maintenance work	• Physical hazard

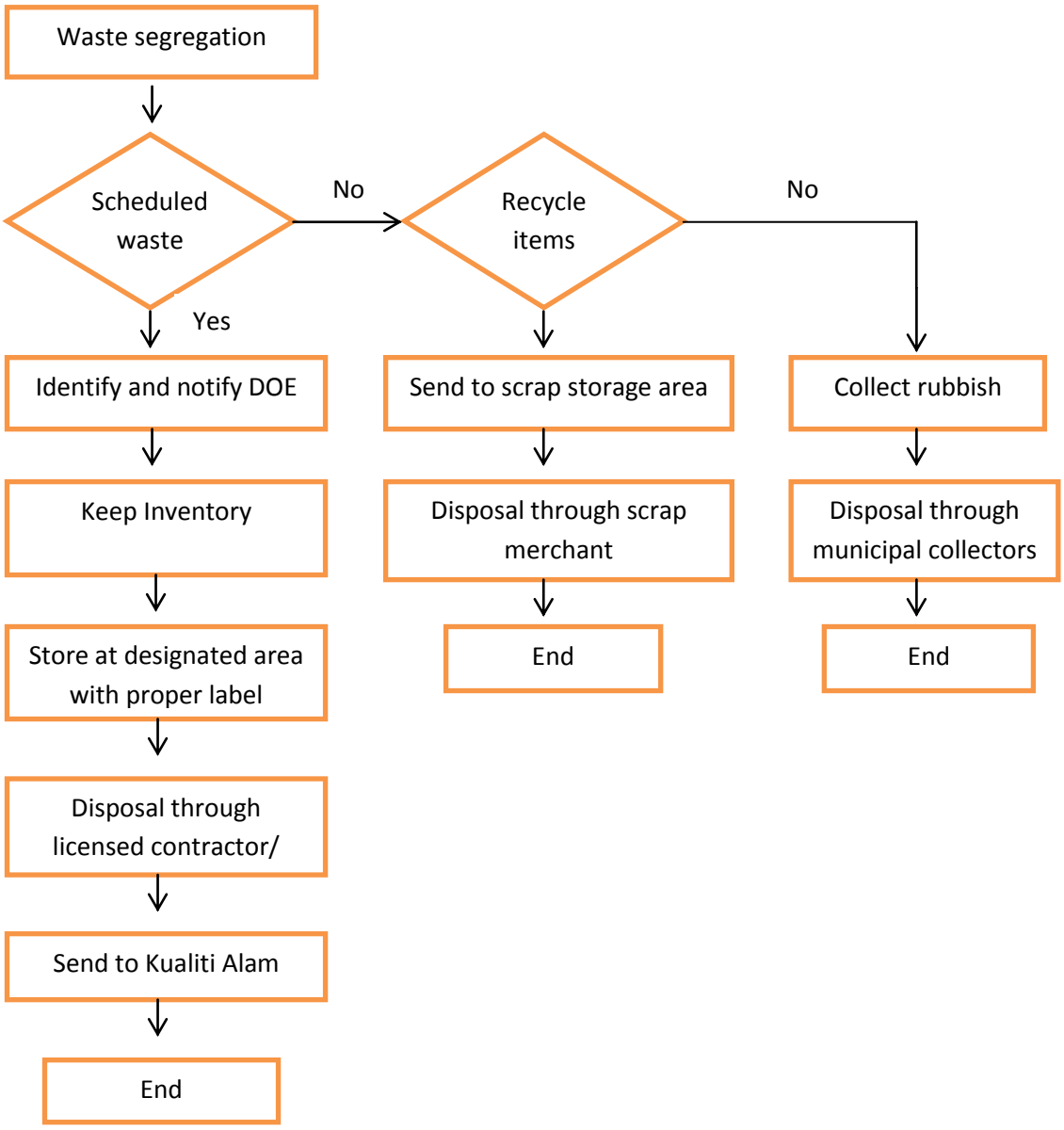
The above classified wastes are distinguished as main waste types at the AAA incineration plant. Therefore, the safety committee with the plant management have established and implemented a proper management procedure and guide for handling and disposal of this hazardous waste. The scheduled waste regulations 2005 under Environmental Quality Act and Guidelines on the Handling and Management of Clinical Waste in Malaysia, Department of Environment 2009 were used to develop the procedure in order to reduce risk through appropriate control measures.

Based on the interview with the plant manager, below flowchart shows the management of received clinical waste and how ash from incineration process is disposed accordingly.

Flowchart 4.1: Clinical waste management process flow at the AAA incineration plant.



Flowchart 4.2: Waste management process flow at the AAA incineration plant



All hazardous wastes are classified as scheduled waste. Therefore, the category of scheduled waste should be identified and notified to Department of Environment (DOE). Transportation of clinical waste requires license from Department of Environment as per stated in Environmental Quality (Prescribed premises) (Scheduled waste treatment and disposal facilities) order 1989. All clinical waste collection Lorries owned by AAA management are registered under Department of Environment with appropriate license.

Inventory of clinical waste received every day is done accordingly to plan the incineration process and helps in better storage management. The clinical waste is received in yellow bins. The waste is then removed from the bins and stored in cold room prior to incineration process. The waste to be incinerated is taken from the cold rooms. The inventory of clinical waste received, stored and incinerated is reported to Department of Environment and Ministry of Health every 3 months once as per required in Environmental Quality (Prescribed Premises)(Scheduled Waste Treatment and Disposal Facilities) Regulations 1989.

The next stage in managing scheduled waste is the disposal of ash from the plant. It should be done through Department of Environment authorized licensed scheduled waste collectors. Providing information by issuing consignment note during disposal of hazardous component and observation during loading are the main parameters given consideration.

The amount of ash produced through everyday process is recorded accordingly based on jumbo bag numbers. Each jumbo bag accommodates 700-900 Kg of ash. Around two metric tonnes of ash produced from twenty metric tonnes of waste incinerated every day.

The AAA incineration plant cooperated with “Kualiti Alam Sdn Bhd” to manage and disposed all the hazardous waste. This includes the ash produced from incineration process, other lubricants generated from maintenance activities and the saw dust used to absorb oil spillage. The ash disposal is done every three days once.

Non-hazardous waste is the other type of waste collected generated at the plant by the name of scrap yard. Waste is segregated at the store area and sent for recycling through scrap merchant while other non-recyclable items are considered as rubbish and disposed as normal waste.

5.0 DISCUSSION

HIRARC study for clinical waste handlers at the hospital and incineration plant was conducted to identify the hazards and to improve the safety at the workplace. This study particularly focusing on clinical waste collectors at Hospital Raja Permaisuri Bainun, Ipoh and operators at AAA incineration plant. The hazards were analysed to prioritize the risk and assess the existing control measures for better improvements.

Identification of hazards at the study area was conducted using hazard identification checklist, workplace audit through observation, inspection, interview questionnaire, job hazard analysis and accident incident investigation report reviews. Hazards occur for various reasons during the waste handling at the hospital and in the plant. The main objective was to identify the hazards related to facilities and workers using the best effective method. The hazards during waste handling were identified through workplace audit and review of accident reports. As for hazard identification and risk assessment at the incineration plant, a process flow diagram was created. Basic information regarding the process flow was collected through interview with the plant manager and this was used to familiarize with the system. This helped to select the best method to study the hazards at the plant. Finally, identified hazards were classified into 2 main groups, safety hazards and health hazards. These two main classes of hazards were then categorized into 7 main types. The categories are physical, mechanical, chemical, biological, ergonomic, physiological and electrical. The level of risks was determined as high, medium and low based on the likelihood and severity.

In general, there are two possible purposes for hazard identification under this study:

- To get a list of hazards for subsequent evaluation of risks through risk assessment techniques.
- To perform a qualitative evaluation or "hazard assessment" to determine the significance of the hazards and identify measures for reducing the associated risks.

5.1. Hazard identification

Hazard identification was done through hazard identification checklist, workplace inspection through observation and previous accident report reviews.

5.1.1 Hazard identification through checklist

The hazard identification checklist comprises of general safety conditions and practices and this was used to identify the existing and potential hazards at the workplace. Various kinds of hazards were noticed from the replies compiled from workers and safety officer at the plant. Workers are exposed to various kinds of biological hazards while handling of clinical waste. Workers come into contact with various kinds of bacteria and virus during the processing and maintenance stage. Inhalation and ingestion of contaminated air or direct contact with clinical waste may lead to severe infectious diseases. According to Bdour et al., (2007) clinical waste handlers posed high risk for infection through direct contact with waste. Workers are also exposed to sharp items during transferring of ash into disposal bags. Needle prick injury is considered as one of the highest risk biological hazard which could lead to various kind of infectious disease.

Sharp waste such as hypodermic needles considered as highly hazardous waste due to contamination of patient's blood (Pruss et al., 1999).

It was found that internal air quality is not tested regularly to ensure safe working condition with clean air. Management had proposed to conduct internal air quality inspection to ensure clean air at working area.

In certain areas of the plant, workers are also exposed to heat hazard due to high temperature of the process, however most of the ducting was covered with insulators.

Growth of microorganisms in the cold room waste storage area is control by low temperature at 6°C. Usage of all appropriate personal protective equipment (PPE) was implemented according to Occupational Safety and Health Act 1994 (Act 514) to avoid any unintended biological hazards. Workers are also sent for complete medical check-up every six months to ensure good health condition. The results obtained were within the healthy condition limit. However, no comparison analysis was done on each worker's medical check-up results to see the differences in values of reading.

The comparison analysis is important to see the changes in the health condition of employees because long term exposure could lead to various health complications (World Health Organization, 2011).

All employees were aware of potential hazards during chemical handlings. All employees are required to use appropriate personal protective equipment when in contact with chemicals according to guidelines available. While, all parameters of safety were in order, sometimes certain practices were unintentionally not applied.

For example, lack of respirators or mask usage and employees are not given instruction on how to use it even when not handling chemicals. From observation at the plant, it was essential to use mask or appropriate respirators while at the plant to avoid exposure to dust, fume and dark smoke emitted through stack during the process.

According to Blenkharn (2005), heat resistant pathogenic bacteria released through stack gas and bottom ash. The plant is located in an open area, thus there is no ventilation system or equipment available for removing contaminates in air. Employees are exposed extensively to ash during the final stage of the process, however appropriate personal protective equipment (PPE) was need to be use during ash handling to minimize the effects to health.

There were no major complaints from workers during the study regarding health problems such as difficulty in breathing, headache, dizziness, irritation or any other discomfort when they were in contact with chemicals or while working at the plant .According to US cohort studies (2000), long term exposure to low concentration of chemical pollutants from incinerators are associated with chronic health effects such as bronchitis, reduced lung function, shortened life span, elevated rate of respiratory symptoms and lung cancer.

Yuhas et al., (1994) mentioned that heavy metals emitted through fumes, ash and particles during the incineration process. Inhalation of chemical components during plant preparation and extensive exposure to ash during the ash collection process are the main chemical hazards encountered by the workers at incineration plant.

Therefore, the plant manager and safety officer should conduct regular inspections on the workers to strictly and ensure the usage of appropriate personal protective equipment to reduce the specific hazard.

Electrical hazard in incineration plant is another hazard identified but generally it is under control. All the electrical appliances in the incineration plant are handled by competent authorized electrical engineers. These electrical engineers are trained and their competency is acknowledged by '*Jabatan Bekalan Elektrik*" Malaysia. Training is provided for employees who handle electrical parts especially in managing the control room. Improper maintenance of the plant could lead to electrical hazards (Jeyakumar, 2008). As a precautionary action set by the incineration plant management, preliminary inspections carried out by the electrical engineers on electrical parts at the plant mainly the control room to ascertain the conditions during weekly maintenance works.

Electrocution is one of the hazard in incineration plant. Workers are exposed to electrical hazards mainly during maintenance works. Some parts in the plant are energized by shielded or unshielded conductors. It works when the shield is removed during maintenance work. Electrocution risk potential to happen from purposeful entry into restricted areas or following failure to implement safety aspects needed during handling of electrical parts. Overhead power lines, downed electrical wires and buried cables pose danger for electrocution or shock if workers come into contact during operation (Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH, US).

All the electricity supply and installation works at the incineration plant are being governed by the:

1. Electricity Supply Act 1990 - Act 447

2. Licensee Supply Regulations 1990

3. Electricity Regulations, 1994

4. Occupational, Safety & Health Act 1994

5. Malaysian Standard MS IEC 60364 Electrical Installation of Buildings

The mechanical hazard studied comprehensively at this study area shows all equipment and machineries are placed securely and anchored. Yearly inspection is carried out by DOSH on air compressor system tank and it is certified to be used.

Employees are at high risk to mechanical hazards such as impact by gas cylinders or stabbing by forklift during plant preparation stage. During the process stage, accidents can happen to workers due to lack of concentration or mishandling of waste bins.

Entanglement and impact by jet spray nozzle can happen during bin washing. Maintenance works also contain high risk for mechanical hazards such as impact or entanglement can lead to serious bodily injuries.

Mechanical failure in burners can happen due to low maintenance or overloading of waste. However, the plant safety officer believes that these hazards can be avoided by applying good safety practices, suitable training for workers and proper scheduled maintenance of the system.

Based on checklist and observation, ergonomic hazards are likely to happen frequently at the incineration plant. Employees are trained and prohibited from lifting heavy parameters such as gas cylinders or waste bins without assistance from either forklift or roller. Job task is designed in such a way where the workers does not need to stoop their neck, shoulder or kneel to do work or monitor the task for a long time. However unnatural movement sometimes leads to musculoskeletal related health problems. Usage of jet spray during washing of bins, exposure to vibration and prolonged work may result in musculoskeletal disorder. Some physiological stresses in employees were identified due to repeated exposure on a same job task and working schedule. To overcome these problems, the management has agreed to implement job rotation schedule to decrease the stress level and minimize musculoskeletal disorders.

As required by the OSHA and industrial hygiene regulation, the incineration plant has adequate first aid equipment. These supplies were replenished as they are used, and regularly checked on the availability of adequate supply every 6 months. According to the plant manager, first aid trainings and fire drills are conducted annually to ensure all employees are aware of emergency situations and know how to react immediately.

Special panel clinic with qualified occupational health doctor is assigned to look into health problems and monitor employee health condition.

Fire preventive measures were implemented and adequate emergency response plans were well prepared. All necessary fire-fighting equipment were installed, maintained and certified as required by OSHA and ready to be used during emergencies.

The local fire department located near to the plant is familiar with all facilities, location, and specific fire hazards in the plant. The management and safety committee has enforced practices and procedures to control potential fire hazards and ignition sources.

In many cases, combination of few control measures is needed to bring down risk level to safer condition (Smith, 2000). Risk management involves measure to prevent the risk from turning into incidents or trying to control the risk level.

Guidelines from Department of Environment are being practiced in handling and management of clinical waste and after process ash products at the incineration plant. Orientation and training programs have been introduced to handle new situations and current implemented control measures shows that employees working in a good condition. This avoids any new hazards and reduces the risk posed by current hazards.

5.1.2 Workplace inspection (observation and interview)

Periodic workplace inspections play an important role to ensure appropriate occupational safety and health administration. Inspection checklist is used to ensure important elements are not neglected, it helps to control the activities and prepare report. A regular workplace inspection is practiced as a preventive measure for occupational safety and health problems. It enables identification of workplace hazards for subsequent control measures. Planning, conducting, monitoring and reporting of workplace inspections can be done by safety committee members.

Hospital Raja Permaisuri Bainun, Ipoh

Currently, there are insufficient research data on public health problems from clinical waste (Viswanathan C., 2006). In this study, hazard and risk evaluation was done for clinical waste collection and disposal activities carried out at Hospital Raja Permaisuri Bainun, Ipoh. Based on the observation, the management of clinical waste in Hospital Raja Permaisuri Bainun Ipoh is in accordance with the guidelines set by Department of Environment for handling and management of clinical waste in Malaysia.

The usage of personal protective equipment complies with guidelines set by Department of Safety and Health. However, some biological and physical hazards identified directly effects the clinical waste collectors at the hospital due to mismanagement of clinical waste by other parties such as doctors and nurses. Awareness among clinical waste collectors and cleaners on health risk associated with hazards found at workplace is still lacking. This was found through interviewing of staffs during workplace inspection. Employees were inducted only once throughout their employment and this is considered not sufficient.

Continuous education is essential to ensure hazards are handled accordingly to minimize the associated risk. During the study, a suggestion was made to the management to conduct trainings and seminars on sufficient intervals to create awareness among the workers on safety and health related matters.

AAA incineration plant

From the checklist, the plant site overall complies with occupational safety and health requirements set by Department of Occupational safety and health (DOSH). However some inadequacies were observed at the plant and safety committee was informed to take appropriate actions.

The safety committee agreed to display a summary of occupational illness and its symptoms at the safety notice board to create awareness among plant operators. The management is also aware on matters regarding the inappropriate location of emergency assembly point and accommodation of dark smoke from chimney at plant surrounding area. The management and safety officer are aware and familiar with those problems and have plans to solve them in the near future.

As mentioned in Occupational Safety and Health Act 1994 part IV general duties of employers section fifteen subsection one, every employer is responsible to ensure the safety, health and welfare of the employees at work; subsection two indicates that without prejudice to the generality of subsection one, employer shall provide and maintain the plant by keeping the system safe without risk to health and ensure safety at workplace (Laws of Malaysia, act 514, 2013).

According to section sixteen of Act 514, it shall be the duty of every employer and self-employed person to prepare a written statement of general policy. After the observation conducted in the study area, the plant manager and safety committee agreed to all above statements and they had control to keep the site under standard and legal requirements.

On job training plays a vital role in reducing any risk cause by safety and health hazards at workplace. The US National Research Council while acknowledging the need for further study stated, modern waste incinerators pose little risk to human health when operated properly by well trained employees (Allsopp et al., 2001). During interview with plant operators, it was found that employees are not aware of 'right to refuse' procedures.

Recommendations had been made to the management to include this awareness on during training session to the employees. Overall observation at the study area shows, the trainings conducted are adequate and at acceptable level.

According to occupational safety and health administration, the process flow diagram shows how different parts of the job tasks involved in the process are interrelated. There are three main stages of process involved in the operation of the incineration plant.

Each part consist of specific elements and associated hazards, so the management and safety committee has to be familiar with each part of the job tasks in order to select the best hazard identification technique and implement appropriate control measures to minimize the risks.

An appropriate and up to date record keeping is important to ease the review and analysis of conditions at workplace to minimize hazards through better control measures.

All relevant records on employee training, medical surveillance and accident were well maintained at the plant. These records were reviewed yearly by the management to make changes in the policy and procedures according to need.

As incineration process involves high temperature fire, it is highly prone for fire incidents. The fire response plan at the plant was prepared in accordance to Fire Services Act 1988 and Occupational Safety and Health Act 1994. However, it was observed that the fire response plan is not displayed for employee's awareness. The management was advised to place the plan in all the notice boards around the plant area to ensure all employees are aware and ready to response accordingly when there is a fire breakout.

Emergency exit routes and appropriate signage is essential at all workplace. This plays an important role in saving lives during emergency incidents. Adequate emergency exits were observed at the plant, however certain locations in the plant is lacking of appropriate signage and emergency exit lights. Following OSHA regulations, all exit routes must be clearly designated and easily seen during emergency situations; the signs should be clear and equipped with adequate lighting for clear visibility.

Routes that may mislead for emergency exit, shall be identified and marked as 'Not an Exit' or appropriate signs. Emergency exit routes must be indicated with an arrow sign to show direction of travel to reach the nearest exit which is not apparent. It was noticed that some emergency exits at the plant were not accessible without keys. A number of employees were also not aware of the emergency exit routes.

Therefore the safety department should mark all emergency routes with clear signs and emergency lights to make it accessible without the use of key during emergency situations. New employees should be briefed on emergency exit during pre-employment training.

Lighting safety standards have been set by the Department of Occupational Safety and Health. Injuries resulting from poor workplace lighting happen often in various workplace conditions. Poor or wrong lighting may cause eye strain and severe headaches. General lighting normally depends on the type of building or work space. Ceiling lights are sufficient at many premises. General workplace lighting includes access lighting at the stairways. General lighting should be sufficient to allow safe movement around the workplace. Windowless or closed room areas should be provided with more lighting. Specific task lighting is used as an aid to carry out specific job task safely and avoid strains to eyes; it may be needed during maintenance work inside drums or burners.

The emergency lights installed were sufficient but the management was advised to check its functionality on quarterly or half yearly basis instead of yearly inspection.

OSHA regulation indicates that machine guards are essential for protection of machine operators from operational hazards. Appropriate machine guards were installed at the incineration plant for the fans, scrubbers and waste tipping lifter. Lockout procedure implemented during maintenance works helps to ensure safety of operators.

All the tools and machineries at the plant were maintained well in accordance to Factory & Machinery Act 1967. However, no special trainings were conducted for the employees on tools and machinery handling. Appropriate initial training is essential to ensure safe handlings of machineries in order to avoid accidents.

OSHA indoor air quality standard is followed for the confine space ventilation. Primary and secondary burners are the two confine spaces at the incineration plant. All works at the confine space are monitored closely by the safety officer.

An assistant employee is placed outside the confine space during maintenance work is carried out, to monitor and seek for help in any emergency situations.

Housekeeping is also important in order to minimize work related hazards. The housekeeping is carried out regularly at the incineration plant. However, extensive debris and dust were found at the ash collection area. Upon observation and discussion with the management, it is difficult to control the debris and dust at this area. However the hazards were control through proper usage of full appropriate personal protective equipment.

Noise or sound level at the incineration plant is one of the important parameter to be monitored and the records show that employees were exposed to noise below 85dBA in compliance with OSHA standard requirements. McManus (2011) said steady-state noise from generators and other sources could exceed mandated limits.

According to OSHA standard regulations for noise, exposure to average noise level of 85dB or greater on 8 hour workday is hazardous to workers. Noise level exposure is determined by monitoring the workplace actual noise level and estimate the noise exposure to employees during the working period of time.

The periodic audiometric testing results show that employees are in safe working environment in term of noise exposure. Any significant changes in noise level should be followed by a re-monitoring to determine whether more employees should undergo hearing conservation programs.

Au Yong (2009) mentioned that, OSH hazards are controlled through a hierarchy; elimination, substitution, engineering control, administrative control and personal protective equipment.

The management and safety committee must ensure safety of every individual who enters the plant area is strictly monitored for usage of PPE. Both employee and employer must be aware of the PPE limitations to ensure the PPE is working properly to avoid false sense of protection. Strict enforcement of PPE utilization must be implemented to minimize the risk posed by hazards.

5.1.3 Accident investigation review

Accident investigation was selected as one of the parameter in this study to evaluate the hazard that causes accidents. According to OSH definition, 'accident' is an unanticipated occurrence that prevents completion of an activity that may results in property damage or injuries to human.

A total of 15 needle prick injuries have been recorded at Hospital Raja Permaisuri Bainun, Ipoh in past 11 years. However, total number of needle prick injuries in Perak state for the same period of time was 60. According to the reports, most of the injuries occur during cleaning and waste collection works. It was noticed that, some of the doctors and nurses tend to throw the used needles in clinical waste yellow bins or normal waste bins instead of sharp bins. This happened due to lack of responsibility among the healthcare professionals.

From the observation during walkabout at the wards, it was also noticed that some of the insulin dependent patients are also throwing the used needles into normal waste bins which results in needle prick injuries among the cleaners.

Previous epidemiological studies indicate needle prick injuries from an infected source patient has 30% risk to become infected by HBV, 1.8% risk to get HCV infection and 0.3% risk to get HIV infection (World Health Organization, 2004). Programmes such as placing posters about good practices on needle usage can be done to create awareness to patients as well as reminders to healthcare professionals. During the interview with some of the safety committee members, puncture resistant gloves were suggested to be used during transferring of waste into cold rooms and lorries. They agreed to raise this suggestion and placement of awareness posters during their safety committee meeting.

There are no any accidents records available at the plant. Hence, accident investigation cannot be conducted. However, interview with plant operators show minor accidents and injuries such as trip and fall, needle prick injuries during waste transfer to cold room and plant preparation activities were not recorded, no further investigation was carried out. This is due to lack of awareness among employees on the seriousness and importance of reporting minor incidents. Management issues have been identified as factors in many accidents (Holloway and Johnson, 2005). After discussion with management and safety committee on this matter, they agreed to look at the matter seriously. It was suggested to include accident incident reporting process in the pre-employment training to all the workers in order to create awareness.

5.2 Hazard classification and risk assessment

Hazard classification was done through job hazard analysis to categorized the hazard as either safety or health hazard followed by classification as biological, chemical, ergonomics, electrical, physical, mechanical or physiological. After classification, a quantitative risk assessment was done using a standard scale set by Department of Occupational safety and health.

5.2.1 Job hazard analysis

The job hazard analysis (JHA) , focus on job tasks, break the job task into specific parts, identify the type of hazard, classify the hazards and finally determine the cause of hazards and the consequences. According to OSHA, job hazard analysis focus on interrelation between the employees, task, tools and work environment. Job hazard analysis in this study was useful to identify many hidden potential hazards. Some of the hazards were identified by the management for appropriate control measure implementation, however some potential hazards were missed out. The job hazard analysis helped to identify the cause and consequences of each hazard and the identified hazards were then included for quantitative risk assessment.

5.2.2 Risk assessment

The data on hazards were obtained through observation and inspection at the hospital and incineration plant, hazard identification checklist, interviews, job hazard analysis and accident report reviews. Quantitative risk assessment was done for all the identified existing and potential hazards using standard risk assessment scales set by Department of Safety & Health. From the risk assessment, hazards were ranked as high, medium or low based on the scales. The analysis showed 10 hazards at the hospital during collection and disposal of clinical waste whereby 4 of the hazards posed high risk while another 6 posed medium risk.

As for the incineration plant, there were 26 Low, 40 Medium and 16 High risk hazards have been identified at the incineration plant. The number of hazards identified, show a total of 92 hazardous job task have been identified through checklist analysis technique.

Based on the results of HIRARC obtained at hospital and incineration plant, the risks identified were ranked based on priority. The following list gives some of the main hazards with high risk rating found at the studied plant.

1. Chemical hazard inhalation due to extensive exposure during preparation of diesel, Dettol pine, carbon, Clorox, fuel
2. Chemical hazard inhalation due to extensive exposure during preparation of hydraulic system
3. Biological hazard during waste collection from wards, waste movement to cold room, loading into lorry and cleaning of cold room, expose to waste could lead to infection of dangerous bacteria or virus through inhalation or direct contact.
4. Biological hazard during waste movement to cold room or loading of waste from lorries, exposed to waste could lead to infection of dangerous bacteria and virus.
5. Chemical hazard during waste burning and incineration process, expose to extensive smoke inhalation and ingestion could results in lung infection.
6. Physical hazard during waste burning and incineration process have chances for occurrence of fire and explosion could results in fatality or disability.
7. Electrical hazard during maintenance of fan system, hydraulic system or air dryer unit could lead to electrostatic which may result in death or disability.
8. Chemical hazard during maintenance of primary and secondary zone involves contact and inhalation of dust could lead to lung infection
9. Chemical hazard during maintenance of ash conveyer involves contact, ingestion and inhalation of dust may lead to lung infection or skin related diseases
10. Electrical hazard during maintenance of secondary burner could lead to electrostatic which may result in death or disability

11. Chemical hazard during lime preparation, inhalation of lime could lead to lung infection
12. Chemical hazard during maintenance of grease trap, contact with grease could lead to skin irritation or skin disease
13. Biological hazard when handling ash conveyer cause exposed to sharp items in the ash could lead to bodily injury and infectious disease.
14. Mechanical hazard through ash pusher cause cutting or scratch leads to bodily injury
15. Physical hazard during waste collection from wards and clinics, clearing the spillage of waste could cause bodily injuries through needle pricks.

Risk assessment at Hospital Raja Permaisuri Bainun, Ipoh

In general, the implementation of safety and health aspects during clinical waste collection and disposal are at an acceptable level, however some of the practices need improvement in order to reduce the risk posed by hazards identified. Contaminated clinical waste poses various risks to clinical waste handlers (World Health Organization, 2011).

Previous studies indicate that low knowledge among healthcare waste handlers on disease transmitted with contact of infectious waste (Yenesew et al., 2012). The current control measures implemented met the requirements set by authority; however best practices in clinical waste management and awareness among clinical waste handlers on the risk associated with each hazard plays a vital role to minimize the risk to avoid any serious health impacts in future.

Risk assessment at AAA incineration plant

Generally, the safety aspects is given priority by the incineration plant management and safety committee, so there is an acceptable level of safety and health programs being implemented at the incineration plant. To stay safe at workplace, understanding of the hazards is important.

Hazards can be a part of the job task, like extreme noise, expose to high thermal heat, expose extensively to chemicals and smoke. According to Battermann (2004), a well operated incinerator should have zero visible emission from the stack but it was observed that incinerator operators are exposed to extensive smoke during the process.

Hazards could also be due to human error, insufficient housekeeping, low maintenance and structural, machinery or control panel failure. Therefore, the management and safety committee must be aware of all relevant information and knowledge on the main hazards in the plant. This is important to ensure all control measures are being implemented to prevent or minimize the hazards.

Waste management at the incineration plant

Two major types of scheduled waste were identified in the incineration plant. The clinical waste posed biological risk due to infectious and sharp items contain in it. A comprehensive observation in this study shows the clinical waste received at this plant contained partly or wholly human tissue, excretions, blood or body fluids, medical treatment related materials, collection and transfusion bloods, drugs and pharmaceutical products.

Biological hazard occur through direct contact during waste storage or preparation for incineration process. Disease could spread by direct or in direct contact, needle prick injuries, inhalation or ingestion of infectious virus or bacteria.

Inhalation and ingestion during ash handling accumulate the chemicals in the body (World Health Organization, 2013). Ash produced from incineration process is the other scheduled waste which is categorized as hazardous industrial waste. This ash posed biological and chemical risk to the employees at the plant.

Biological hazard occur due to needle prick injuries when transferring ash from ash conveyer into jumbo bags for disposal because needles does not burn during incineration process.

These injuries are also potential to cause infection because viral pathogen such as Hepatitis B can survive in dry air upto to seven weeks (Paintsil et al., 2009). Inhalation of ash during transferring and packing of ash in jumbo bags cause chemical hazard for workers.

The used oil and grease generated from maintenance works could cause physical and chemical hazards. Slippery floor could result in trip and fall hazard. Chemical hazard occur due to direct contact of oil and grease with skin can results in skin and eye irritation (World Health Organization, 2013).

Saw dust used as control measure is also categorized as one of the scheduled waste found at the plant. It could result in skin irritation due to direct contact with skin. The non-hazardous waste, scrap metals from maintenance works would cause trip and fall hazard if housekeeping is not properly managed.

The storage of clinical waste in cold room is safe and managed well, however the house keeping need to be improved to control the growth of microorganisms.

5.3 Evaluation on risk control implementation

The current risk control implementation was assessed to see the effectiveness and at the same time to give recommendations for improvement.

5.3.1 Hospital Raja Permaisuri Bainun, Ipoh

Based on the worksite observation, interviews and record inspections, the clinical waste collection and disposal activity is in accordance with guidelines set by Department of Environment in terms of good management practices.

The occupational safety and health risk control measures were implemented well in order to minimize the risk posed by identified hazards. An overall safety committee is established under XXX Sdn Bhd for Hospital Raja Permaisuri Bainun, Ipoh. The clinical waste management is also monitored by this committee.

Employee representative from clinical waste collectors and cleaners are involved in the committee as well. A weekly walkabout and inspection is done by this committee to ensure all safety aspects are implemented well. The safety committee meeting with the management is held once a month to discuss any emerging issues.

Personal protective equipment is distributed to all cleaners and clinical waste collectors adequately. The aprons used by clinical waste collectors are sent for washing daily and gloves are advised to be changed for every collection.

Hand sanitizers are placed in all the wards for the usage of cleaners and the clinical waste collectors are advised to wash their hands with sanitizers each time after transferring the waste in temporary storage area.

As for administrative control, all clinical waste bins and the clinical waste collection area in the wards are seen to be labelled well. Regular inspection is done by the supervisors to ensure clinical waste bins and the collection areas are clean and free from any spillage. All clinical waste spillage are cleaned immediately. In-case of waste overloading on the bins, the clinical waste collectors are informed for immediate collection. All yellow bags collected from the wards and clinics are sealed before transfer into collection bins. Ministry of Health (1993), advised to use double layer plastic for waste from high risk areas such as operation theatres.

The collection bin is locked when transferring the waste from wards into temporary storage area to avoid any spillage or expose to public.

Induction trainings were conducted for new staff however lack of awareness on hazards and associated risks were observed among the workers. According to Arab et al (2008), clinical waste handlers are exposed to hazards due to improper handlings.

It was noticed that no continuous toolbox talks or safety briefings were conducted for the cleaners as well as clinical waste collectors. The interviewed safety committee member agreed to propose about implementation of toolbox talks during the safety committee meeting.

The accidents investigation records shows record keepings are done efficiently. The hazard identification, risk assessment and risk control are reviewed on yearly basis. However, it was noticed that risk assessment was not done quantitatively.

This does not give a clear picture to the management on the risk rating of the hazards found at the workplace.

Quantitative risk assessment methodology has been proposed to the safety committee. This could help to enhance the risk control on clinical waste management at Hospital Raja Permaisuri Bainun, Ipoh.

5.3.2 At AAA incineration plant

Followed by observation, inspection through checklist and overall interview at the incineration plant, the risk control implementation is in accordance to Guidelines for hazard identification, risk assessment and risk control (HIRARC) 2008.

The safety officer controls the hazard at the plant by monthly safety audits and regular inspections to ensure appropriate maintenance is done accordingly. Regular weekly toolbox safety briefings are also conducted to the plant operators and this also helps to discuss emerging safety and health related issues at the plant. Regular meetings are also held between safety committee and the top management to discuss issues on hazards and other safety and health related issues.

This is to ensure better control through elimination, substitution, engineering, administrative or personal protective equipment. Latest updates and requirements on OSHA regulations are also discussed by the safety committee with the management during this meeting.

The risk control implementation at the incineration plant is aimed to ensure that all activities are conducted according to safety plan requirements to reduce the risk and impacts on the environment and employees.

Safety and health of workers are given priority at the incineration plant. Frequent monitoring is done at the plant by the safety officer and plant manager to ensure all safety aspects are implemented accordingly by the employees. The zero accidents at the plant indicate good safety practices by the management.

Control measures are implemented strictly at the plant. This can be seen through all employees using PPE while working at the plant and machine guards are used widely as an engineering control measure. Appropriate safety signage is placed at designated areas to show administrative control measures are applied as well.

Personal protective equipment is the last choice in hierarchy of control. The use of personal protective equipment among healthcare workers, is recommended strongly to reduce exposure to hazards when administrative and engineering control is not feasible or effective enough in reducing those exposures to acceptable level (Jeyakumar, 2008). Employers are responsible to determine the type of PPE to be used and inculcate awareness among health care workers to enable them to understand the reasons for using PPE. For example, exposure to blood or body samples from unknown source increase risk of workers for serious infectious diseases.

In such situations, personal protective equipment act as barrier to protect healthcare workers from hazardous infectious materials. Therefore, PPE is used as the best controlling method to ensure workers safety.

Breakdown of fan system happens frequently at the incineration plant and it sometime causes electric static which have the risk for death. So, as one of the engineering control, machine guards are fixed on each fan at the plant for safety purposes.

Administrative control is another type of control measure used to reduce exposure on the risk of various kinds of hazards. Basically, this control measure is suggested and implemented through safety committee of safety officer who have the knowledge of hazards and safety at plant. Slip and fall is one of the common physical hazards that occur at the incineration plant.

Therefore, ensuring adequate housekeeping through administrative control by proper instructions and housekeeping schedule is important to avoid such hazards at the incineration plant.

On job training is provided to all the staff at the plant to ensure they are aware of any changes made in the system in order to avoid any human errors and keep all the risk in control. Meanwhile, new workers are briefed clearly about the whole system despite only on their job task for them to get familiarized with the system and management of the plant. During probation period, each new staff is monitored by a senior staff.

Continuous education to employees also helps to reduce and control risk at workplace. At the incineration plant, yearly ISO awareness seminars are conducted for employees.

During those seminars, HIRARC study is included as well. This helps to increase employee's knowledge on safety and control methods. It is important to make employees aware of the advantages and the reason behind implementation of safety programs and control measures. It educates them prevent long term health effects from any risk due to hazards at workplace.

Communication between plant operators with safety officer and plant manager is given priority to ensure any hazards or problems encountered at workplace were solved immediately. Toolbox briefing is used as the main platform to communicate regarding control measures, new concept of regulations, do and don't at the plant area.

Technicians involved in maintenance works are sent out for specific job training at NIOSH (National Institute of Occupational Health & Safety) and some other private training institutes in order to keep them competent in performing their assigned job task. All training records were well kept by the Human Resource Department.

Record keeping of the weekly, monthly, quarterly and yearly for maintenance and monthly hazard identification checklist is done effectively at the incineration plant and it is also considered as a hazard control measure. Proper procedures and forms were developed and implemented for reporting purposes. Therefore, maintaining the risk control measures for initial hazards identified and appropriate identification of any emerging hazards is well managed. Generally, record keeping for accident reports, maintenance records, hazard identification and control records helps the management to increase the safety effectiveness and health administration at the work place.

6.0 CONCLUSION

Clinical waste poses serious hazards and risk to human health. The clinical waste handlers are exposed to these hazards during the daily waste collection and disposal activities. In this study, the existing and potential hazards found during clinical waste collection and disposal practices in a hospital and an incineration plant focusing on clinical waste handlers were identified. The hazard identification checklist, workplace inspection through observation and interview questionnaire and accident incident investigation report reviews were used for hazard identification process. The hazards were then categorized as either safety or health hazard followed by classification into seven different classes of hazards (biological, chemical, physical, mechanical, ergonomic, electrical & physiological) through job hazard analysis. Along with hazard identification and classification, a quantitative risk assessment has been done to prioritize the risk control management. Finally, the current risk control measures were assessed and recommendations made for improvement to minimize the associated risk.

6.1 Hospital Raja Permaisuri Bainun, Ipoh

A total of 10 hazards were identified at the hospital during clinical waste collection and disposal activities; 2 existing hazards and another 8 potential hazards. These hazards were then categorized as safety or health hazards. Those hazards fall under biological, physical, mechanical & ergonomic class. Biological hazard is the main existing hazard found during handling of clinical waste due to direct contact with waste, inhalation and the risk cause by needle prick injuries. The extensive exposure to clinical waste has high chances to cause infectious disease if appropriate preventive measures are not implemented accordingly.

Some potential physical, mechanical and ergonomic hazards were also found during transferring of waste to temporary storage area and during cleaning activities.

From the study on hazard and risk assessment, 40% of the hazards found during clinical waste collection and disposal activities are categorized under high risk rating while another 60% are medium risk hazards. None of the hazard found is under low risk category.

All the risks are manage and kept under control through appropriate personal protective equipment usage and well managed administrative control. The HIRARC study was done by the safety committee on qualitative basis. Quantitative risk analysis was suggested to the management to get better knowledge on the risk ratings, therefore the risk control can be improvised.

The study at Hospital Raja Permaisuri Bainun,Ipoh suggest the need for detail continuous awareness and training to the clinical waste collectors and cleaners. This is important to reduce the risk level posed by them. The management need to improvise on the current method of HIRARC study and analysis.

The clinical waste collection and disposal at Hospital Raja Permaisuri Bainun, Ipoh is managed well in accordance to the guidelines set by Ministry of Health, Malaysia, Department of Environment, Malaysia and Environmental Quality Act, 1974. The safety implementations at worksite fulfil the guidelines and requirements set under Malaysian Occupational Safety & Health Act, Act 514.

6.2 AAA Incineration Plant

From the total of 82 hazards identified during the study at incineration plant, 18 were existing hazards and another 64 were potential hazards. These hazards were then categorized as safety or health hazards followed by classification as biological, chemical, physical, mechanical, ergonomic, electrical and physiological.

Experimental data from previous studies confirms that incinerators release toxic substances where incinerator workers are exposed to chemical hazard extensively. Wide range of associated health impacts have been identified among hazardous waste incinerator workers (Bakoglu et al., 2004). However according to study conducted at the AAA incineration plant, chemical hazard is an existing hazard but there is no evidence of health reports that show impact on operator's health. This may be due to short term employment. The most senior plant operator and maintenance technician at the plant are only with 2 years of employment. Previous studies showed severe health effects is observed only after long term of employment (Bakoglu et al., 2004).

Referring to literatures, most incineration plants have similar hazards which cause more health implications compare to safety hazards. According to Allsopp et al., (2001), incinerators are highly potential to create health damage. The other common existing hazard found at the AAA incineration plant was the biological hazard due to clinical waste exposure during plant preparation and waste storage activities.

Direct contact with clinical waste may results in severe infectious diseases. Needle prick injuries occur during handling of waste or during transferring of incineration ash into jumbo bags.

As per records in AAA incinerator, there was no case of infectious disease reported. However, through interviews with operators it was found that there were needle prick injuries happened before but no accident reports were recorded. According to Redy N.K.S. (2009), risk of viable HIV has been discovered in blood samples and needles up to 16 days after death of a HIV infected individual. Previous needle prick injuries at the plant were managed by immediate blood check-up to identify if there is any serious viral or bacterial infection.

Study conducted at the AAA incineration plant showed electrical shock as one of the potential hazard that could not be ignored from this type of plant. Electrical shock hazard is considered prone to happen at the incineration plant during maintenance works. This can cause permanent disability or fatality to the employees.

According to Poulsen OM et al., (1994), occupational accident occurrences have been found to be higher among waste handlers compare to other workforce at the plant. Ergonomic hazard due to unnatural movement is an existing hazard that frequently happens at the studied AAA incineration plant. Waste handlers involved in heavy lifting job task as well as manual handling of large containers may increase risk to musculoskeletal disorders.

Most of the physical, mechanical and physiological hazards found were potential hazards highly prone to happen but currently is managed well through administrative and engineering controls.

The quantitative risk assessment shows only 19% from overall hazards show high level risk, thus the safety committee is satisfied with the plant environment.

The 49% of medium risk level hazards and a 32% of low risk level hazards were considered as in manageable level. However, all the risk solved and control measures implemented must be instituted and documented properly for reference and improvisation purpose.

More reduction may be unnecessary except certain control measures can be implemented for improvisation to ensure the risks are always under control. Therefore, the safety management at the plant have implemented certain engineering controls such as machine guards on some of the parts. High administrative control and regular inspections are done on the whole system according to schedules. Awareness is given to employees to prevent the hazards or reduce the risk at the studied plant area.

During safety studies at the plant, it was observed that certain duties were incumbent on the plant manager, safety officer and other operators to ensure the HIRARC is applied well. The plant manager required to ensure the HIRARC is carried out periodically according to preparation, process and maintenance works involving all staff at the plant. The safety officer is responsible to coordinate, prepare and update the HIRARC list accordingly with assistance from other engineers and technicians in the plant. The HIRARC is discussed in the safety committee meeting and any emerging significant issues on hazards are informed to the top management for appropriate control measures. All plant operators are kept in close communication through weekly toolbox briefing to ensure effective risk control implementation.

The safety and health management at the AAA incineration plant must be improved in terms of risk control measures to ensure the safety and health of employees is kept at top priority.

The current control measures are managed well, however long term health impacts were not considered. The details analysis on workers' health records, internal air quality inspection and detailed accident investigations are essential to improvised and make changes on risk control measures according to needs.

Overall, to ensure safety program is implemented well at the incineration plant, well established maintenance and supervision program is important. The safety committee and the plant top management follows OSHA and EQA standard by doing appropriate maintenance, inspection and administration control measures to reduce risk posed by the hazards and maintain it at an acceptable level.

In comparison with Department of Occupational Safety & Health HIRARC guidelines and OSH Act 514, Law of Malaysia, the AAA incineration plant is under control of safe condition.

The primary conclusion from this dissertation is that there are opportunities to reduce risks associated with clinical waste management. For better monitoring and control, Malaysia needs proper national legislation on clinical waste management and practices. This is necessary to ensure the hazards and the associated risks does not cause harmful effects on individuals involved in clinical waste handling and disposal activities. The results from this study can be used as a baseline data to establish a hazard and risk management guidelines to improve clinical waste management in Malaysia.

6.3 Recommendations:

The following recommendations are suggested to improve clinical waste hazard and risk management at Hospital Raja Permaisuri Bainun, Ipoh and AAA incineration plant.

1) Hospital Raja Permaisuri Bainun, Ipoh should established a comprehensive training manual for clinical waste handling and management practices.
2) All details on hazards and its associated risks must be briefed to all the clinical waste handlers to avoid any incidents during improper handling.
3) A demonstrative program should be conducted for those who have had direct contact with clinical waste to create better understanding on the risk and importance of good handling practices to minimize the risk
4) A quantitative risk assessment must be established for clinical waste management at Hospital Raja Permaisuri Bainun, Ipoh. This will help to evaluate and get better picture on the risk rating for each hazard.
5) The HIRARC must be reviewed when there is an accident reported, thus it will make changes in the risk rating. This will help to improve the risk control measures.
6) Internal air quality inspection should be done at the AAA incineration plant to evaluate and ensure the air quality is within the safe limit for working condition.
7) Detail comparison analysis must be done on the medical check-up records of incinerator operators. This would aid in early detection of health problems.
8) All accidents regardless of severity shall be recorded and investigated accordingly in order to identify the root cause and take appropriate preventive measures.

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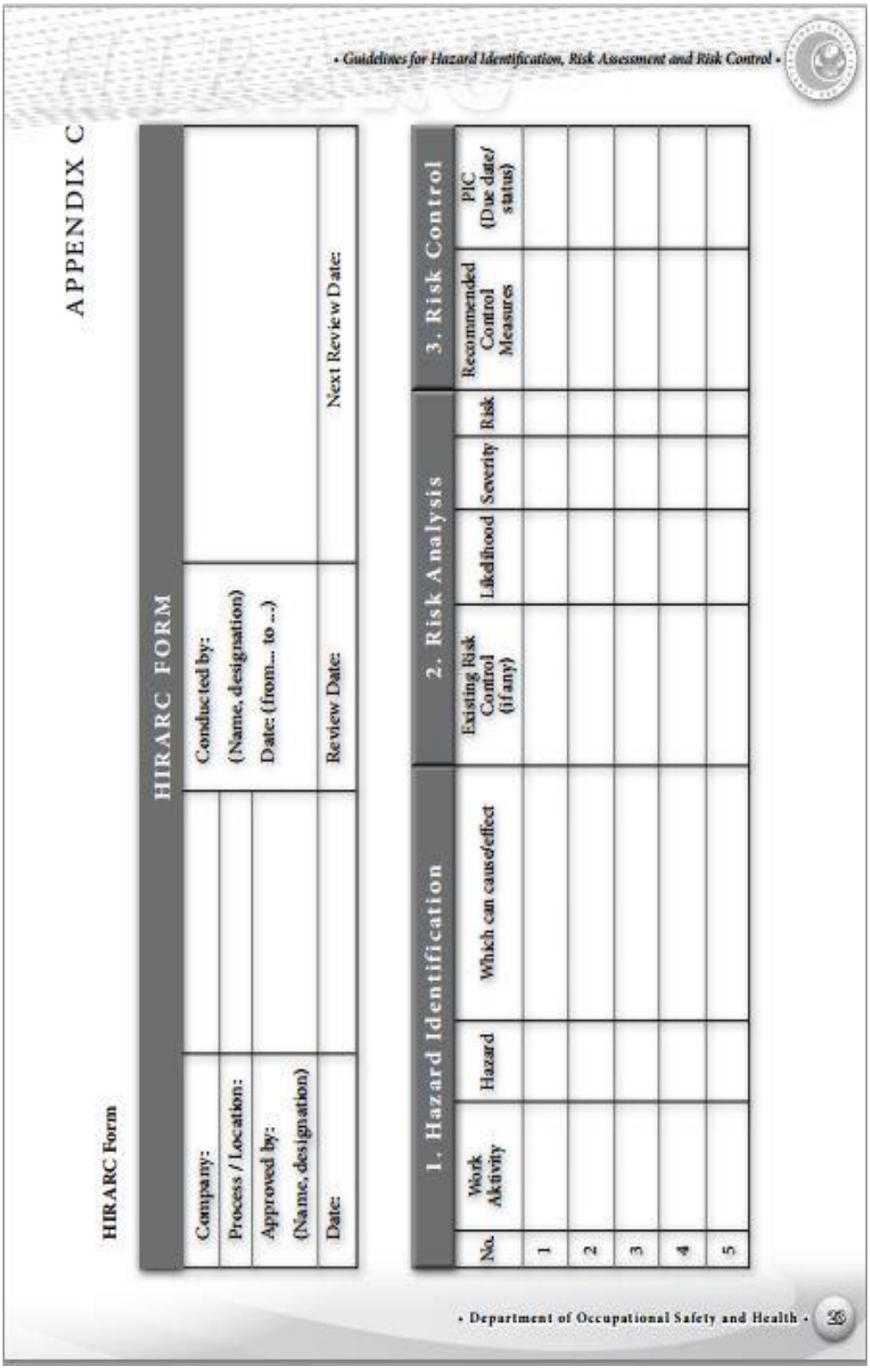
APPENDICES

Appendix A : HIRARC Form (DOSH)



• Guidelines for Hazard Identification, Risk Assessment and Risk Control •

APPENDIX C

HIRARC Form

HIRARC FORM

Company:		Conducted by: (Name, designation)	
Process / Location:			
Approved by: (Name, designation)		Date: (from... to ...)	
Date:		Review Date:	Next Review Date:

No.	1. Hazard Identification			2. Risk Analysis				3. Risk Control	
	Work Aktivity	Hazard	Which can cause/effect	Existing Risk Control (if any)	Likelihood	Severity	Risk	Recommended Control Measures	PIC (Due date/ status)
1									
2									
3									
4									
5									

• Department of Occupational Safety and Health •

Appendix B: Preliminary Accident Report form

[redacted]

[redacted]

ACCIDENT / INCIDENT REPORT (PRELIMINARY)

Ref. No. : _____

SITE / HOSPITAL / PLANT : _____ This report is to be filled within 24 hours

COPY 1	:	Senior Manager Operations (Healthcare)
COPY 2	:	Health, Safety, Security, Environment Manager
COPY 3	:	HR Dept. – HQ KL
COPY 4	:	Customer Service Manager
COPY 5	:	Legal Advisor
COPY 6	:	BRI Manager – Clinical Waste Accident/Incident Only
COPY 7	:	Ministry of Health / Hospital (Processed by Owner of Copy 2)

ACCIDENT INFORMATION (WHAT)		VICTIM INFORMATION	
DATE OF ACCIDENT :		VICTIM NAME :	
TIME OF ACCIDENT :		DESIGNATION :	
LOCATION :		WITNESS (IF ANY) :	
WHAT :		NAME :	
		DESIGNATION :	

DESCRIPTION OF ACCIDENT (HOW IT HAPPENED)	CORRECTIVE PREVENTIVE ACTION TAKEN
RESULT OF ACCIDENT (DAMAGE, INJURY AND NUMBER OF MEDICAL LEAVE GIVEN)	REPORT PREPARED BY :
	NAME :
	DESIGNATION :
	DATE :
	VERIFIED :

FOR USE BY SAFETY SECTION	
	DATE RCVD :
	REPORT NO :
	LTA YES/NO :
	LOST TIME :
	APP COST :
	CC DIV AREA / INS

Appendix C: Accident Investigation Report

[redacted]

[redacted]

ACCIDENT / INCIDENT INVESTIGATION REPORT (AFTER INVESTIGATION)

Ref. No. : _____

GENERAL INFORMATION

[ ] Significant Inc./Damage [ ] First Aid/Injury [ ] Medical Treatment	[ ] Restricted Work [ ] Lost Time [ ] Fatal / Other	Victim (Div/Loc. ID)	Accident No :

Date & Time Accident	Date Incident Reported	Witnesses

SUMMARY Describe the incident (photo and/or sketch may be necessary)

ANALYSIS Describe conditions and/or actions that lead to the incident

RECOMMENDATIONS Describe the control and/or corrective, preventive measures

MANAGEMENT SYSTEM IMPROVEMENT Describe measures that should/will be taken to improve system

COMPLETE THIS SECTION IF THE INCIDENT INVOLVED AND INJURY/ILLNESS

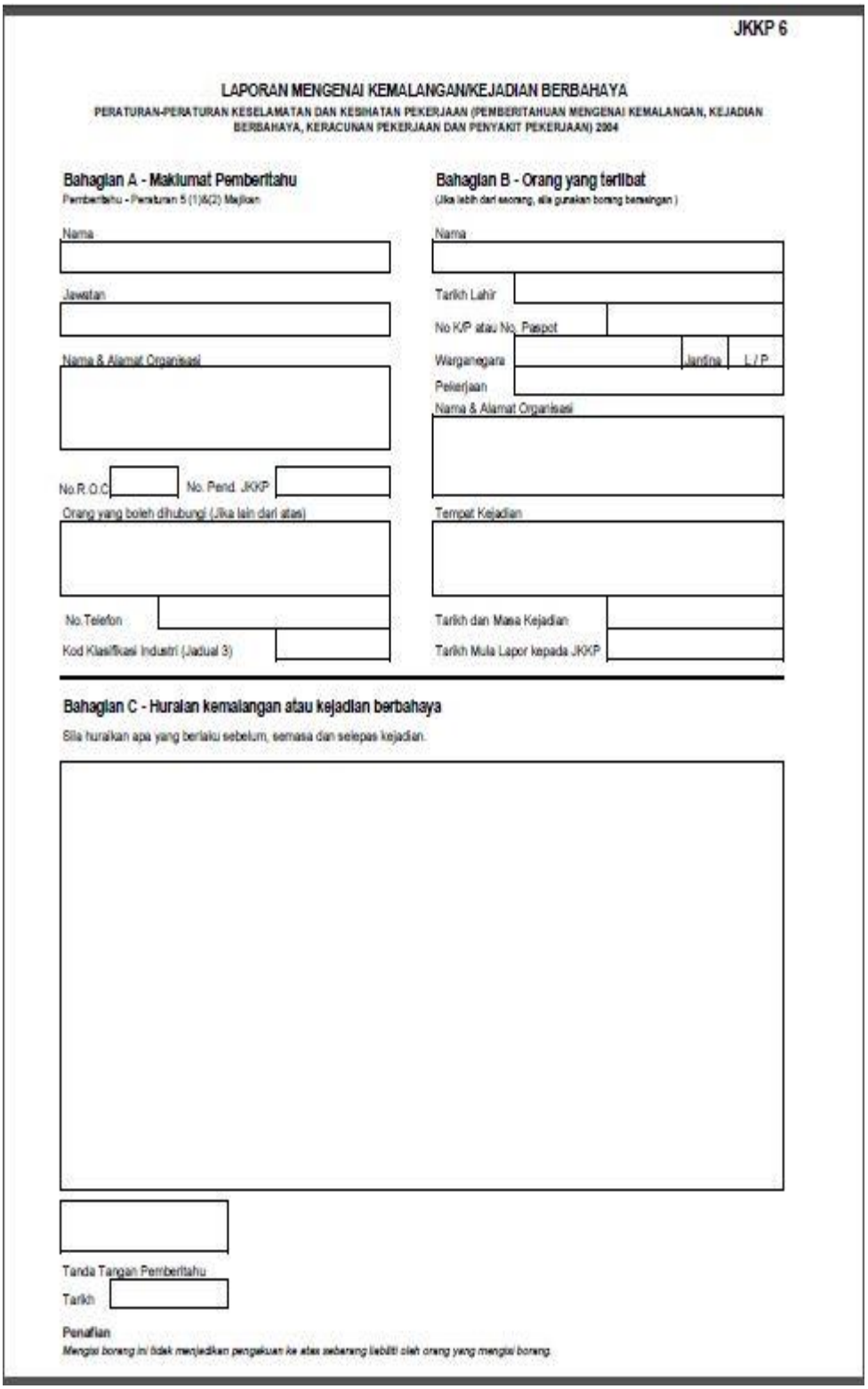
Name of injured/ill patient		Home Address	
SOCSO Number/EPF	Assigned Department	OCC. At Time inj./ill	Supv. At time of inj./ill

Describe injury of illness in detail, part of body affected & treatment received

Doctor :	Hospital :
Address :	Address :

Report completed by : Date :	Report reviewed by : Date :

Appendix D: JKKP 6 Form



JKKP 6

LAPORAN MENGENAI KEMALANGAN/KEJADIAN BERBAHAYA

PERATURAN-PERATURAN KESELAMATAN DAN KESIHATAN PEKERJAAN (PEMBERITAHUAN MENGENAI KEMALANGAN, KEJADIAN BERBAHAYA, KERACUNAN PEKERJAAN DAN PENYAKIT PEKERJAAN) 2004

Bahagian A - Maklumat Pemberitahu

Pemberitahu - Peraturan 5 (1)&(2) Majikan

Nama

Jawatan

Nama & Alamat Organisasi

No.R.O.C. No. Pend. JKKP

Orang yang boleh dihubungi (Jika lain dari atas)

No.Telefon

Kod Klasifikasi Industri (Jadual 3)

Bahagian B - Orang yang terlibat

(Jika lebih dari seorang, sila gunakan borang berasingan)

Nama

Tarikh Lahir

No K/P atau No. Pasipot

Warganegara Jantina L / P

Pekerjaan

Nama & Alamat Organisasi

Tempat Kejadian

Tarikh dan Masa Kejadian

Tarikh Mula Lapor kepada JKKP

Bahagian C - Huraian kemalangan atau kejadian berbahaya

Sila huraikan apa yang berlaku sebelum, semasa dan selepas kejadian.

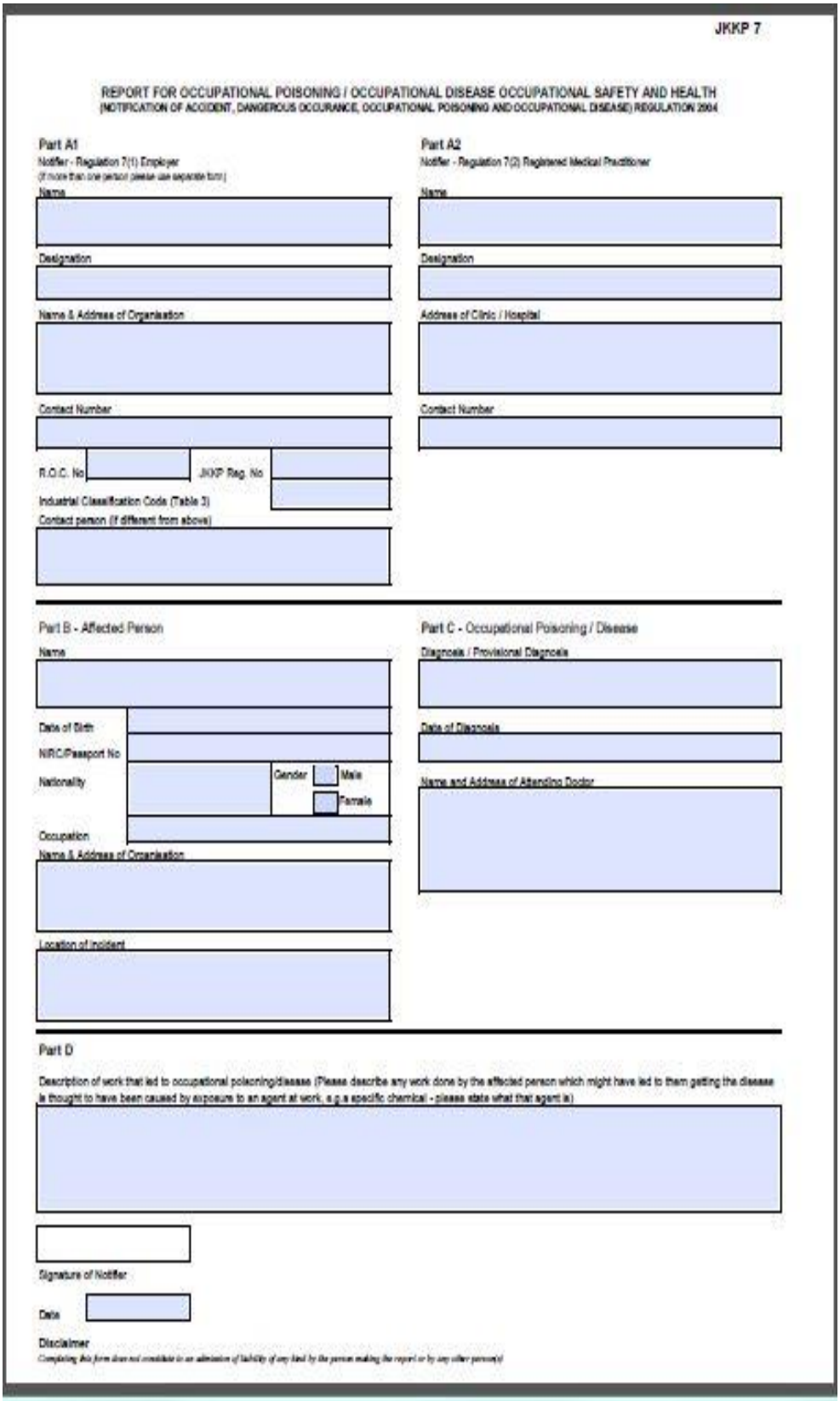
Tanda Tangan Pemberitahu

Tarikh

Penafian

Mengisi borang ini tidak menjadikan pengakuan ke atas sebarang liabiliti oleh orang yang mengisi borang.

Appendix E: JKKP 7 Form



JKKP 7

REPORT FOR OCCUPATIONAL POISONING / OCCUPATIONAL DISEASE OCCUPATIONAL SAFETY AND HEALTH
(NOTIFICATION OF ACCIDENT, DANGEROUS OCCURANCE, OCCUPATIONAL POISONING AND OCCUPATIONAL DISEASE) REGULATION 2004

Part A1
Notifier - Regulation 7(1) Employer
(If more than one person please use separate form)

Name

Designation

Name & Address of Organisation

Contact Number

R.O.C. No | JKKP Reg. No

Industrial Classification Code (Table 3)

Contact person (if different from above)

Part A2
Notifier - Regulation 7(2) Registered Medical Practitioner

Name

Designation

Address of Clinic / Hospital

Contact Number

Part B - Affected Person

Name

Date of Birth

NRIC/Passport No

Nationality

Gender: Male / Female

Occupation

Name & Address of Organisation

Location of incident

Part C - Occupational Poisoning / Disease

Diagnosis / Provisional Diagnosis

Date of Diagnosis

Name and Address of Attending Doctor

Part D

Description of work that led to occupational poisoning/disease (Please describe any work done by the affected person which might have led to them getting the disease is thought to have been caused by exposure to an agent at work, e.g. a specific chemical - please state what that agent is)

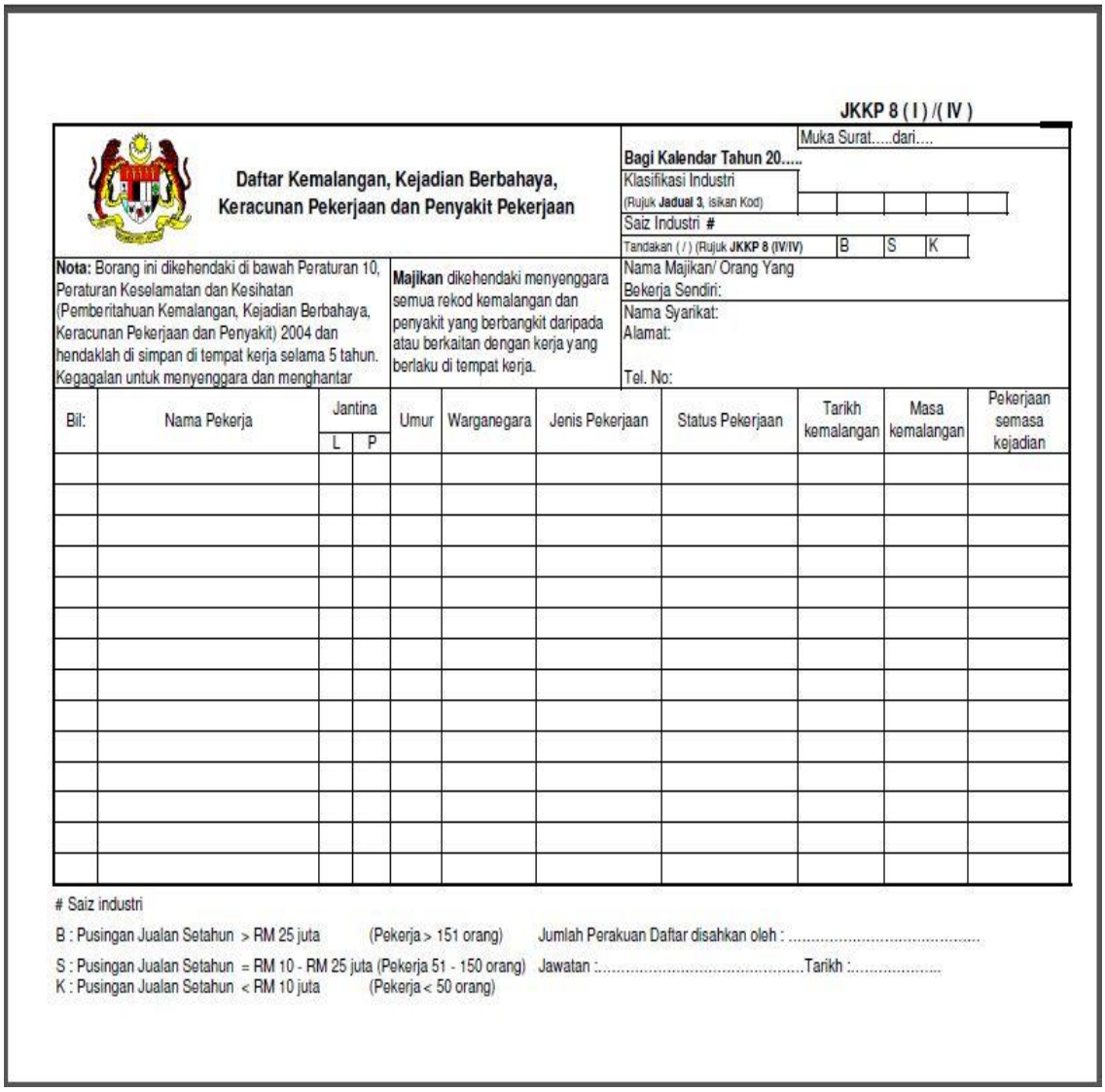
Signature of Notifier

Date

Disclaimer

Completing this form does not constitute to an admission of liability of any kind by the person making the report or by any other person(s)

Appendix F: JKKP 8 Form



JKKP 8 (I) /(IV)

Daftar Kemalangan, Kejadian Berbahaya, Keracunan Pekerjaan dan Penyakit Pekerjaan

Muka Surat.....dari....

Bagi Kalendar Tahun 20.....

Klasifikasi Industri (Rujuk **Jadual 3**, isikan Kod)

Saiz Industri #

Tandakan (/) (Rujuk **JKKP 8 (IV/IV)**) B S K

Nota: Borang ini dikehendaki di bawah Peraturan 10, Peraturan Keselamatan dan Kesihatan (Pemberitahuan Kemalangan, Kejadian Berbahaya, Keracunan Pekerjaan dan Penyakit) 2004 dan hendaklah di simpan di tempat kerja selama 5 tahun. Kegagalan untuk menyenggara dan menghantar

Majikan dikehendaki menyenggara semua rekod kemalangan dan penyakit yang berbangkit daripada atau berkaitan dengan kerja yang berlaku di tempat kerja.

Nama Majikan/ Orang Yang Bekerja Sendiri:

Nama Syarikat:
Alamat:

Tel. No:

Bil:	Nama Pekerja	Jantina		Umur	Warganegara	Jenis Pekerjaan	Status Pekerjaan	Tarikh kemalangan	Masa kemalangan	Pekerjaan semasa kejadian
		L	P							

Saiz industri

B : Pusingan Jualan Setahun > RM 25 juta (Pekerja > 151 orang)

S : Pusingan Jualan Setahun = RM 10 - RM 25 juta (Pekerja 51 - 150 orang)

K : Pusingan Jualan Setahun < RM 10 juta (Pekerja < 50 orang)

Jumlah Perakuan Daftar disahkan oleh : .....

Jawatan :.....Tarikh :.....

Appendix G: Consignment note for clinical waste

[redacted]

Serial No.

ENVIRONMENTAL QUALITY (SCHEDULED WASTES)
REGULATIONS 1989
SIXTH SCHEDULE
(Regulation 10)

CONSIGNMENT NOTE FOR CLINICAL WASTES

I. WASTE GENERATOR *(Pengeluar Sisa)*
Waste Generator Code : *(Kod Pengeluar Sisa)* / State Code : *(Kod Negeri)*
Name Of Waste Generator : *(Nama Pengeluar Sisa)*
Address : *(Alamat)*
Name Of Responsible Person : *(Nama Orang Yang Bertanggungjawab)* Tel. No. : Fax. No.
Type Of Waste : *(Nama Buangan)* Waste Category Code : *(Kod Kategori Sisa)*
Waste Origin : *(Punca Buangan)*

Bin No.	Wt. Kg.	Bin No.	Wt. Kg.	Bin No.	Wt. Kg.	Bin No.	Wt. Kg.	Bin No.	Wt. Kg.	Bin No.	Wt. Kg.

Total Waste Quantity Kg : *(Jumlah Kuantiti Sisa)*
Authorised MoH Representative Signature : *(Tandatangan Wakil MoH)* Print Name : *(Nama)* Date of Delivery : *(Tarikh Penyerahan)*
Name And Address of Final Destination : *(Nama Dan Alamat Destinasi Akhir)*

II. CONTRACTOR *(Kontraktor)*
Contractor Code : *(Kod Kontraktor)* / State Code : *(Kod Negeri)*
Name Of Contractor : *(Nama Kontraktor)*
Address : *(Alamat)*
Name Of Responsible Person : *(Nama Orang Yang Bertanggungjawab)* Tel. No. : Fax. No.
Contractor Representative Signature : *(Tandatangan Wakil Kontraktor)* Print Name : *(Nama)* Date : *(Tarikh)*

III. TRANSPORTER *(Pengangkut)*
Transporter Code : *(Kod Pengangkut)* / State Code : *(Kod Negeri)*
Company Name Of Transporter : *(Nama Syarikat Pengangkut)*
Address : *(Alamat)*
Name Of Responsible Person : *(Nama Orang Yang Bertanggungjawab)* Tel. No. : Fax. No.
Driver's Signature : *(Tandatangan Pemandu)* Print Name : *(Nama)*
Vehicle Reg. No. : *(No. Pendaftaran Kenderaan)* Date : *(Tarikh)*

IV. DISPOSAL FACILITY OPERATOR *(Operator Kemudahan)*
Facility Code : *(Kod Kemudahan)* / State Code : *(Kod Negeri)*
Name Of Facility : *(Nama Kemudahan)*
Address Of Facility : *(Alamat Kemudahan)*
Name Of Responsible Person : *(Nama Orang Yang Bertanggungjawab)* Tel. No. : Fax. No.
Type Of Operation : *(Jenis Operasi)*

- ☐ Storage : *(Penyimpanan)*
- ☐ Reprocessing *(Pengolahan)*
- ☐ Recovery *(Pemulihan)*
- ☐ Landfill *(Tapak Pelupusan)*
- ☐ Secure Landfill *(Tapak Pelupusan Selamat)*
- ☐ Incinerator *(Pembakar)*
- ☐ Physical/Chemical Treatment : *(Rawatan Fizikal/Kimia)*
- ☐ Others (specify) : *(Lain-lain)*

Quantity Of Waste Received Kg : *(Jumlah Kuantiti Sisa Diterima)*
Number Of Bins Received : *(No. Tong Diterima)*
Date Of Received *(Tarikh Diterima)*
Received By Signature : *(Tandatangan Penerima)* Print Name : *(Nama)*

Copy No. 1 (of 3), to be retained by the Waste Generator
Untuk disimpan oleh Pengeluar Sisa