CHEMICAL HEALTH RISK ASSESSMENT (CHRA) AT WATER TREATMENT SERVICE PROVIDER FOR SEMICONDUCTOR INDUSTRY

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CHEMICAL HEALTH RISK ASSESSMENT (CHRA) AT WATER TREATMENT SERVICE PROVIDER FOR SEMICONDUCTOR INDUSTRY

ABSTRACT

The assessment of chemical health risk in the workplace is necessary for every employer to ensure their employee's wellness under the Occupational Safety and Health Act 1994 and the Use and Standard of Exposure of Chemicals Hazardous to Health (USECHH), 2000 Regulations. In this assessment, the goal is to determine and analyse the level of chemical exposure to the workers. One work unit, which is the Facilities Workers, has been selected. The assessment was carried out according to CHRA Manual 3rd Edition. A qualitative approach was used to assess the risk and adequacy of control measures, which included a site visit, observation of employee tasks while handling chemicals, and examination of the work manual and other relevant record and documents. A total of 12 chemicals were assessed. It was concluded that all chemicals were classified as Chemicals Hazardous to Health (CHTH) but Action Priority 3 (AP3) was given, where the existing control measures were adequate to curb the exposure.

Keywords: Chemical Health Risk Assessment, control measures, hazardous chemical

PENAKSIRAN RISIKO BAHAN KIMIA KEPADA KESIHATAN (CHRA) DI PERKHIDMATAN RAWATAN AIR UNTUK INDUSTRI SEMIKONDUKTOR

ABSTRAK

Akta Keselamatan dan Kesihatan Pekerjaan 1994 serta Peraturan-Peraturan Keselamatan dan Kesihatan Pekerjaan (Penggunaan dan Standard Pendedahan Bahan Kimia Berbahaya kepada Kesihatan) 2000, mengkehendaki setiap majikan untuk melaksanakan penaksiran risiko bahan kimia di tempat kerja bagi memastikan kesihatan dan kebajikan pekerja adalah terjamin. Tujuan penaksiran ini dilakukan adalah untuk menganalisa tahap pendedahan bahan kimia kepada pekerja. Kawasan kerja di bahagian menara penyejuk yang dipanggil pekerja fasiliti telah dipilih untuk kajian ini. Manual CHRA Edisi ke-3 telah digunakan sebagai panduan dalam melaksanakan kajian tersebut. Lawatan tapak, pemerhatian terhadap pekerja semasa mengendalikan bahan kimia dan pemeriksaan manual kerja serta dokumen-dokumen lain yang berkenaan merupakan kaedah kuantitatif yang telah dilaksanakan untuk menaksir risiko dan kecukupan langkah kawalan sedia ada. Sebanyak 12 bahan kimia telah ditaksir dan didapati kesemua bahan kimia tersebut mendatangkan bahaya kepada kesihatan. Namun, keutamaan tindakan 3 (AP3) telah diberikan membawa maksud, langkah kawalan sedia ada adalah mencukupi untuk mengurangkan pendedahan terhadap pendedahan bahan kimia.

Keywords: Penaksiran Risiko Bahan Kimia, langkah kawalan, bahan kimia berbahaya

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LIST OF SYMBOLS AND ABBREVIATIONS

AP	:	Action priority
CHRA	:	Chemical Health Risk Analysis
CHTH	:	Chemical hazardous to health
CLASS	:	Classification, Labelling and Safety Data Sheet of Hazardous Chemicals
DOSH	:	Department of Occupational Safety and Health
ER	:	Exposure rating
GV	:	General ventilation
HR	:	Hazard rating
LC50	:	Lethal concentration, 50%
LEV	:	Local exhaust ventilation
OSHA	:	Occupational Safety and Health Act
OEL	:	Over exposure limit
PCW	:	Process Chilled Water
PPE	:	Personal Protective Equipment
RR	:	Risk Rating
SDS	:	Safety Data Sheet
USECHH	:	Use and Standard of Exposure of Chemicals Hazardous to Health

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

1.1 Chemical Health Risk Assessment (CHRA)

The Chemical Health Risk Assessment (CHRA) was carried out as a review assessment due to more than five years have elapsed since the previous assessment at the Water Treatment Service Provider located at Penang in compliance to the OSHA Act 1994 and the Use and Standard of Exposure of Chemicals Hazardous to Health (USECHH) Regulations 2000. One work unit was selected for the assessment which is the Facilities Workers. The work unit was selected based on the recommendation in the CHRA Manual 3rd Edition. A work unit is defined by a worker, or a group or workers doing similar tasks and are all exposed to the same health-hazardous chemical.

The Water Treatment Service Provider provides NSF-approved, biodegradable, non-toxic, and safe-to-use solutions for industrial water treatment, biodegradable cleaning and maintenance supplies, and emergency pipe leakage repair. The Water Treatment Service Provider is owned and managed by people, who care about their customers and have developed a healthy neurosis to meet their customers' needs. One of the serving customers is a German multinational engineering and electronics company in Penang, which it headquarters is located near Stuttgart, Germany. In terms of revenue in 2011, it is the world's largest provider of automotive components. In 1886, the company was started in Stuttgart. Brakes, controls, electrical drives, electronics, fuel systems, generators, starting motors, and steering systems are among the automotive components, whereas industrial items (drives and controls, packaging technologies, and consumer goods) and building products are among the industrial items, which are the company's mainstays (including household appliances, power tools, security systems and thermotechnology).

The company pays big attention to health and safety management aspect by consistently performing a health and risk assessment on the chemical's exposure towards staff at work. The evaluation's outcome will then decide on the type of control measures that are suffice to control the threat. There are several pathways for hazardous chemicals to go into the human body, which are inhalation, skin absorption, ingestion and injection (OSHA, 1994). At Facilities Workers work unit, the route of chemical entry is mainly through inhalation and dermal exposure. The factors that need to be considered are physical form of the chemicals, physicochemical properties of the chemicals, nature of the work, the workers working method and working environment and work procedures. In this CHRA assessment, the focus is on exposure via inhalation and dermal exposure.

The exposure assessment was carried out as stated under Use and Standard of Exposure of Chemicals Hazardous to Health (USECHH) Regulations 2000, which is to perform CHRA assessment to any activities starting from its use, handling, storage or transportation of chemicals hazardous to health (CHTH) in their work environment (DOSH, 2000). It is the employer's responsibility to make certain the assessment is carried out every 5 years once in order to monitor the chemicals exposure effect toward the workers' health. The employer needs to ensure a healthy working environment and to provide place for the employees too to prevent or reduce any non-safe working condition that could harm the employees.

In order to prove that the employer care about the employees, control measures such as engineering control, personal protective equipment (PPE) provision, training of the work for employees, emergency response preparedness, monitoring and health surveillance are to be reviewed during the assessment. During the assessment, the control

measured will be assessed whether it is adequate or need to be improved to ensure the employee wellbeing are taken care.

The evaluation carried done in accordance with Regulation 9 need to be examined by a certified assessor if:

I. There is any significant change in the work that is the subject of the evaluation.
II. The previous assessment has been done more than 5 years ago; or
III. Given order by Director General, Deputy Director General or the Director of Occupational Safety and Health (OSHA, 1994).

In January 2016, a previous CHRA was conducted at three work units that were recognised as being involved in chemical handling, namely Cooling Tower Worker, Process Chilled Water (PCW) Worker, and Chiller Worker, with a total of 14 chemicals utilised throughout the assessment. The report completed the work units with a conclusion that included C1 and C2, indicating that the risks are properly managed. Table 1.0 shows the assessment's conclusion, which is no longer utilised in the most recent CHRA guideline. The provided PPE merely needs to be maintained and recorded all of the time, and workers should remember to wear the PPE at all times.

Table 1.1: Conclusion of the assessment (Husin, S.N.N, 2012)

Risk	Sufficiency of current control measures	Conclusion
Risk not significant		C1
Risk significant	Adequate	C2
	Not adequate	C3
Insufficient information	-	C4
Uncertain about exposure	-	C5

1.2 Aim and Objectives

The aim of the CHRA is to identify and assess the health risk employees from exposure to chemical hazardous to health during normal operations. The other things which were assessed too were the control measures that are appropriate, employees' exposure health surveillance and monitoring, which were to protect the health of the employees. The CHRA assessment is used as an evaluation of risk to health posed by the use of CHTH and to identify various hazards that workers face while using CHTH in the workplace.

The objectives of this study are:

a) To evaluate the degree of workers' exposure to CHTH through either inhalation, dermal or ingestion.

b) To examine the degree of control measures already in place such as technical control, organization control and to suggest relevant preventative measures to minimize the exposures when required.

c) To propose suitable further control measures if required and prioritize actions to be carried out after the assessment.

CHAPTER 2: LITERATURE REVIEW

2.1 Hazardous Chemical Exposure

Poisoning, skin rashes, lung, kidney, and liver disorders, among other short- and long-term health effects, can be caused by chemicals commonly used in the workplace. The route a chemical enters your body can influence the likelihood of negative health impacts. Chemicals come in a variety of forms and are absorbed by the body in various ways. Chemicals can be liquid, gaseous, or solid, and they can be synthesized or found naturally. They are absorbed into the body through inhalation, cutaneous absorption, ingestion, or injection. At work, the most prevalent modes of exposure are inhalation and skin absorption (Videnros, C., 2019). Some chemicals absorb quickly through the skin, whereas others do not. The toxicity of the substance that entered your body has an impact on your health. Some substances are extremely dangerous in little quantities, whereas others are toxic only in high quantities.

In water treatment, Calcium Hydroxide (Lime) is normally delivered as a dry powder, and it can be applied either dry or as a slurry prepared on-site from the powder. Soda ash is normally delivered dry and mixed into a solution on site for dosing (Moran, S. 2018). It is used to raise pH and alkalinity, and it is widely used in drinking water to “soften,” or eliminate hardness minerals like calcium and magnesium. Lime slurries reduce the likelihood of scaling in the water distribution system. It is often used to maintain the alkalinity levels for its low cost and many treatment benefits, such as assisting in the removal of manganese and iron from water (Chemready, n.d.).

2.2 The Importance of Chemical Health Risk Assessment (CHRA)

The CHRA assessment which has been put in detail in A Manual of Recommended Practice on Assessment of the Health Risk Arising from the Use of Chemicals Hazardous to Health at the Workplace 3rd Edition, 1st reprint (2018) is used to evaluate chemical exposures and risks to workers at their respective workplace. It is the employers' responsible to ensure the workers safety and health while at work. Control measures need to be implemented accordingly to minimize the occupational health risk at the workplace (Segun, B. 2012). Many of the health concerns linked with workplace chemical exposure appear to have vanished as a result of the hard work and attention of occupational health and safety specialists over the previous several decades. Furthermore, we must recognize that the low occurrence of serious health problems is due to prior efforts to better understand the toxicological of these dangerous compounds and manage them through safer work systems, not because humans have become resistant to their adverse effects. (Levy, L., 2004).

2.3 Chemical Management at Water Treatment Plant

There were 12 chemicals were assessed in the work unit and the chemicals were classified as chemical hazardous to health (CHTH). The employees need to ensure that the workers were provided with proper chemical management and training to make them aware about the potential hazards pertaining to the chemicals used. A case report has been reviewed by Lipski, M. (2012) that a dentist accidently spilled calcium hydroxide into her own eye while doing an endodontic treatment to her patient, which cause her to lost her sight. Preventative actions must be implemented largely in order to prevent any tragic incidents. Chemical management practice which include chemical register, chemical inventory and chemical storage need to be implemented to minimize the chemical and hazard exposure to workers.

2.3.1 Chemical Register

According to the Guidelines for the Preparation of a Chemical Register, all chemicals must be registered in a form known as the Register of Chemical Hazardous to Health. The chemical register will include information on the chemical composition, quantities used, and places where are chemicals used or kept, as well as trade and common names. Occupational Safety and Health Regulations (USECHH, 2000) states that an employer must identify and record all chemicals dangerous to health used at work in a register. This chemical register is used to inform employees and to act as a guidance about the hazards of the chemicals used at their workplace and the precautions that must be followed in the event of an accident (Husin, S.N.H. et. al., 2012)

2.3.2 Chemical Storage

Department of Occupational Safety and Health, (2005) has listed out that the employer should adhere to the guidelines given:

a) To provide and maintain plant and systems that are both safe and free of health concerns.

b) To establish plans for the safe use, operation, handling, storage, and transportation of plants and chemicals so that they do not pose a health concern.

c) To safeguard the safety and health of his people at work by providing information, guidance, training, and supervision.

d) To provide and maintain a working atmosphere that is both safe and healthy for his employees, including means of entry and exit from any place of business;

e) To maintain and offer a safe and healthy working environment for his employees, including suitable welfare facilities.

2.3.3 Chemical Inventory

Chemical inventory accuracy is a legal necessity for using, handling, and storing hazardous compounds, as well as a foundation for effectively communicating and controlling chemical dangers in the workplace. It needs to be maintained and update regularly to avoid unnecessary purchase which could lead to stock outs, overstocks, losses, damages, misuses and unnecessary disposal of chemicals (Shukran, M. 2017).

2.4 Safety Data Sheet (SDS)

Safety Data Sheet (SDS) is a document which contain all the information about the properties of each chemical, as well as the physical, health, and environmental hazards, protective measures, and safety precautions for handling, storing, and transporting the chemical. In the SDS, Personal Protective Equipment (PPE), First Aid Procedures, and Spill Clean-Up Procedures are all covered for each specific chemical. The SDS throughout contain 16 sections. Sections 1–8 include general information on the chemical, including identification, dangers, composition, safe handling methods, and emergency control methods (e.g., fire fighting). This material should be beneficial to people who require quick access to information. Physical and chemical parameters, stability and reactivity information, toxicological information, exposure control information, and other technical and scientific information, such as the date of production or last revision, can be found in Sections 9 through 11 and 16 (OSHA, 2013).

2.5 General Description of Processes at the Water Treatment Service Provider

The Water Treatment Service Provider provides chemical treatment services for Open and Closed recirculating cooling water system and Process cooling water system. There are the four processes involve which are:

a) Chemical treatment for open re-circulating water system which were conducted weekly and monthly basis

b) Chemical treatment for evaporator water system

c) Chemical treatment for process chilled water system

d) Legionella Water Sampling Analysis

For chemical treatment for open re-circulating water system, the process involves transportation of chemicals to the cooling tower site. Then only the chemical will be pumped or poured into the tank. For other chemical treatment process, the chemicals will be dosing when the chemical residue is below the control limit. For Legionella Water Sampling Analysis, it was done in 3 months' period once and the water samples were directly collected from the basin. The assessed workers in the Water Treatment Service Provider operates in 8 hours start from 8.30 a.m. to 5.00 p.m., with a one-hour break.

2.6 Description of the Process Which Involves Chemicals Hazardous to Health (CHTH)

A walk-through inspection and study of the process was done after interviewing relevant staff concerned with each process area. It was found that most likely work areas with the work units where chemicals are used and likely to pose hazards to workers' health are Condenser, Evaporator & PCW System Area in the Semiconductor Plant.

2.7 Description of Work Unit Which Involves Chemical Hazardous to Health (CHTH)

2.7.1 Condenser, Evaporator and PCW System Area in the Semiconductor Plant

Workers are responsible to refill or manually pour the chemicals into the storage tanks. On a daily basis, the chemicals were automatically dosed into the chiller/cooling tower system. Workers were also expected to sample the cooling tower water, which included submitting the samples to a laboratory for Legionella testing.

2.7.2 Facilities Workers

There were 2 male workers from the Water Treatment Service Provider and 1 male worker assistant from the Semiconductor Plant with working time from 8.30 a.m until 5.00 p.m. with one-hour of rest time. The daily work on the facilities in this region took roughly two hours. Workers at this work unit were responsible for manually refilling and pouring chemicals into storage tanks. On a daily basis, the chemicals were automatically dosed into the chiller/cooling tower system. Workers were also obliged to collect cooling water samples, which were subsequently forwarded to a laboratory for Legionella testing.

In cooling towers, the deadly Legionella bacteria thrives because they provide optimal conditions for it to survive and multiply. Legionella is a bacterium that can cause major health problems, including respiratory infections. It's critical to keep legionella at bay in places where a large number of people could be exposed, such as hospitals, hotels, and schools. It was reported that cooling towers, by design, emit large amounts of aerosols, which, when contaminated with L. pneumophila, can disseminate the bacterium to the surrounding environment, reportedly up to 12 kilometres away. Individuals inhaling the aerosols in the dispersion region are at risk of infection, with the risk increasing as the distance between the source and the dispersion region decreases (Paranjape, K. et al., 2020).

CHAPTER 3: METHODOLOGY

3.1 Method on conducting the CHRA

The choice to take suitable action will be based on the CHRA's risk evaluation of health, which will then influence the decision on appropriate control measures (Susanto, et. al, 2020). The method in carrying out this CHRA was carried out as a qualitative assessment and was in accordance with the DOSH CHRA Manual: 3rd Edition, 1st reprint (2018). The guideline provides the assessment of all chemicals used in workplace by detecting, assessing, and managing any health risks associated with job activities pertaining to the use of chemicals. The overall procedure in implementing the CHRA is shown in Figure 3.1. However, for this study the steps will only be concluded until step 9 where it is considered that this is a generic assessment and not full assessment which need to be completed until submission of report to the employer.

This assessment will focus on evaluating inhalation and dermal exposure. The particular work place did not permit eating and drinking in the working area, thus making ingestion exposure towards chemical almost impossible.

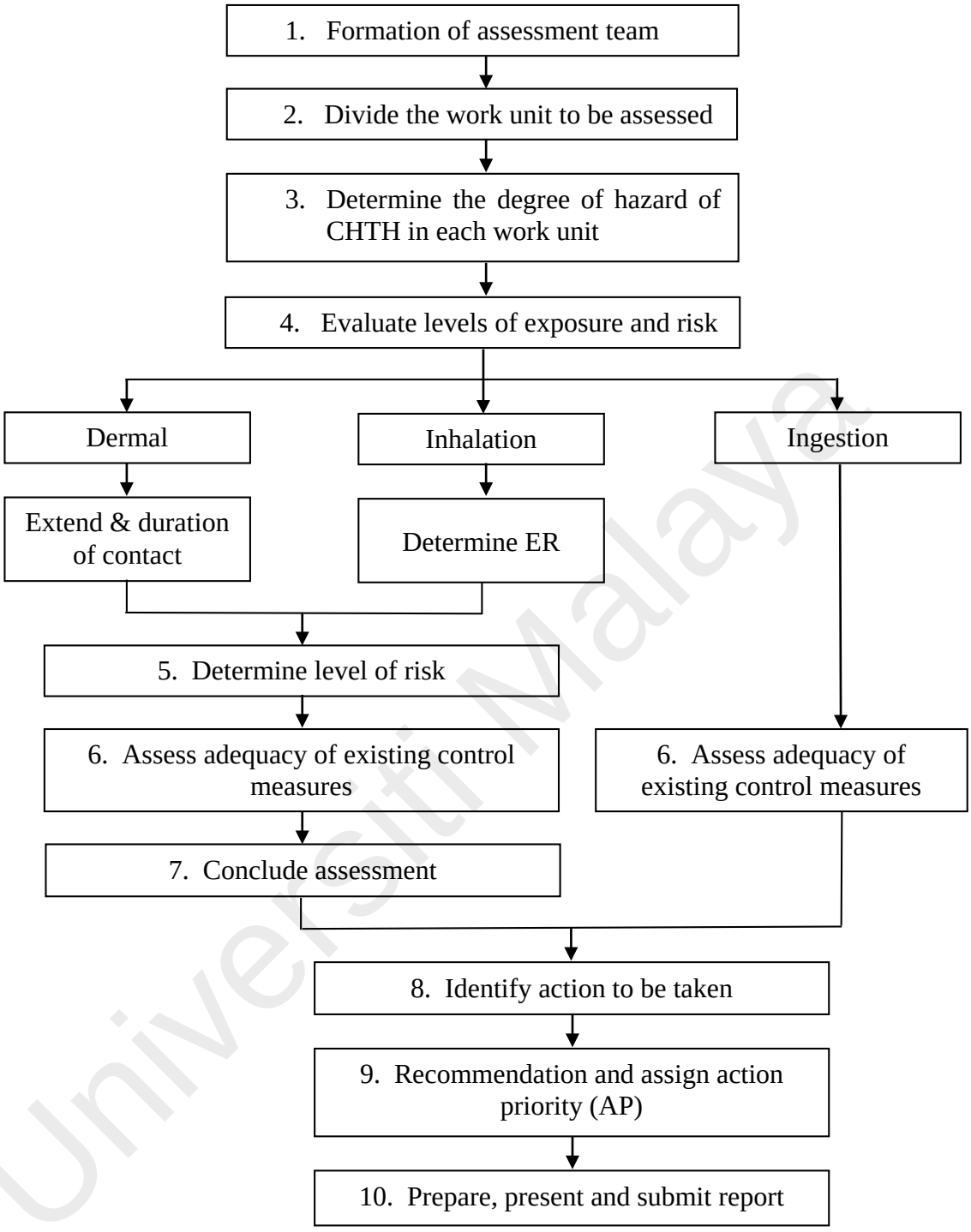

Figure 3.1: Steps for conducting CHRA

3.1.1 Formation of the Assessment Team

The first step is to decide the assessor, who will conduct the CHRA. In order to conduct the evaluation, the designated assessor must possess the necessary knowledge and fundamental scale. He or she should be granted the power to do the task and be provided with sufficient resources to gather data, confer with the appropriate employees, analyse documents, and inspect the workplace. A registered assessor with the Director General of Occupational Safety and Health, Malaysia is required, in order to comply with the USECHH Regulations 2000 (Zainon, N & Ghazali, M.F., 2009). The person chosen must gather all the details that could include:

a) Details on CHTH used, handled, stored or released at the workplace

This refers to the safety data sheet (SDS) of the chemicals where it contains the hazard information, the nature and exposure degree of the chemicals and the recommended control measures for the chemical substance. The SDS need to available at all times and be stored at reachable area in the lab for it to be use whenever needed.

b) Layout plan of the Facilities Workers area

The layout plan or a sketch of the work area need to be obtained to indicate where the work unit, CHTH and the workers are located while performing the task.

c) Process flowchart

The process flowchart needs to be obtained for each and every work procedure, which are performed in the work unit. The flowchart should start from the preparation stage until end of the process of the works done in the work area.

d) Risk towards the workers

Information of the workers who are exposed to CHTH need to be gathered:

i) Total of workers (male and female) in each work area respectively

ii) Hours of working

iii) Type of task performed in the work area and number of male and female workers for each type of task

e) Engineering control measures

Engineering controls should be applied whenever applicable in order to minimize or eliminate hazardous chemicals exposure towards workers. The information is important as engineering controls place a higher hierarchy in terms of hierarchy of controls and are much favoured compared to personal protective equipment (PPE) due to its effectiveness (Centres for Disease Control and Prevention, 2015).

f) Accident and incidence

Records of any accidents and incidence including near miss need to be obtained to gather the information as an input for preventive measures.

g) Personal monitoring programme

Gather if there is any record of exposure monitoring which has been done by competent person or hygiene tech.

h) Health / medical surveillance programme

Any medical record pertaining to exposure levels to hazardous chemicals which includes list of complaints and incidents of work-related injuries or illness diagnosed of workers shall be obtained.

i) Training program

Obtain all records of training program which has been conducted such as PPE donning and its management including usage and maintenance, chemical storage, usage and waste disposal and emergency response preparedness. Information on training schedules, tentative and record of attendance should be included too.

j) Personal Protective Equipment (PPE) Program

The assessor needs to observe the PPE used during work whether they comply with the Guidelines on the Use of Personal Protective Equipment against Chemicals Hazards, 2005. The PPE first and foremost must be adequate enough supplied to the workers and available whenever needed. Secondly, The PPE must fit and suitable with the task that the workers do in the work area. The assessor needs to identify too whether there is any implication on health of the workers while donning the PPE.

3.1.2 Dividing the work units to be assessed

Workers exposed to the chemicals were separated into work units based on the information received. A work unit means the workers were doing similar tasks and are potentially exposed to the same chemical hazardous. The work unit could be identified based on the job, task or process of which the workers are associated with.

To identify the work unit are by following these steps:

a) A walk-through inspection to the work area needs to be conducted to identify workers who are exposed to the risk including the workers who:

i) Work directly and indirectly with the chemicals, which includes during usage, transportation to the cooling tower and laboratory for sample analysis, storage and disposal.

ii) Being in the area where chemical may be present; or

iii) Use chemicals for maintaining the system.

b) Get the work list for each work area including the tasks and processes;

c) Workplaces where chemicals are utilized, handled and stored are subjected to inspection to get the list of hazardous chemicals used in the work area;

d) Interview with personnel exposed to hazardous chemicals

3.1.3 Determine the degree of hazard of CHTH in each work unit

An updated list of chemicals with required details such as SDS or labels were drawn up in a register as according to DOSH Guidelines on Preparation of a Chemical Register. Hazard information about CHTH was then obtained through SDS, label or waste card of scheduled waste and rating of hazards (HR) was then determined for each chemical. Other reliable sources such as product description and List of Hazardous Chemicals in the Guidelines for the Classification of Hazardous Chemicals are also referred to complement missing or cross-check the information. The degree of hazard for exposure is divided into two parts which are through inhalation and dermal.

3.1.4 Degree of hazard for exposure through inhalation

On a scale of 1 to 5, the degree of hazard associated with inhalation exposure is graded. Rating of 1 indicates the least harmful health impacts, while a value of 5 indicates the most harmful health consequences. Table 3.1 is used to determine the HR by using information of Section 2 and Section 11 from SDS can be used to determine the HR.

Table 3.1: Hazard Rating for Inhalation Based on Health Effect, Hazard Classification, H-Code and Acute Toxicity Data (Department of Occupational Safety and Health, 2018)

HR	Health Effects	Hazard Classification	H-code	Acute Toxicity
5	● Injury of sufficient severity to threaten life ; ● Causing fatality at low doses or concentration; ● Severe irreversible effects (damage to target organ e.g. central nervous system effects, kidney necrosis, liver lesions, anaemia or paralysis) after a single exposure; ● Known to have carcinogenic potential for humans; ● Known to induce heritable mutations in the germ cells of humans; ● Known human reproductive toxicant	Acute toxicity category 1 (inhalation)	H330	LC50≤ 0.5 mg/l (vapours) LC50≤ 100 ppmV (gases) LC50≤ 0.05 mg/l (dusts/mists)
		Carcinogenicity category 1A	H350, H350i	
		Mutagenicity category 1A	H340	
		Reproductive toxicity category 1A	H360, H360D, H360F, H360FD, H360Fd, H360Df	
		Specific target organ toxicity – single exposure category 1	H370	
4	● Injury of sufficient severity to cause permanent impairment, disfigurement or irreversible change from single or repeated exposure. ● Very serious physical or health impairment by repeated or prolonged exposure; ● Serious damage to target organ from single exposure; ● Presumed to have carcinogenic potential for humans; ● Chemicals which should be regarded as if they induce heritable mutations in the germ cells of humans; ● Presumed human reproductive toxicant	Acute toxicity category 2 (inhalation)	H330	0.5 < LC50 ≤ 2.0 mg/l (vapours) 100 < LC50 ≤ 500 ppmV (gases) 0.05 < LC50 ≤ 0.5 mg/l (dusts/mists)
		Carcinogenicity category 1B	H350, H350i	
		Mutagenicity category 1B	H340	
		Reproductive toxicity category 1B	H360, H360D, H360F, H360FD, H360Fd, H360Df	
		Effects on or via lactation	H362	
		Specific target organ toxicity – single exposure category 2	H371	
		Specific target organ toxicity – repeated exposure category 1	H372	
		Respiratory sensitisation category 1	H334	

Table 3.1 continued

HR	Health Effects	Hazard Classification	H-code	Acute Toxicity
3	● Serious damage to target organ from repeated exposure; ● Toxic effects after exposure; ● Suspected human carcinogens; ● Chemicals which cause concern for humans owing to the possibility that they may induce heritable mutations in the germ cells of humans; ● Suspected human reproductive toxicant. ● Effect to respiratory tract after single exposure.	Acute toxicity category 3 (inhalation)	H331	2 < LC50 ≤ 10 mg/l (vapours) 500 < LC50 ≤ 2500 ppmV (gases) 0.5 < LC50 ≤ 1 mg/l (dusts/mists)
		Carcinogenicity category 2	H351	
		Mutagenicity category 2	H341	
		Reproductive toxicity category 2	H361, H361f, H361d, H361fd	
		Specific target organ toxicity – repeated exposure category 2	H373	
		Specific target organ toxicity – single exposure category 3 (respiratory tract irritation)	H335	
2	●Reversible effects, not severe enough to cause serious health impairment; ● Changes readily reversible once exposure ceases ● Harmful effects after exposure	Acute toxicity category 4 (inhalation)	H332	10 < LC50 ≤ 20 mg/l (vapours) 2500 < LC50 ≤ 20000 ppmV (gases) 1 < LC50 ≤ 5 mg/l (dusts/mists)
		Specific target organ toxicity – single exposure category 3 (narcotic effect)	H336	
1	● Minimal adverse health effects	Chemical not otherwise classified	H333	LC50 > 20 mg/l (vapours) LC50 > 20000 ppmV (gases) LC50 > 5 mg/l (dusts/mists)

3.1.5 Degree of Hazard for Exposure Through Dermal

Meanwhile, in the case of route of exposure through dermal, degree of hazard is Chemicals' effect on the dermis is used to classify them (skin and eyes) which are based on the hazardous properties. Table 3.2 is used to determine the hazardous properties for dermal exposure.

Table 3.2: Hazardous Properties for Dermal Exposure (Department of Occupational Safety and Health, 2018)

Hazardous Properties	Description	Corresponding Hazard Classification and H-code
Irritation	Chemicals which is irritating to skin or eyes after contact	• Skin corrosion or irritation category 2 (H315) • Serious eye damage or eye irritation category 2 (H319)
Corrosion	Chemicals which have damaging effect on skin or eyes after contact	• Skin corrosion or irritation category 1 (H314) • Serious eye damage or eye irritation category 1 (H318)
Sensitisation	Chemicals which lead to allergic response following skin contact	• Skin sensitisation category 1 (H317)
Acute toxicity	Chemicals which cause adverse effect following dermal administration of a single dose of a chemical or multiple dose given within 24 hours	• Acute toxicity (dermal) category 1 (H310) • Acute toxicity (dermal) category 2 (H310) • Acute toxicity (dermal) category 3 (H311) • Acute toxicity (dermal) category 4 (H312)
Skin-absorption and other properties	Enter human body through dermal due to their physical chemical properties; Dermal application studies shown that absorption could cause systemic effect.	• Specific target organ toxicity-single exposure category 1* (H370) • Specific target organ toxicity-single exposure category 2* (H371) • Specific target organ toxicity-repeated exposure category 1* (H372) • Specific target organ toxicity-repeated exposure category 2* (H373) • Carcinogenicity category 1*(H350) • Carcinogenicity category 2*(H351) • Germ cell mutagenicity category 1*(H340) • Germ cell mutagenicity category 2*(H341) • Reproductive toxicity category 1*(H360, H360D, H360F, H360FD, H360Fd, H360Df) • Reproductive toxicity category 2*(H361, H361f, H361d, H361fd)

Note: *to conclude whether the cause is via dermal exposure

3.1.6 Evaluate Levels of Exposure and Risk

The goal of measuring exposure is to determine the likelihood of CHTH enters the body in a variety of ways of entry and the degree of exposure that causes unfavourable health consequences in workers in each specified work unit. The likelihood and extent of exposure to chemicals for each work unit was assessed qualitatively by interview and observation using the methods, tables and exposure rating (ER) as recommended in the DOSH CHRA guideline. The following must be evaluated for the work unit identified:

a) Which workers are exposed

b) What is the nature of the exposure and under what conditions does it occur

c) Possible exposure route

d) Frequency, duration and magnitude of exposure

e) Existing workplace safety measures

The assessed workers in the Water Treatment Service Provider operates in 8 hours beginning from 8.30 a.m. until 5.00 p.m. with one-hour rest time.

3.1.7 Determine Level of Risk

To determine the risk level for inhalation exposure, risk rating (RR) is to be calculated first by using HR and ER. The risk rating equation is:

RR = HR x ER

Where:

RR = Risk rating (1-25) represent the likelihood of injury or illness;

HR = Hazard rating (1-5) represent the severity of adverse effects

ER = Exposure rating (1-5) represent the chance of overexposure to the CHTH

Table 3.3 Level of Risk Determination (Department of Occupational Safety and Health, 2018)

Hazard Rating (HR)	Exposure Rating (ER)				
	1	2	3	4	5
1	RR=1	RR=2	RR=3	RR=4	RR=5
2	RR=2	RR=4	RR=6	RR=8	RR=10
3	RR=3	RR=6	RR=9	RR=12	RR=15
4	RR=4	RR=8	RR=12	RR=16	RR=20
5	RR=5	RR=10	RR=15	RR=20	RR=25

Low risk level Moderate risk level High risk level

To determine level of risk for dermal exposure, Table 3.2 (Information of the hazardous properties), Table 3.4 (Observation/condition on extent of dermal contact) and duration of exposure are used. Risk of matrix, which is shown in Table 3.5 is used to determine the risk level. Risk level for dermal exposure is categorized as shown in Table 3.6.

Table 3.4: Extent of Dermal Contact (Department of Occupational Safety and Health, 2018)

Extent of contact	Observation/Condition
Small	• Small area of contact with chemicals capable of skin absorption, skin sensitising or hazardous to the dermal e.g. limited to palm (intact skin) (< 2% or 0.04 m2); • No indication of any skin condition; intact/normal skin; • No contamination of skin or eyes.
Large	• Contact with chemicals capable of skin absorption, skin sensitising or hazardous to the dermal; • Gross contamination with chemicals capable of skin absorption, skin sensitising or hazardous to the dermal – skin soaked or immersed in chemicals; • Area of contact not only confined to hands but also other parts of body. Skin area >2%; • Follicle rich area; • Skin dryness or detectable skin condition (e.g. peeling, cracking, skin redness)

Table 3.5: Risk Matrix for Dermal Exposure (Department of Occupational Safety and Health, 2018)

Hazardous properties	Relevant H-code	Duration/ Extent of skin contact			
		Short-term (< 15 min)		Long-term (≥ 15 min)	
		Small area	Large area	Small area	Large area
Irritation	H315	L	M1	M1	M2
	H319	M1		M2	
Corrosive	H314	M1	H1	H1	H2
	H318	H1		H2	
Sensitisation	H317	L	M1	M2	H1
Acute toxicity	H312	M1	M1	M1	H1
	H311	M1	M1	M2	H1
	H310	H1	H1	H1	H2
Combination effect*	H310 with H314	H1	H1	H1	H2
Skin absorption and other properties**	H351	M1	M1	M2	H1
	H350	H1	H1	H1	H2
	H341	M1	M1	M2	H1
	H340	H1	H1	H1	H2
	H361, H361f, H361d, H361fd	M1	M1	M2	H1
	H360, H360F, H360D, H360FD, H360Fd, H360fD	H1	H1	H1	H2
	H370	H1	H1	H1	H2
	H371	M1	M2	M2	H1
	H372	M1	M1	M2	H1
	H373	L	M1	M2	M2

L: Low risk M: Moderate risk H: High risk

Note:

1. *For chemicals classified both as acute toxicity (dermal) category 1 or 2 and skin corrosion or irritation category 1 (1A/1B/1C);
2. **If indicate as skin absorption or effect is due to dermal exposure;
3. M2 and H2 stipulated higher risk compare with M1 and H1 thus to be consider when deciding priority of action to control exposure i.e. M2 is higher moderate risk compare to M1 and H2 is higher high risk compare to H1.

Table 3.6: Categories of Level of Risk for Dermal (Department of Occupational Safety and Health, 2018)

1	Low Risk (L)
2	Moderate Risk (M1 & M2)
3	High Risk (H1 & H2)

3.1.8 Evaluate the effectiveness of existing control measures

Various existing control measures to control exposure of workers to CHTH includes technical controls, which were evaluated for suitability, use and effectiveness and maintenance while organization controls and emergency preparedness, which were evaluated by making sure information, training and occupational safety and health practices are reviewed from time to time. The need to include exposure monitoring programme, medical surveillance and selected workplace training were also considered after reviewing the extent of exposure of workers to CHTH.

The efficiency of control measures can be observed by looking at the following:

a) The working environment
    a. Contamination of the air, work gear, and work surfaces is kept to a minimum in general.
    b. Chemical discharge or emission into the workplace is minimal;
    c. Worker exposure or contact with chemicals is minimal or almost to no-contact.

b) The Personal Protective Equipment (PPE)
    a. The PPE need to be properly worn and the workers must have received instruction or training session.

b. They are need to be correctly fitted and the workers should have undergone fit testing.

c. Worn constantly at the designated work area with regular supervision.

d. Equipment still working properly.

3.1.9 Conclusion of Assessment

After the level of risk (LR) posed by each CHTH and the adequacy of existing control measures were determined, each of the CHTH was then concluded with risk rating (RR) (1 to 25) for inhalation exposure, while for dermal exposure it is either low, moderate or high risk and either adequately controlled or inadequately controlled.

Table 3.7: Conclusion of Assessment (Department of Occupational Safety and Health, 2018)

RISK DECISION	ADEQUACY OF CONTROL MEASURE	CONCLUSION
High Risk	Adequate	High risk and adequately controlled
	Inadequate	High risk and inadequately controlled
Moderate Risk	Adequate	Moderate risk and adequately controlled
	Inadequate	Moderate risk and inadequately controlled
Low Risk	Adequate	Low risk and adequately controlled
	Inadequate	Low risk and inadequately controlled

3.1.10 Identify Action to be Taken

Once the assessment has been done completely, the assessor has to identify the control measures which are required to be administered by the employer to control the exposure of CHTH to the employees.

3.1.11 Recommendation and Assign Action Priority (AP)

Recommendation or actions that need to be taken by employer were listed out and action priority (AP) were assigned to each of them in order to help the employer to implement the actions to be taken. The AP was divided into three levels and Table 3.8 is referred on how to assign AP based on the degree of risk and the effectiveness of the control measures.

Table 3.8: Action Priority Determination (Department of Occupational Safety and Health, 2017)

Level of Risk	Adequacy of Control Measures	Action Priority (AP)	Risk Rating (RR)
High	Inadequate	1	≥15
HR or ER could not be determined	-		
Moderate/Low	Inadequate	2	≤15
High/Moderate/Low	Adequate	3	-

CHAPTER 4: RESULT AND DISCUSSION

4.1 Work Unit Observation

There were 12 chemicals assessed in this work unit and all the chemicals were classified as chemical hazardous to health (CHTH). Figure 4.1 shows the location of the work unit. While Figure 4.2 shows where the chemical handling took place (work unit).

Figure 4.1: The location of the work unit

Figure 4.2: Work unit

Table 4.1 below shows the detail of the work unit which took place at the cooling tower.

Table 4.1: Work Unit Detail

Working space	Facilities Workers
No. of personnel	3
No. of work unit	1
No. of chemicals	12

The summary of the findings is shown as in Table 4.2, which shows the assessment of the risk rating (RR), exposure rating (ER), the adequacy of the control measures and the action priority (AP) status.

Table 4.2: The summary of the findings

No.	Chemicals	ER	HR	RR-Inh	LR-Der	TC: Adequacy (Y/N/NA)				AP
						Inhalation	Dermal (Eye)	Dermal (Skin)	Ingestion	
1	Kurisour Pack	2	4	RR=8 (Moderate Risk)	H1 (High Risk)	Y	Y	Y	NA	3
2	Kuritex F-7510	2	3	RR=6 (Moderate Risk)	H1 (High Risk)	Y	Y	Y	Y	3
3	Kuritex T-7280	NA	NA	NA	M1 (Moderate Risk)	NA	Y	Y	NA	3
4	Kuritex NT-7562	NA	NA	NA	H1 (High Risk)	NA	Y	Y	NA	3
5	Kuritex S-7180	NA	NA	NA	M1 (Moderate Risk)	NA	Y	Y	Y	3
6	Ferrocid 4601	NA	NA	NA	H1 (High Risk)	NA	Y	Y	NA	3
7	Ferrocid 8583	NA	NA	NA	M1 (Moderate Risk)	NA	Y	NA	NA	3
8	Kuritex L-7111	NA	NA	NA	M1 (Moderate Risk)	NA	NA	Y	Y	3

Table 4.2 continued

No.	Chemicals	ER	HR	RR-Inh	LR-Der	TC : Adequacy (Y/N/NA)				AP
						Inhalation	Dermal (Eye)	Dermal (Skin)	Ingestion	
9	Kuritex L-7107	2	4	RR=8 (Moderate Risk)	M1 (Moderate Risk)	Y	NA	Y	Y	3
10	Kuritex MP7904	NA	NA	NA	M1 (Moderate Risk)	NA	NA	Y	Y	3
11	Aktiphos 4251	NA	NA	NA	M1 (Moderate Risk)	NA	Y	NA	NA	3
12	Cetamine F300	NA	NA	NA	M1 (Moderate Risk)	NA	Y	NA	NA	3

Note : Y: Yes (Adequate), N : No (Not adequate), NA means Not Applicable

In inhalation exposure assessment, qualitative evaluation has shown that the level of risk of 3 chemicals were categorized as moderate. While in dermal exposure assessment, observation also has shown that the level of risk of 8 chemicals were categorized moderate (M1) and the other 4 chemicals as high risk (H1). Based on the level of risk and the effectiveness of existing control measures, all the 12 chemicals can be concluded with Action Priority 3 (AP3), which means the existing control measures are to be maintained without further issues.

4.2 Potential of Exposure

In the work unit, 12 chemicals were assessed, and these chemicals have been determined as dangerous to human health (CHTH). Workers are responsible to refill or manual pour chemicals into the storage tanks. On a daily basis, the chemicals were auto-dosed into the chiller/cooling tower system. Workers must also collect water samples from the cooling tower and send them to a lab for Legionella testing. The frequency of chemicals used are depending on the system condition with the duration were less than 2 hours of exposure each time. The potential exposure of chemicals hazardous to health are mainly through two main routes which are inhalation and skin or eye contact. The degree of chemical inhaled or contacted are low or moderate according to the work procedure. There is almost zero probability for ingestion exposure due to no food and drinks were allowed in workplace.

4.3 Work Practice

Current control measures had been identified to be maintained without further issues. In this work unit, the workers were provided with chemical respirator, goggles, nitrile gloves, apron and safety shoes as personal protective equipment (PPE) while manually handling the chemicals and refilling into the storage tanks in the work area (USECHH, 2000). Fire extinguishers were easily available in the work area and all are up to date. The

management does provide safety awareness and chemical safety training to the workers such as Chemical Spill Training, Fire Drill, First Aid, Chemical Handling and Safety Awareness to the workers from time to time and the records were kept. Training on specified work procedure has been provided through on-job training too. To have a more efficient chemical safety management and practices, specific training which focus on chemical safety management to all workers pertaining to their chemical work need to be conducted. Once in 2 years, the workers need to be trained on chemical knowledge related to the topics of chemical safety handling, selection and maintenance of PPE, understanding the safety data sheet (SDS) and the chemical label. Other safety policy, which were the emergency eye wash and shower, emergency exit and chemical spill kit also available at the work site which was maintained by the Water Treatment Service Provider management.

The management does provide chemical handling spillage kit to be prepared and available in the car too. However, should there be any incident of bulk leakage, it will be counter by the Water Treatment Service Provider management. SDS were also available in the work area and PPE issuance with records were maintained.

4.4 Warning Sign

The warning sign should be displayed around the facility and need to be:

a) Clearly visible, well-lit, and spotless

b) The legend is highly visible and identifiable.

c) Give notice about potential dangers.

Safety signs had been placed in the work area. To create a general degree of knowledge and understanding, warning signs should be printed in both national and English

languages. According to USECHH Regulations, the individual chemical warning sign should be printed in dark red against white background. The warning sign should be of a reasonable size and in good condition.

4.5 Air Monitoring

Air monitoring is not needed in this particular work unit for this current assessment due to the minimal exposure to the workers, which only refill or pour the chemical into the storage tanks of the enclosed system and the chemicals will be auto-dosed into the system (USECHH, 2000).

CHAPTER 5: CONCLUSION

This Chemical Health Risk Assessment (CHRA) was completed successfully in the case that the Water Treatment Service Provider activity involved the use of hazardous chemicals. In conclusion, the following objectives were met during the course of this assessment:

a) The degree to which workers are exposed to CHTH through inhalation and dermal has been observed and it is considered low or moderate according to the work practice.

b) The 12 chemicals are classified as Action Priority 3 (AP3) based on the effectiveness of control measures applied to chemicals that are dangerous to human health.

c) Based on the findings, there are further recommendations or actions to be taken and it will be discussed in 5.1.

5.1 Recommendations on Actions to be Taken

Although the assessment was concluded that the Action Priority 3 (AP3) is given, which means the existing control measures shall be maintained, there is always room of improvement. The recommendations are:

a) For all work units, the workers shall continue to practice good personal hygiene and practice safe work procedure to prevent any ingestion hazard.

b) For the workers, who might be exposed to chemicals or is likely to be exposed to chemicals hazard to health (CHTH), information and training shall be provided in order to alert them the risk to health that could be the hazards that such exposure can cause, as well as the actions that should be taken.

c) Employer should provide safety briefing to the vendor who came for chemical dosing and loading. It is the employer responsibility to provide necessary information, instruction and supervision on the workers who carried out the work.

d) Information and training on the safe use of chemicals pertaining to chemical labelling, storage requirements, chemical disposal and personal protective equipment (PPE) to the worker should be on continuous mode and consistently given. The trainings need to be reviewed at least once every 2 years and to conduct structured training on:

   i. Importance of respiratory protection including selection, use and maintenance
   ii. General PPE (selection and maintenance)
   iii. Recognize and interpret SDS and chemical labels
   iv. Chemical Handling
   v. Emergency Response Training
   vi. Understanding of control measures to be utilized in the workplace

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