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CERTIFICATION OF APPROVAL

Qualitative Risk Assessment of Chemical Hazardous to Health in Electronic Industry

by

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Approved by,

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TRONOH, PERAK
May 2004

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or person.

JESMIN JAMEL

ABSTRACT

The objective of this project, in short, is to identify, evaluate and control any health risk associated with the work activities that involves the use of hazardous chemicals. Other than that, this project seek to find out if the method provided by OSHA in the CHRA manual is sufficient in ensuring the safety of employees while exposed to hazardous chemicals.

The problem to the project is to protect employees in Motorola Penang from the adverse effects of hazardous chemicals usage. It is mandatory to do this under the Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Regulations 2000.

The scope of my project would be limited to the two production floors of Motorola Penang, an electronic company chosen as my case study. The CHRA method would be used in conducting the assessment in the four work units namely, CGISS Battery - Jedi Cenelec, MDI Glue Machine and TPM for Reflow.

In order to achieve the end product of my project, a step-by-step methodology is deployed. First of all, a multi-national company was identified as a case study. Then, literature review on the chemical health risk assessment and other related issues are done. On-site work needs to be carried out to determine the risks or hazards that exist in each of the work units and then further embark on the analysis and evaluation of the information obtained.

ACKNOWLEDGEMENT

First and foremost, I would like to thank Allah for being the head of my life. Thank you for the unmeasured blessings that You have had given me to complete this final report.

For the past 14 weeks of doing research on this subject matter, I have the following people to express my sincerest appreciation to. Without their advises, support and help, the research that I had done might not be as smooth flowing and successful. My gratitude goes out to these people who has helped me in their very own way :

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5. Khoo Ee Fei – Trainee, Motorola Penang
6. Facilities Department staffs, Motorola Penang

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CHAPTER 1
INTRODUCTION

1.0 Background of Study

A Chemical Health Risk Assessment (CHRA) is conducted with the purpose of enabling decisions to be made on appropriate control measures, induction and training of employees, monitoring and health surveillance activities as may be required to protect the health of employees who may be exposed to chemicals hazardous to health at work

This project is closely related to the Occupational Safety and Health (Use and Standards of Exposure of Chemical Hazardous to Health) Regulations 2000, which is also known as USECHH. This regulation consists of 12 sections. Among all the sections, the one section that is of great concern and is directly related to this particular research project is the Chemical Health Risk Assessment.

1.1 Problem Statement

1.1.1 Problem Identification

Protecting employees from the adverse effects of chemicals is one of the primary duties of an employer under the Occupational Safety and Health Act 1994. Under the Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Act 2000, referred to as USECHH Regulations 2000, the duty to perform an assessment of health risks arising from the use of chemicals hazardous to health at the place of work is mandatory whereby employers are not permitted to use any chemicals hazardous to health unless as assessment has been conducted.

An example of a scenario would be, a work unit, which is involved in degreasing parts in an electronic company, requires a washing task, using a hazardous chemical, toluene. One of the problem that worker might face is strong odour produced by the named chemical while transporting them to the washing area. At this point, CHRA needs to be done at that particular work

unit due to the fact that the strong odour might be carcinogenic and prove to be hazardous to health either by long-term or short-term exposure. Therefore, CHRA will help come up with a control measure in making sure the employees are working in a safe and healthy environment.

1.1.2 Significant of the Project

The findings of this project would help the company in the case study to be aware of any risk that might occur in the workplace and whether the control measure that has been implemented is sufficient. For the cases where no control measure has been put in place, this research would help put one in place, where necessary. It will also ensure that the industry providing a minimum-risk working environment for the employees.

1.2 Objectives and Scope of Study

A CHRA has the following objectives :

a) to identify the hazards posed by each chemical substance used, stored, handled or transported within the place of work

b) to evaluate the degree of exposure of employees to the chemicals hazardous to health, either through inhalation, skin absorption or ingestion

c) to evaluate the adequacy of existing control measures

d) to conclude on the significance of the health risk posed by the chemicals hazardous to health

e) to recommend further appropriate control measures to prevent or reduce risks

Other than the above mentioned objectives, this project seek to analyze the method and come up with appropriate recommendations on how it can be further improved.

Basically, this project would require the use of Chemical Health Risk Assessment method. The scope of this project covers Motorola Technology Penang, which is one of the biggest companies in the electronic industry as case study.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction to Department of Occupational Safety and Health (DOSH)

The Department of Occupational Safety and Health (DOSH) is a government department under the Ministry of Human Resources Malaysia. From the DOSH website, (*www.dosh.gov.my*), the department is responsible for ensuring the safety, health and welfare of persons at work and protections of other people from hazards to safety and health arising from the activities of persons at work in various economic sectors.

2.1.1 Occupational Safety and Health (Use and Standards of Exposure of Chemical Hazardous to Health) Regulations 2000

The regulation, which is known as USECHH, commenced on 4th April 2000 under the Occupational Safety and Health Act (OSHA). This regulations consists of 12 sections namely :

- Part I : Preliminary
- Part II : Identification of chemicals hazardous to health
- Part III : Permissible Exposure Limit
- Part IV : Assessment of risk to health
- Part V : Action to control exposure
- Part VI : Labelling and Relabelling
- Part VII : Information, Instruction and Training
- Part VIII : Monitoring of exposure at the place of work
- Part IX : Health surveillance
- Part X : Medical Removal Protection
- Part XI : Warning Sign
- Part XII : Record Keeping

Though each section needs to be fully understand, the most vital components in the regulations that are directly related to this research is the Chemical Health Risk Assessment.

2.1.2 Classification of Hazards

Health hazards are defined as conditions that can cause diseases or illness whereas safety hazards are related to conditions where harm to workers is immediate and of violent nature. These may result in injury. (*www.niosh.com.my*)

Quoted from the same source are a few examples of health hazards and safety hazards respectively :

Health Hazards :

- Physical - heat, vibration, noise, radiation, lighting, ventilation
- Chemical - solvents, heavy metal, pesticides, acids
- Biological - bacterial, viral, fungal, insects
- Ergonomic - manual handling, computer work, repetitive work
- Psychosocial - stress, shift work, alcohol, drug abuse

Safety Hazards :

- Mechanical/Machinery - cuts, entanglement, struck by or against
- Height/Gravity - falling objects or people
- Electrical - shock/burns
- Fire/Explosion - burns, injury or death
- Confined space poisoning

2.2 Electrical and Electronic Industry in Malaysia

Taken from the Malaysian Information.Com website (*www.malaysiainformation.com*), Malaysia is one of the leading electrical and electronic product exporters worldwide.

Almost 1000 companies in this industry are incorporated in Malaysia. The industry includes major brads like Panasonic, Sony, Philips and Samsung and local brands like I, MEC, Khind and Pensonic. The production range includes air-conditioners, refrigerators, washing machines, vacuum cleaners, electric fans, instant water heaters, rice cookers, blenders and microwave ovens. Malaysia is also a major exporter of semiconductor devices, which

accounted for over 30% of total electronic exports in 2000.

Malaysia is currently investing in R&D in order to expand its production to include more sophisticated high-end products such as silicon ingots, polishing silicon wafers, chip design, digital video disc players, electronic games, multimedia products and high resolution TFT-LCD and LED plasma displays.

Malaysia's rapidly expanding electronic industry has, however, been hit by the sluggish global economy and the saturated markets of the last couple of years. Additionally increased production of electronic items in Mainland China has put further pressure on the industry. Nevertheless Malaysia's exports of electrical and electronic products still accounted for US$4.5 billion and 55.4 percent of Malaysia's total exports in 2002.

2.3 What is Risk Assessment

Quoted from 'A Survey of Methods for Chemical Health Risk Assessment Among Federal Regulatory Agencies', prepared by Lorenz R. Rhomberg, Ph.D., "Risk assessment," according to the NAS (NRC, 1983), is "the use of the factual base to define the health effects of exposure to individuals or populations to hazardous materials and situations." It has four components; quoting from the red book (with slight punctuation modification) they are:

- "hazard identification—the determination of whether a particular chemical is or is not causally linked to particular health effects;"
- "dose response assessment—the determination of the relation between the magnitude of exposure and the probability of occurrence of the health effects in question;"
- "exposure assessment—the determination of the extent of human exposure before or after application of regulatory controls;" and
- "risk characterization—the description of the nature and often the magnitude of human risk, including attendant uncertainty."

From the quoted source above, the risk assessment process is seen as distinct from that of "risk management," which is defined as "the process of

weighing policy alternatives and selecting the most appropriate regulatory action, integrating the results of risk assessment with engineering data and with social, economic, and political concerns to reach a decision."

2.4 Risk and Health Hazards in Electronic Industry

From (*www.netstoreusa.com/tabooks/047/0471292850.shtml*), according to Pohanish, the chemicals used in the electronics and computer industries are among the most lethal and carcinogenic of any industry. For example, chip production workers suffer a rate of occupational illnesses nearly three times that of manufacturing workers in other industries.

The authors of '*Perspectives to Understand Risks in the Electronic Industry*', etal. E. Magrab, stated that when developing a competitive electronic product or system, risks can arise from the inability to meet factional requirements and business expectations throughout the life cycle, from first inception to final disposal. The risks can be broadly grouped into four categories which are :

1. *Technological*
2. *Business risks*
3. *Societal risks*
4. *National risks*

From www.adhesive.de, the following are some of the compounds that might pose health hazards to its users. They are mainly used in the electronic industry.

2.4.1 Epoxy resins

Epoxy-based adhesives are commonly used as conductive adhesives in combination with silver. The polymers themselves do not have toxicological effects but the content of low-molecular weight epoxides may cause skin allergy by contact. During heating the epoxides may evaporate and pose a

risk to the respiratory tract, central nervous system and blood-forming tissues of the workers. The molecules can also be genotoxic and mutagenic. However, the adhesives were developed not to cause environmental hazards, although the use of metallic filler materials like silver may have an impact on the environment.

2.4.2 Denatured alcohol

Ethanol denatured with mineral spirit can be used as a cleaning agent. The primary route of exposure is by inhalation or by skin contact of people working with the agent. The vapours of denatured alcohol in high concentrations may irritate the eyes and the respiratory tract and on rare occasions they may cause shortness of breath. The long-term inhalation of ethanol by pregnant women may damage the fetus. Denatured alcohol may also be a degreaser and irritate the skin when the contact is prolonged.

2.4.3 Flux

Flux consists of different components including solvents, rosins and activators. The hazard evaluation is therefore based on the evaluations of one critical component. When flux is heated, vapours from the solvents and resins may be inhaled and irritate the mucosa of the airways. This may result in asthma-like symptoms. Also, the vapours may irritate the eyes and affect the central nervous system. When the flux is in contact with skin there is a possibility that the skin will be irritated and that the sensitization will result in allergic dermatitis. Some rosin may emit formaldehyde, which is a human carcinogen.

2.5 Relevance of Threshold Limit Value in Chemicals Used in Motorola

Under this case study, five chemicals under three different work units were assessed. The names of the chemicals are, Polyurethane Hardener Composition HP304 E/NC, Polyurethane Resin Composition RP304 E/BK and Chemcrest 121 for work unit number one : CGISS (Commercial Government Industrial Solution Sector) Battery - Jedi Cenelec. For the second work unit : MDI (Modificated Diphenylmethadiisocyanat) Glue Machine, the chemical used is Pur-Fect Cleaner 9T (polyurethane hotmelt).

Lastly, 2-Propanol or Isopropyl Alcohol (IPA) is used in the third work unit : TPM for Reflow.

Of all the chemicals, only one is harmful and highly flammable (*Occupational Safety and Health (Classification, Packaging and Labelling of Hazardous Chemicals) Regulations*) and requires the use of reference on threshold limit value, which is 2-Propanol (IPA).

Taken from '*Occupational Safety and Health (Use of Standard of Exposure of Chemicals Hazardous to Health) Regulations 2000*', the threshold limit values for selected chemicals are as below. The one that is of concern in this case study is IPA.

APPENDIX 15

ODOUR LEVEL THRESHOLDS

	**TLV (ppm)	*OT (ppm)	OT/TLV
Acetaldehyde	c25	0.5	0.02
Acetic acid (glacial)	10	2.0	0.2
Acetone	750	2.0	0.003
Acrolein	0.1	2.0	20
Acrylonitrile	2	20.0	10
Allyl alcohol	2	2.0	1
Ammonia	25	20.0	0.8
Aniline	2	1.0	0.5
Arsine	0.05	0.5	10
Benzene	10	2.0	0.2
Butane	800	5000	6.25
2-Butanone (MEK)	200	5.0	0.025
n-Butyl Acetate	150	10.0	0.07
Carbon disulphide	10	0.1	0.01
Carbon tetrachloride	5	70.0	14
Chlorine	0.5	3.0	6
Chloroform	10	100.0	10
Cyclohexane	300	300.0	1
Dioxane	25	150.0	6
Ethyl Acetate	400	10.0	0.025
Ethyl alcohol	1000	5.0	0.005
Ethyl ether	400	1.0	0.0025
Ethylene oxide	1	1.0	1
Formaldehyde	c0.3	1.0	3.3
Hexone (MIBK)	50	0.5	0.01
Hydrogen chloride	c5	10.0	2
Hydrogen cyanide	c4.7	1.0	0.2
Hydrogen selenide	0.05	0.5	10
Hydrogen sulphide	10	0.0002	0.00002
Isopropyl alcohol (IPA)	400	50.0	0.125
Methyl alcohol	200	10.0	0.05
Methyl methacrylate	100	0.2	0.002
Methylene chloride	50	200.0	4
Nitrobenzene	1	0.005	0.005
Nitrogen dioxide	3	1.0	0.3
Perchloroethylene (tetrachloroethene)	25	5.0	0.2
Phenol	5	0.3	0.06
Phosgene	0.1	0.5	5
Phosphine	0.3	0.02	0.07
Pyridine	5	0.01	0.002
Stibine	0.1	0.05	0.5
Styrene, monomer	50	0.05	0.001
Toluene	50	2.0	0.04
Toluene-2,4-diisocyanate	0.005	0.2	40
Trichloroethylene (TCE)	50	20.0	0.4
Vinyl toluene	50	25.0	0.5
Xylene	100	0.5	0.005

Table 1 : Odour Level Thresholds

CHAPTER 3
METHODOLOGY

3.1 Procedure Identification

The procedures in carrying out a Chemical Health Risk Assessment, benchmarked from the CHRA manual are summarized in Figure 1.

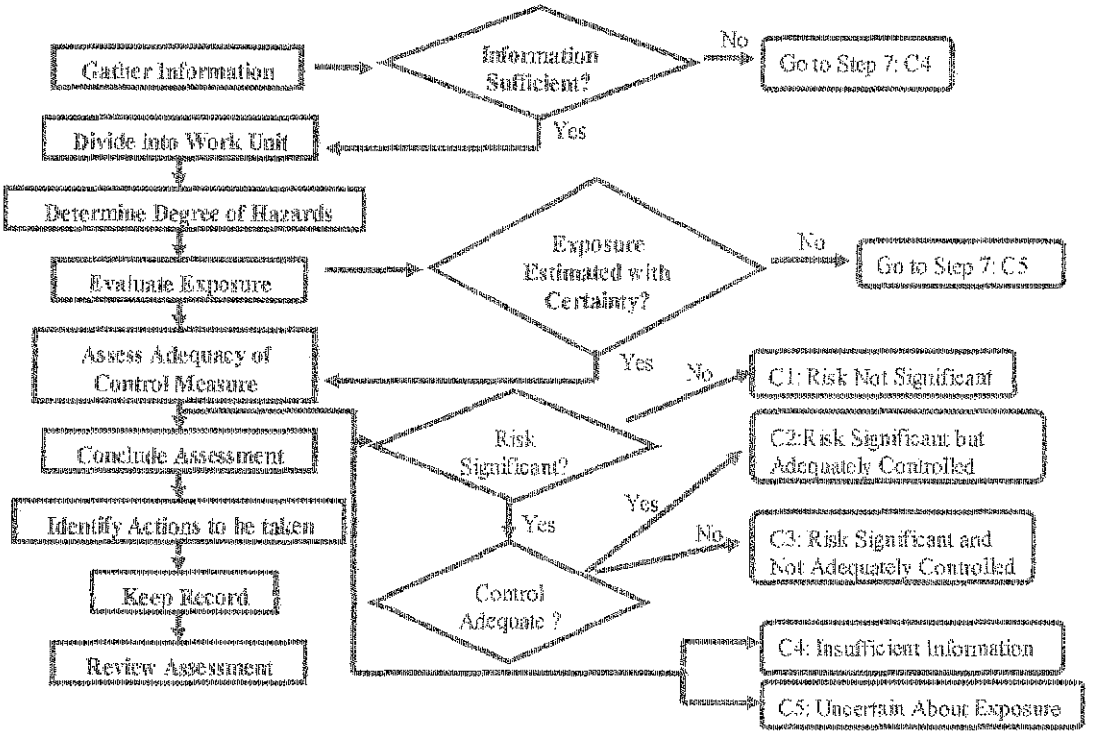

Figure 1 : Process flow for assessment method

3.1.1 Information gathering

Preliminary information is gathered from each line in the production and also all the support units such as maintenance team and the laboratories. It includes the chemicals used, the operations and breakdown tasks, number of operators involved in different tasks and their gender. The information is later arranged properly in a format.

3.1.2 Divide into work unit

The information obtained is analyzed to divide the work areas into different work units. A work unit is essentially a group of workers doing the similar tasks and having the same potential for the hazardous chemical exposure. After the work units are identified, a questionnaire[1] is used to interview the operators to gather further information needed to complete CHRA.

3.1.3 Determine hazard rating

Hazard rating is then identified. The hazard is used to prioritize hazard based on the possible health effect of the chemical. The hazard is rated on the scale of 1 to 5 with the rating of 1 indicating not hazardous and rating of 5 showing most hazardous. The hazard information can be obtained from the Chemical Safety Data Sheet (CSDS). CSDS is an information sheet containing relevant information pertaining to the hazardous chemical or preparation, which is vital for establishing provisions in the safe use of the chemical during work.

Based on the toxicity data, health hazards or the ingredients of the chemicals, hazard rating can be conducted. Firstly, the toxicity data in the CSDS needs to be compared to *Chemical Classification According To Health Effects Criteria As Stipulated In Part B of Schedule 1 of The Regulations* from *Guidelines for the Classification of Hazardous Chemicals.* (DOSH,1997)

Other than using the toxicity data, *Appendix VII : List of hazardous chemicals* in the same guideline can also be used to determine the rating. The health hazards posed by the chemicals will be indicated. Compare the concentration cut-off given with the weight percentage of the specific ingredients or chemicals. If the weight percentage is higher or equals to the concentration cut-off, the hazard indicated will be considered as significant.

The third method that can be used is referring to the hazard identification in the CSDS and comparing it with *Chemical Classification According To*

[1] A sample of the questionnaire is attached in Appendix I.1

Health Effects Criteria As Stipulated In Part B of Schedule I of The Regulations, which was mentioned earlier, to determine the category it falls into. Then, use *Appendix IV: Health-Effects Based Classification of Non-Listed Chemicals And Recommended Risk Phrases* to compare the concentration of the chemical with its concentration cut-off level listed in the table row.

Lastly, the physical hazard can be determined to know the flammability of the chemical. This can be done by analyzing the flash point, boiling point or physiochemical properties listed in the CSDS. Using the information and compare with *Summary of the Criteria of Chemical Classification According To Physiochemical Properties* (DOSH,1997) in the same guideline.

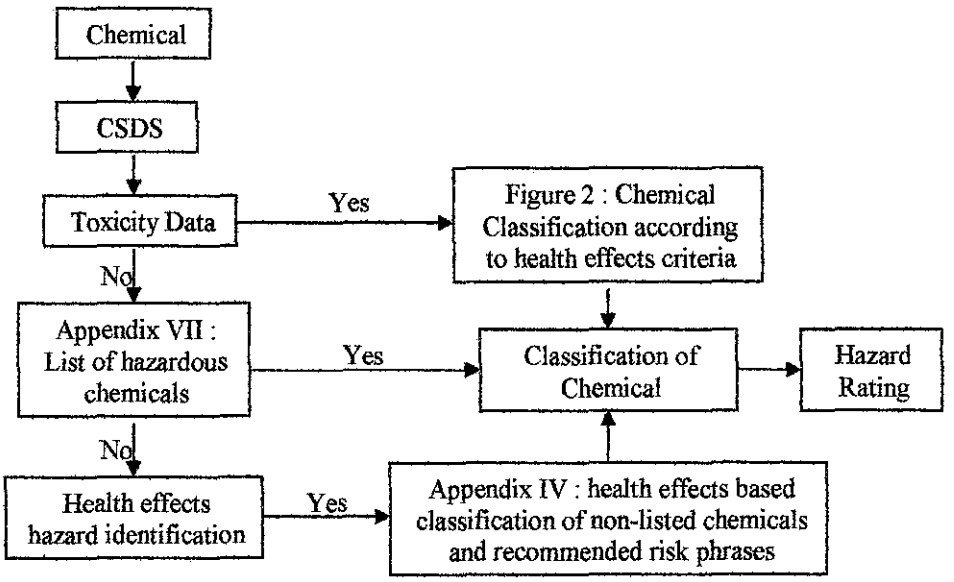

Figure 2 : Process flow summary for hazard rating
(The Appendix and figure number is based on the Guidelines for the Classification of chemicals)

3.1.4 Evaluate exposure

After hazard rating is done, the exposure of the operators to the chemicals hazardous to health needs to be evaluated. This is to assess the potential of the chemical hazardous to health entering the body through different routes

of the body such as eyes, skin, inhalation or ingestion. In determining the exposure rating, the frequency rating or duration rating and magnitude exposure has to be obtained.

Frequency rating is used when assessing chemicals having acute effects. For acute effects, the frequency of exposure has more significant effect on the degree of exposure. The frequency of potential exposure can be estimated from observation of the work activities and feedback from the operators themselves.

Rating	Description	Definition
5	Frequent	Potential exposure one or more time per shift or per day
4	Probable	Exposure greater than one time per week
3	Occasional	Exposure greater than one time per month
2	Remote	Exposure greater than one time per year
1	Improbable	Exposure less than one per year

Table 2 : Frequency Rating

On the other hand, duration rating is used to assess chronic or routine exposure. The total exposure duration is the product of the number of exposures and the average duration of each exposure.

Table 4: Duration Rating

Rating	Total Duration of Exposure*	
	% work hour	Duration per 8-hr shift or per 40-hr week
5	> 87.5 %	> 7 hrs/ shift or > 35 hours/ week
4	50-87.5 %	4 to 7 hrs/ shift or 20 to 35 hours/ week
3	25-50 %	2 to 4 hrs/ shift or 10 to 20 hours/ week
2	12.5-25 %	1 to 2 hrs/ shift or 5 to 10 hours/ week
1	<12.5 %	< 1 hr/ 8 hr shift or < 5 hours/ week

Table 3 : Duration Rating

Next, the intensity or magnitude of exposure has to be determined. Qualitative estimation of magnitude exposure is assigned for two main routes of entry, which are inhalation and dermal. For this method, look at the degree of chemical release or presence (DOSH,2000) and the degree of chemical absorbed (DOSH,2000) or likely to be absorbed at the exposure boundary. To determine the degree of chemical release or presence, physiochemical properties, process characteristics, the quantity used, method of handling and the atmospheric conditions need to be considered. This information may be obtained from the CSDS, process descriptions and from observation of environmental conditions. Using the results from degree of release and degree of absorbed, the magnitude rating can be determined.

Table 9: Magnitude Rating

Degree of release	Degree of absorption	MR
LOW	LOW	1
	MODERATE	2
	HIGH	3
MODERATE	LOW	2
	MODERATE	3
	HIGH	4
HIGH	LOW	3
	MODERATE	4
	HIGH	5

Table 4 : Magnitude Rating

Lastly, using frequency or duration rating and magnitude rating, exposure rating[2] can be evaluated.

[2] please refer to Appendix I.2

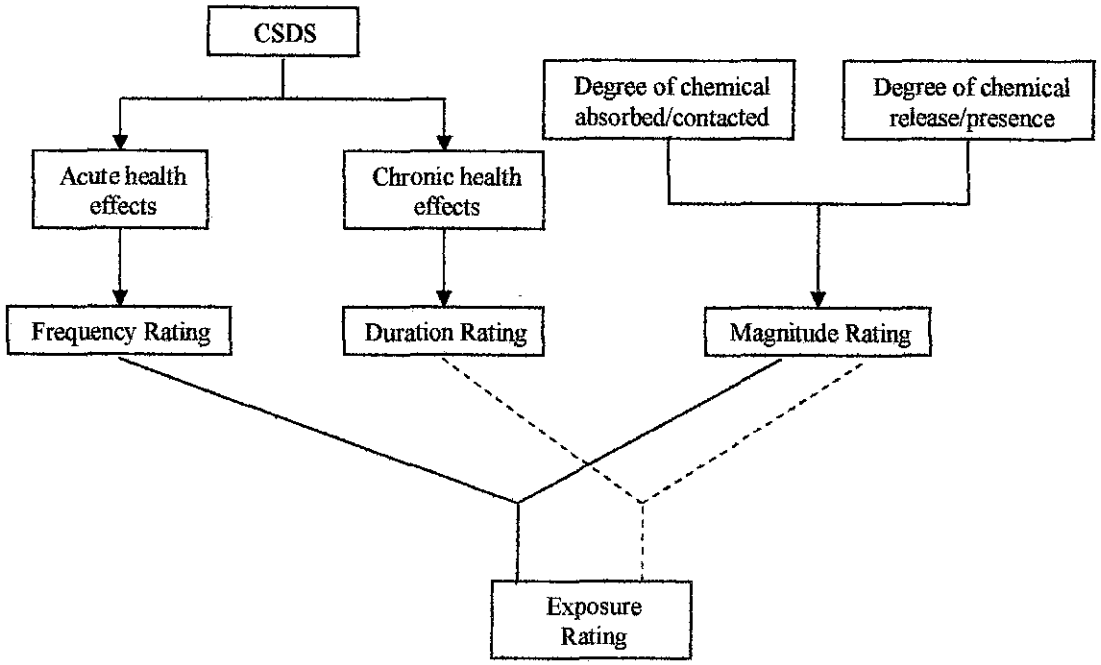

Figure 3 : Process flow summary for exposure rating

3.1.5 Determine control measures to be used

The presence and adequacy of existing measure are evaluated for each work unit. This assessment is to be conducted simultaneously with the exposure assessment. The adequacy of existing control measures is assessed by inspecting the existing control measures; checking records of air sampling, biological monitoring, and checking records on the inspection, testing and examination of control equipment.

Control measures are steps taken to prevent or minimize risks. Control equipment is equipment used for controlling risk, the measures taken should be in a certain hierarchy[3] or order of priority and an assessment of the adequacy of the control measures need to be made.

Other measures although do not directly remove or minimize the risk, are equally important as they support or strengthen the above control measures and is part of chemical health risk management. Such measures include personal hygiene, maintenance of the control equipment, providing

[3] please refer to Appendix I.3

information, instruction and training to workers, monitoring of personal exposures and general air levels and health surveillance and lastly emergency procedure and first aid.

The existing control measures needs to be assessed[4] whether they are adequate or not. Taking into consideration the following factors we can assess whether the control measure are adequate or not :

- ✓ Suitability;
- ✓ Use;
- ✓ Effectiveness; and
- ✓ Maintenance.

3.1.6 Concluding the assessment

The risk to each hazardous chemical is evaluated by combining the hazard rating (HR) and the exposure rating (ER) to give the risk rating. A risk rating of 3 or greater is considered to be significant while below that the risk is considered as not significant. Risk rating (RR) is computed using the below equation

$$RR = \sqrt{HR \times ER}$$

When the square root is not a whole number, the next highest whole number is designated as the risk rating. Another method would be by using the risk matrix[5]. The risk matrix may be used to identify and prioritize control strategies. Priority in implementing control measures will depend on the degree of risk, the number of person at risk, and the practicability of the control measures.

Based on the risk decision and the assessment of existing control measures there are 4 conclusions[6] that could be reached from the assessment. These conclusions are denoted by C1, C2, C3, C4 or C5.

[4] please refer Appendix I.4
[5] please refer Appendix I.5
[6] please refer Appendix I.6

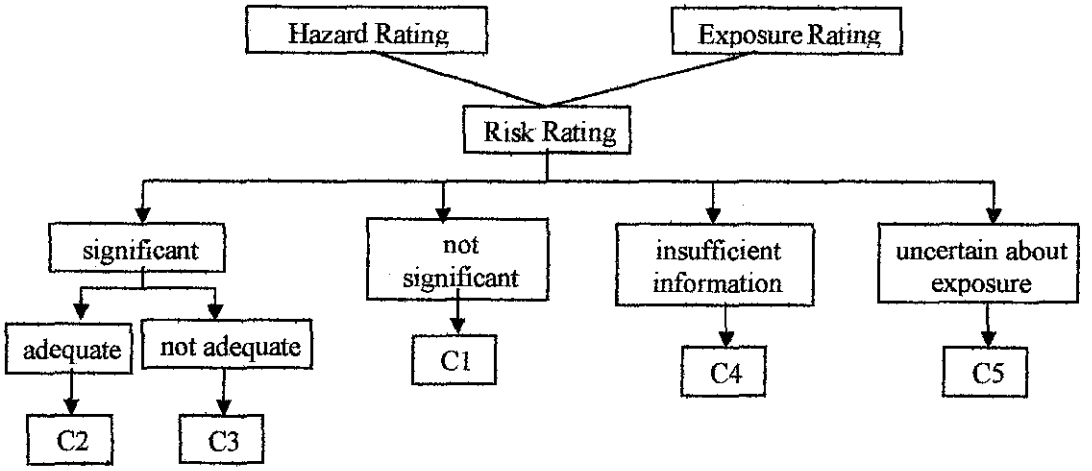

Figure 4 : Process flow summary of concluding assessment

3.1.7 Determine action to be taken

In this step, one would have to identify the possible action to be taken including suggesting further precautions and control measures based on the assessment. The actions to be taken[7] are based on the risk decision obtained at the end of the assessment. These actions include:

a) taking appropriate measures to control overexposures

b) measures to eliminate the risk if the risk is intolerable

c) ending assessment and setting new date for reassessment or review of assessment

d) planning out long term strategies to control exposures to as low as reasonably practicable

e) obtaining information or specialist advice on certain issues

f) maintaining control equipment in good working order by implementing preventive maintenance program

[7] please refer Appendix I.7

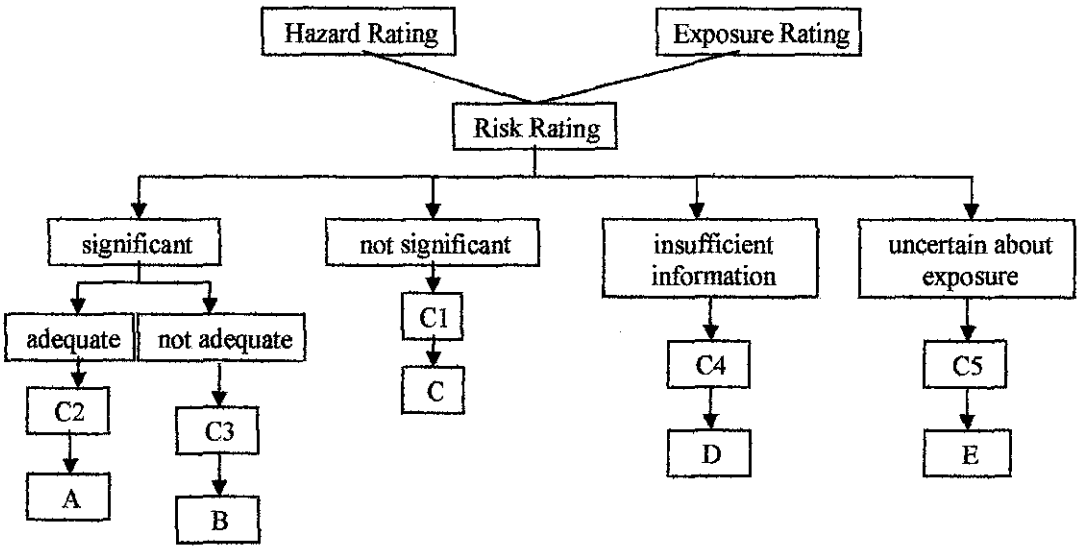

Figure 5 : Process flow summary for determine actions to be taken

Upon completing one work unit, six forms need to be filled up for each work unit as stated in Appendix I.8.

3.1.8 Review Assessment

The assessment shall be reviewed after 5 years of the current assessment or if there is significant changes in the work procedures such as :

- Changes in the chemicals used or handled; or
- Increasing or decreasing utilization of chemicals hazardous to health used; or
- Changes in the methods or rate of work; or
- Deterioration in the efficiency of control equipment; or
- Plant failure or system failure; or
- New information on the hazards of the chemical become available; or
- New improved control measures become practicable.

New assessment has to be conducted if directed by Director General, Deputy Director General or the Director of Occupational Safety and Health.

Refer to the next section for results of completed work units in Motorola Penang.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Overview of work units

4.1.1 CGISS (Commercial Government Industrial Solutions Sector) Battery Jedi Cenelec

There are 3 chemicals used in this work unit : Polyurethane Hardener Composition HP304 E/NC, Polyurethane Resin Composition RP304 E/BK and Chemcrest 121. The estimated amount of usage is 0.5 gram per piece battery for the first two chemicals and around 2 liters for the third chemical. Below is the process flow of the particular work unit.

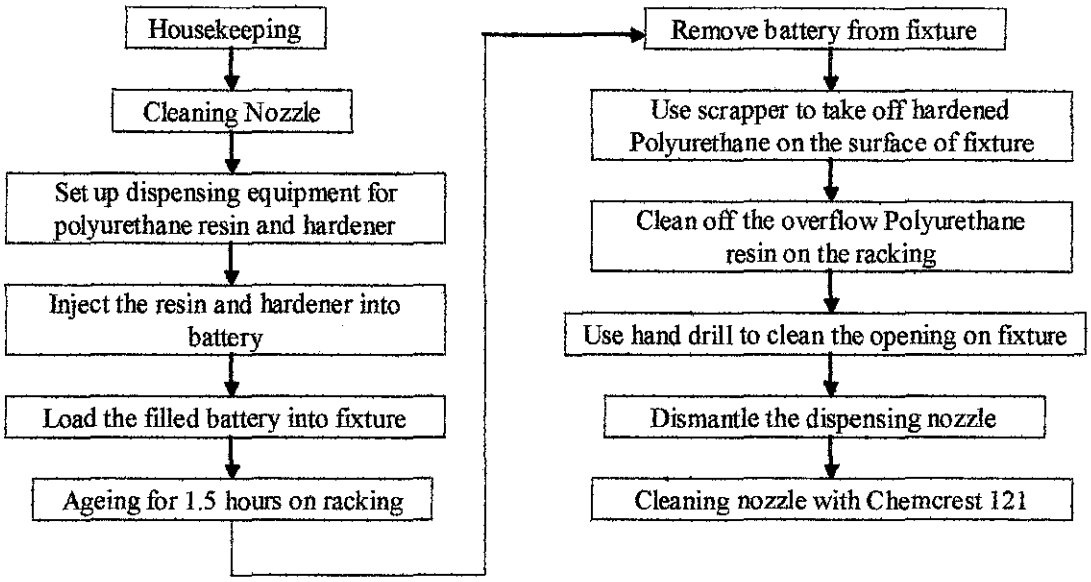

Figure 6 : Process flow of CGISS Battery-Jedi Cenelec

4.1.2 MDI (Modificated Diphenylmethadiisocyanat) Glue Machine

In this second work unit, only one chemical is used which is Pur-Fect Cleaner 9T (polyurethane hotmelt). The estimated amount chemical usage 1 is 0.25 to 0.5 grams per piece of battery. The process flow is as follows :

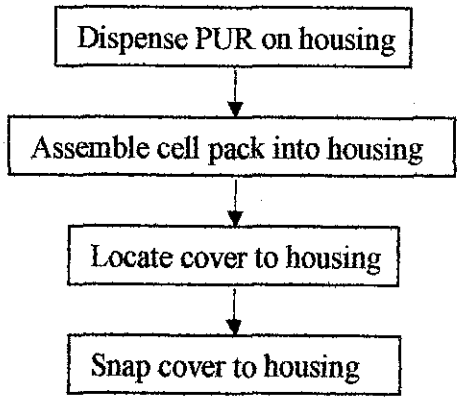

Figure 7 : Process flow of MDI Glue Machine

4.1.3 TPM (Total Preventive Maintenance) for Reflow

This work unit involves BTU machines that are used in the production floor. The BTU machine is actually an oven-like machine that is used to melt solder paste on printed circuit board (PCB). When the solder paste is melted, the components on the PCB will then sink and be stuck on it. While melting the solder paste, thick fumes are produced. This fume is then sucked away by the exhaust fan, via the individual BTU duct. Some of the fumes that are produced will condense and turn into flux. In time, these fluxes will accumulate on the BTU machine parts. The cleaning of the flux off the BTU machine parts is done by using the chemical which is known as 2-Propanol or Isopropyl Alcohol (IPA). The estimated usage of chemical is around 5 liters. Below is a brief process flow involving the chemical mentioned earlier.

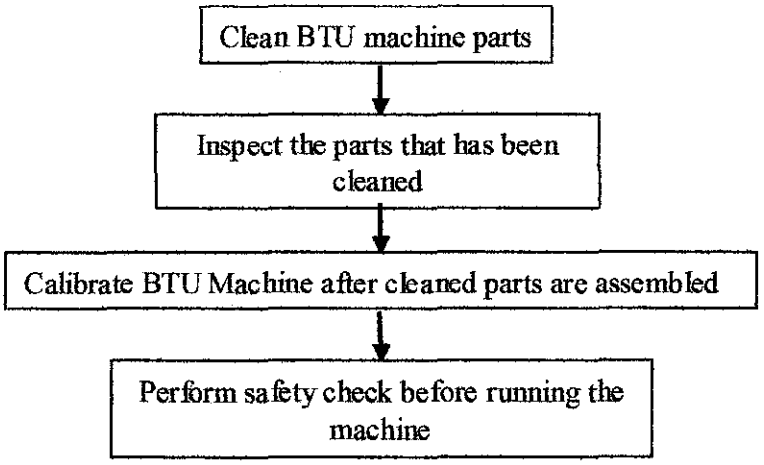

Figure 8 : Process flow of TPM for Reflow

Table 1 shows the results of assessment for all three work units, namely CGISS Battery-Jedi Cenelec, MDI Glue Machine and TPM for Reflow. The following sections will elaborate on how the stated results were achieved and the assessment was concluded.

Work Unit	Chemical Name	Hazard Rating	Frequency/ Duration Rating	Magnitude Rating	Risk Decision	Assessment Conclusion
CGISS Battery - Jedi Cenelec	Polyurethane Hardener Composition HP304 E/NC	3	DR = 4	3	3	C3
	Polyurethane Resin Composition RP304 E/BK	2	DR = 4	3	3	C3
	Chemcrest 121	3	DR = 4	3	4	C3
MDI Glue Machine	Pur-Fect Cleaner 9T (polyurethane hotmelt)	1	DR = 5	2	2	C1
TPM for Reflow	2-Propanol	3	FR = 5	3	4	C2

Table 5 : Results of Assessment

4.2 Hazard Determination

4.2.1 Polyurethane Hardener Composition HP304 E/NC

After classification was conducted, the hazard rating is determined to be harmful HR = 3. The data used to conduct classification are all taken from the Chemical Safety Data Sheet (CSDS). There is no known physical hazard for this chemical as the flash point is not within the range stated in the *Guidelines for the Classification of Hazardous Chemicals.* Therefore it can be concluded to be not flammable.

For Polyurethane Hardener Composition HP304 E/NC, its physical form is liquid. The risk phrases and information needed to conduct hazard classification is again obtained from the CSDS. The risk phrases (DOSH,1997) indicated are R20/21/22 : harmful by inhalation, in contact with skin and if swallowed, R36/37/38 : Irritating to eyes, respiratory system and skin, R42/43 : May cause sensitization by inhalation and skin contact. As the chemical can cause irritation in the respiratory tract, eyes and skin, the

'Sk' notation is needed. This chemical is usually kept in a store. It is only taken out and reacted with its resin when needed. After the usage, any materials such as gloves that are contaminated with this substance will be disposed into the Hazardous Chemical Waste Bin.

4.2.2 Polyurethane Resin Composition RP304 E/BK

In determining the hazard rating, the same procedure was followed for this chemical. The hazard rating was found to be irritant HR = 2. This chemical is not flammable, therefore there is no known physical hazard imposed by it to its users.

Polyurethane Resin Composition RP304 E/BK is liquid. The source of information is also CSDS. Risk phrases shown in the CSDS is R38 : Irritating to skin. Skin notation is also needed for this chemical as inhalation, skin contact and eye contact will cause irritation. The same manner of usage is applied for this chemical as Polyurethane Hardener Composition HP304 E/NC.

4.2.3 Chemcrest 121

For the third chemical used in this work unit, although it is classified as irritant, the hazard rating is HR = 3. This is due to the fact that the Risk Phrases for the chemicals are different. Chemcrest 121 is also not flammable.

Chemcrest 121 is in liquid form. From the CSDS, the risk phrases listed are R36 : Irritating to eyes, R37 : Irritating to respiratory system and R38 : Irritating to skin. Similar to the previous chemicals, skin notation is needed for the same reason. The movement of this chemical is the same as the two previous chemicals, but the usage is different as stated in the process flow (Figure 6).

4.2.4 Pur-Fect Cleaner 9T (polyurethane hotmelt)

This chemical is used in the second work unit and is classified as non-hazardous. Therefore, the hazard rating is HR = 1. It has no physical hazard considering it is a non-hazardous chemical.

Pur-Fect Cleaner 9T (polyurethane hotmelt), which is used in the second work unit, MDI Glue Machine, is in solid form. Again, the CSDS is used to obtain the risk phrases which are R38 : Irritating to skin and R42 : May cause sensitisation by inhalation. Skin notation is needed for this chemical as well. This chemical is collected from the store, dispensed into the glue machine and melted before it is used on the batteries.

4.2.5 2-Propanol

In TPM for Reflow, only one chemical is used, 2-Propanol or IPA, which is classified as harmful with hazard rating HR = 3. Unlike other chemicals in other work units, this particular chemical is known to be highly flammable.

2-Propanol is an alcohol, in liquid form. After looking at the CSDS, the risk phrases are obtained, namely R11 : Highly flammable, R36/37/38 : Irritating to eyes, respiratory system and skin and R40 : Possible risk of irreversible effects. Like other chemicals, skin notation is needed especially for this chemical. The movement of this chemical is almost similar to the earlier chemicals. It is taken out from the store and is used in the production floor. The contaminated material is then put into the Hazardous Chemical Waste Bin.

Table 2 summarizes the health and physical hazards of all the chemicals in the three work units.

Work Unit	Chemical Name	Physical Hazard	Health Hazard	Hazard Rating
CGISS Batetry - Jedi Cenelec	Polyurethane Hardener Composition HP304 E/NC	Nil	Harmful	3
	Polyurethane Resin Composition RP304 E/BK	Nil	Irritant	2
	Chemcrest 121	Nil	Irritant	3
MDI Glue Machine	Pur-Fect Cleaner 9T (polyurethane hotmelt)	Nil	Non-hazardous	1
TPM for Reflow	2-Propanol	Highly Flammable	Harmful	3

Table 6 : Summary of health and physical hazard classification

4.3 Exposure Assessment

4.3.1 Polyurethane Hardener Composition HP304 E/NC

The duration of exposure to Polyurethane Hardener Composition is around 8 hours per shift as the operators are working in shift, the total working time is 12 hours. Hence,

$$\frac{8}{12} \times 100 = 67\%$$

Therefore the duration rating is taken as 4. The magnitude rating of this chemical is determined by using the degree of release and degree of inhaled. Since this chemical has low or little release into the air, no contamination of air, clothing and work surfaces, therefore it has low degree of chemical release. The source is also close to breathing zone, contact with eye or skin irritants and has moderate area of contact, therefore moderate degree of chemical inhaled is chosen. Hence, it has the magnitude rating of 3. Duration Rating of 4 and Magnitude Rating of 3 give Exposure Rating of 4 for the hardener in this work unit.

4.3.2 Polyurethane Resin Composition RP304 E/BK

The same procedure was followed for this chemical in obtaining the Exposure Rating. The duration rating is found to be 4 as it is used together

with the hardener. The magnitude rating is 3 as it has the same manner of usage as the earlier chemical. Therefore having the same degree of chemical release and chemical inhaled, which is low and moderate respectively. So, the Exposure Rating for this chemical in this work unit is 4.

4.3.3 Chemcrest 121

The third chemical used in this work unit was given the duration rating of 4 as well. The degree of chemical release is low and degree of chemical inhaled is moderate based on the manner of its usage. Hence, it was concluded that the exposure rating for this chemical in this work unit is 4.

4.3.4 Pur-Fect Cleaner 9T (polyurethane hotmelt)

In the second work unit, again, applying the same procedure as before, the exposure rating was found to be 4. Before obtaining the exposure rating, the duration rating and magnitude rating was determined. The duration rating is 5 as operators are exposed to the chemical for 10 to 12 hours per shift. After determining the degree of chemical released and inhaled, which is low and moderate respectively, the exposure rating was obtained as stated above.

4.3.5 2-Propanol

In TPM for Reflow, technicians are exposed to IPA. For this chemical, in determining the exposure rating, instead of using duration rating, frequency rating was used. This is because the duration rating is lower than the frequency rating, which is 5. In doing this, the worst case is always considered; therefore, frequency rating was taken into consideration. In this work unit, the degree of chemical released and inhaled are both moderate. The fact that IPA has medium drying time and needed some walking around to be done in the work unit has lead the magnitude rating to be 3. Hence, the exposure rating is 4.

Table 3 summarizes the exposure rating for all chemicals in the three work units.

Work Unit	Chemical Name	Hazard Rating	Frequency /Duration Rating	Magnitude Rating	Exposure Rating
CGISS Battery - Jedi Cenelec	Polyurethane Hardener Composition HP304 E/NC	3	DR = 4	3	4
	Polyurethane Resin Composition RP304 E/BK	2	DR = 4	3	4
	Chemcrest 121	3	DR = 4	3	4
MDI Glue Machine	Pur-Fect Cleaner 9T (polyurethane hotmelt)	1	DR = 5	2	4
TPM for Reflow	2-Propanol	3	FR = 5	3	4

Table 7 : Summary of exposure rating

4.4 Adequacy of existing control measures

There are several options of control measures that can be implemented to prevent or minimize risks such as elimination of chemical hazardous to health from the workplace, modification of the process parameters, application of engineering control equipment or provision of approved personal protective equipment.

4.4.1 CGISS Battery-Jedi Cenelec

The control measures employed in this work unit only include personal protective equipment (PPE). Only general ventilation and safety goggles are provided to the person handling the chemicals in this work unit.

Due to the fact that the resin when reacted with the hardener would produce stench, a face mask and also local exhaust ventilation (LEV) needs to be put in place. Also the chemical used to wash off all the smearing of the resin and hardener is found to be irritant and in liquid form, therefore a chemical resistant glove and apron should also be used while handling it to prevent direct contact with skin and clothes.

Eye protection is needed for all the production operators. In this particular work unit, eye protection can help prevent accidental chemical splash.

4.4.2 MDI Glue Machine

The second work unit can be classified as safe as the chemical used is not hazardous and the dispensing glue machine is well contained. Chemical being dispensed from the machine is being dripped onto the battery cells. Therefore the existing control measures which is the PPE and an application of an engineering control which is the portable fume extractor is adequate. The PPE provided for the operators in this work unit are safety goggles and latex hand gloves.

4.4.3 TPM for Reflow

In this work unit, the control measures employed is personal protective equipment. There are eye protection, latex hand gloves and respirator.

IPA used for doing TPM for reflow produces quite a strong stench. Moreover, chemical handlers handle this chemical at quite a close distance. Therefore, face mask is not sufficient and respirator is more suitable. After implementing the usage of respirator in this work unit, complaints from employees about chest pains has reduced. The latex glove is used to prevent direct skin contact with IPA. IPA is in liquid form and contact can easily occur.

As stated above, eye protection is required for all the production workers. In this particular work unit, those observing at a proper distance can use safety goggles to prevent chemical from splashing into their eyes.

4.5 Concluding the assessment

4.5.1 Risk Decision

Risk rating is computed using the below equation

$$RR = \sqrt{HR \times ER}$$

When the square root is not a whole number, the next highest whole number is designated as the risk rating. Another method would be using the risk matrix, which is enclosed in Appendix I.10. By using the risk matrix, no calculation is needed. The exposure rating column versus the hazard rating column will straight away give risk rating of the chemical.

Polyurethane Hardener Composition HP304 E/NC has the hazard rating of 3 and exposure rating of 4. From the matrix, it found out that risk rating is 4. Polyurethane Resin Composition RP304 E/BK is rated as RR = 3 with hazard rating of 2 and exposure rating of 4. Chemcrest 121 is irritant with HR = 3 and ER = 4, resulting in RR = 4. Pur-Fect Cleaner 9T (polyurethane hotmelt) is non-hazardous with HR = 1 and ER = 4 and results in RR = 2. Lastly, 2-Propanol is highly flammable and harmful with HR = 3 and ER = 4, giving RR of 4.

The summary of risk rating for all the chemicals is as shown in Table 4.

FORM E : RISK MATRIX						
		EXPOSURE RATINGS				
		1	2	3	4	5
HAZARD RATINGS	1	RISK NOT SIGNIFICANT (RR = 1)	(RR = 2)	(RR = 2)	1.Pur-Fect Cleaner 9T (polyurethane hotmelt) (RR = 2)	(RR = 3)
	2	(RR = 2)	(RR = 2)	RISK SIGNIFICANT - CATEGORY 1 (RR = 3)	1. Polyurethane Hardener Composition HP304 E/NC (RR = 3)	(RR = 4)
	3	(RR = 2)	(RR = 3)	(RR = 3)	1.Polyurethane Resin Composition RP304 E/BK 2. Chemcrest 121 3. 2-Propanol (RR = 4)	(RR = 4)
	4	(RR = 2)	(RR = 3)	(RR = 4)	(RR = 4)	(RR = 5)
	5	(RR = 3)	(RR = 4)	(RR = 4)	(RR = 5)	RISK SIGNIFICANT- CATEGORY 2 (RR = 5)

Table 8 : Form E for all chemicals

4.6 Conclusion of CHRA

4.6.1 Actions to be taken

There are several matters that need to be considered to really understand the exposure of the same work units. Form F summarizes the components that will determine whether the operators are really protected from the hazardous chemicals.

4.6.1.1 Technical measures

In the all the work units, the control measures of elimination or substitution are not applicable as sourcing for other chemicals that have the same function would be the same as the contents are almost the same. Isolation and enclosures are not the ultimate option for CGISS Battery – Jedi Cenelec and TPM for Reflow since the generation of the fumes is not to a large extent that those measures are needed but is practiced in MDI Glue Machine.

In the first work unit, CGISS Battery – Jedi Cenelec, general ventilation provided is not sufficient. Other than that, the PPE provided which is eye protection is also too minimal of protection. Therefore in the form it is stated that local exhaust ventilation (LEV) should be put in place and also face mask, chemical resistant gloves and apron should be provided to ensure higher level of protection.

For MDI Glue Machine, the second work unit, the existing control measure such as the portable fume extractor to remove fumes at source, latex gloves and eye protection is sufficient in ensuring sufficient protection. Therefore, what needs to be done for this work unit is review assessment every five years or when there is a procedure change.

The third work unit also has sufficient existing control measures such as the respirator, latex glove and eye protection to ensure higher level of protection. Hence, the only actions that needs to be taken are maintain controls and minimise chances of higher exposure occurring, identify measures, procedures, and equipment to prevent

or control any accidental emission of chemical hazardous to health and review assessment every five years or when there is a change in circumstances or as directed by DOSH.

4.6.1.2 Maintenance of control equipment

The maintenance of portable fume extractor in the second work unit, MDI Glue Machine is adequate and is done by engaging contractor. It is done on monthly basis in order to ensure the long term protection is guaranteed.

4.6.1.3 Monitoring of air contaminant

Monitoring is done for airborne concentration of isopropyl alcohol. This monitoring is done by the Biochem Laboratories Sdn Bhd and the results are as below.

Monitoring	Limits	Results
Isopropyl alcohol	400 ppm	1.197 ppm

Table 9 : Results of monitoring

4.6.1.4 Biological monitoring

Biological monitoring includes blood test and urine test. It has not been conducted for the operators in all three work units before. After conducting the assessment, it is decided that biological monitoring is not necessary.

4.6.1.5 Health surveillance

The case with health surveillance is similar with biological monitoring.

4.6.1.6 Info, instruction and training

Proper training in forms of briefing was conducted to those operators working in these work units.

4.6.2 Risk Decision

4.6.2.1 CGISS Battery-Jedi Cenelec

Based on the risk decision and the assessment of existing control measures such as eye protection and general ventilation, the assessment is concluded to be risk significant now, and not adequately controlled.

4.6.2.2 MDI Glue Machine

The assessment on this work unit was concluded to be risk not significant now and not likely to increase in future after considering risk decision and assessing the existing control measures which is eye protection, latex glove and portable fume extractor.

4.6.2.3 TPM for Reflow

After assessing the existing control measures which is respirator, eye protection and latex gloves and also considering the risk decision, the assessment is concluded to be risk significant but already adequately controlled could increase in future.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion on Findings

5.1.1 CGISS Battery – Jedi Cenelec

There are three chemicals used in the first work unit namely, Polyurethane Hardener Composition HP304 E/NC, Polyurethane Resin Composition RP304 E/BK and Chemcrest 121. All of these chemicals are in liquid form where the hardener is harmful and the other two chemicals are classified as irritant. Here, the hardener is mixed with its resin to form a substance as filling for battery casing. The Chemcrest 121 is used to wash of any smears of the substance on the casing. Therefore, employees in this work unit, is exposed to direct contact with the chemicals.

After assessment was done, it was concluded that the existing control measure is not adequate. It is not capable of minimizing the exposure of the chemicals to the employees. The current personal protective equipments being used for this work unit is merely eye protection. The work unit has only general ventilation.

Upon completing the assessment, some actions need to be taken in order to improve the safety of the work unit. Implementation of new PPE such as chemical resistant glove, chemical resistant apron and face mask should be put in place. Also Local Exhaust Ventilation has to be installed in the work unit to further promote safe working environment.

The following figures represent different views of the Local Exhaust Ventilation improvement design that has been suggested to be put in place for this work unit. The specification is as shown in the drawings. The hood is for covering chemical cleaning, fixture storage, fixture loading and fixture unloading. The suction openings are at the sides instead of on top to improve efficiency.

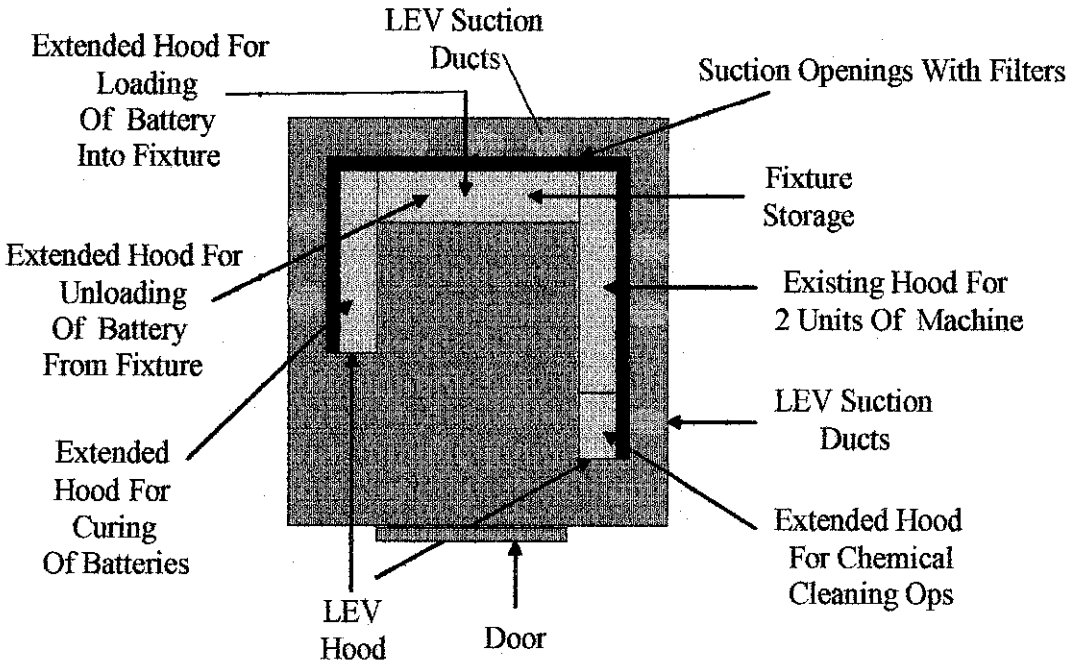

Figure 9 : Local Exhaust Ventilation Design – top view

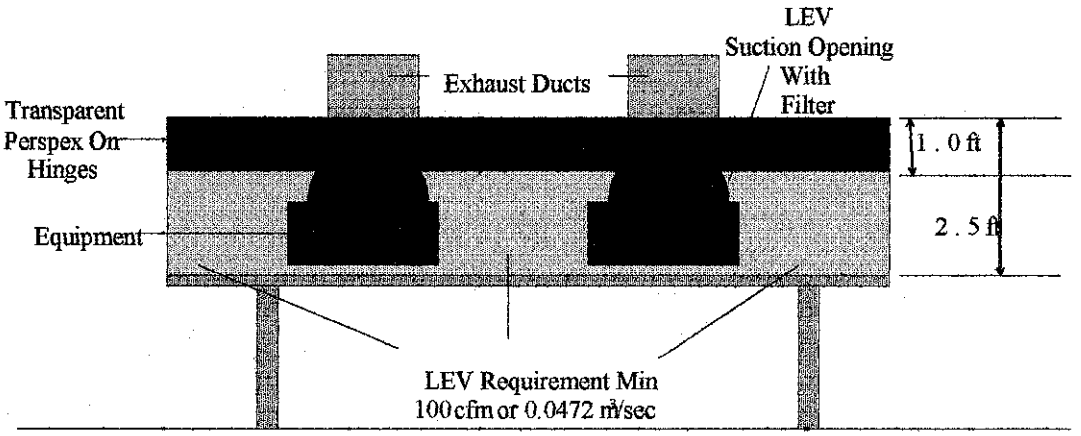

Figure 10 : Local Exhaust Ventilation Design – front view

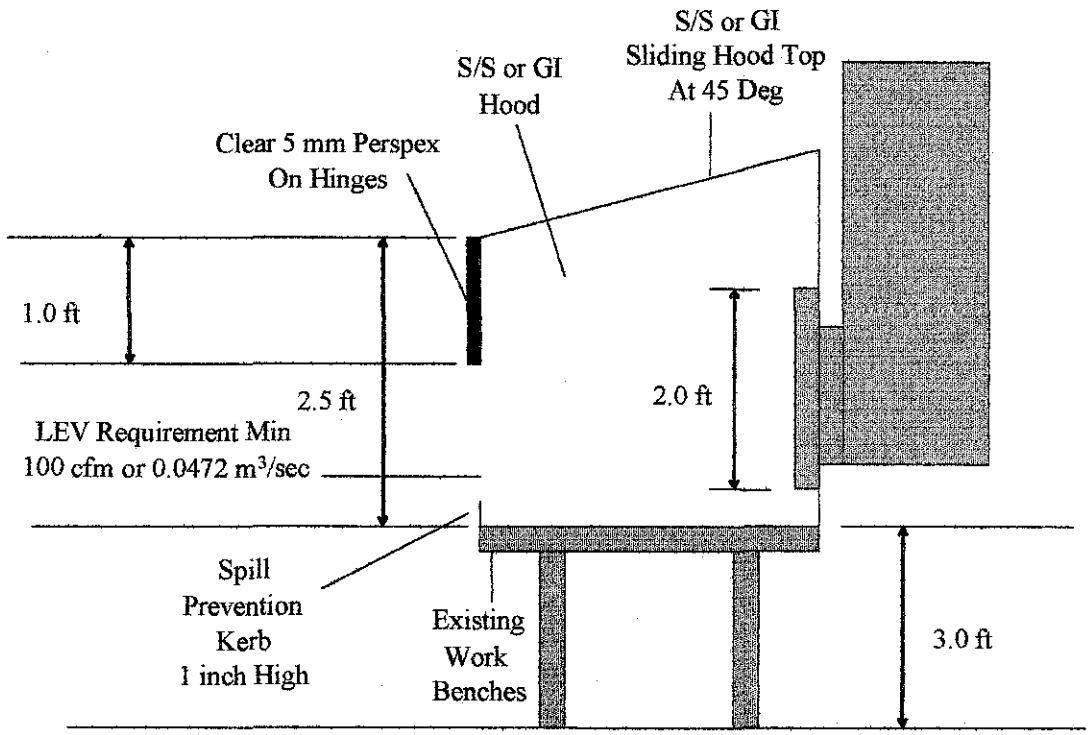

Figure 11 : Local Exhaust Ventilation – side view

5.1.2 MDI Glue Machine

In the second work unit, Pur-Fect Cleaner 9T (polyurethane hotmelt) which is used in this work unit is melted and dispensed by the glue machine. Therefore minimum direct contact with skin is required. Moreover, it is a non-hazardous solid.

After assessment was conducted it is found that the existing personal protective equipment is sufficient in minimizing the exposure of employees to the chemicals. The PPE used for this work unit are latex gloves, eye protection and respirator. Other than that, this work unit uses portable fume extractor as an extra precaution.

Fume extractor works by removing harmful particles and gases before they reach the worker's breathing zone. These systems are easily positioned close to the source, safely capturing fumes, which then pass through the filtration system of pre-filter and HEPA High Efficiency Particulate Air filter.

5.1.3 TPM for Reflow

After assessment is done on the third work unit, it is found that the current personal protective equipment being used for this particular work unit are latex gloves, eye protection and respirators. The control measures to minimize the exposure of the employees to the chemicals are already sufficient. Isopropyl alcohol is generally used in doing preventive maintenance on BTU machines. It is used to clean the machine parts from flux. It is known to be highly flammable due to low flash point. In the wok unit, IPA is kept in a bottle and operators do not use the chemical directly with their glove protected hands but using shammy and brush. This is another safe work practice that is highly recommended.

Monitoring of IPA was done on this work unit to ensure that the exposure of IPA is below the permissible exposure limit (PEL). PEL is the maximum amount or concentration of a chemical that a worker may be exposed to under OSHA regulations. To conduct monitoring, Motorola Technology has engaged Biochem Laboratories Sdn. Bhd. and the method they use is following the *NIOSH Manual of Analytical Methods* (NMAM) Fourth Edition 1994.

5.2 Recommendation

5.2.1 Recommendation on the Work Units

Recommendation can be made with reference to Form F. The overall recommendations for all the work units are :

- Continuous improvement to minimize usage through engineering solutions

  Engineering solutions like use of portable fume extractor and installation of Local Exhaust Ventilation (LEV) should be source for to ensure long term protection to the operators.

- Maintain work practice and personal protective equipment used

  The work system established by the respective departments is highly commended as it gives the operators a guideline to carry out their work. Personal protective equipment used is also sufficient. However,

it should be noted that the work system should be continuously updated when there is any changes in the process.

- Biological monitoring

  It is agreed that biological monitoring is not needed for the work units as the results of Isopropyl Alcohol indicates. It is recommended that when the results of monitoring for IPA rise to around 200 ppm, biological monitoring should be implemented.

- The procedure of emergency and first aid can be further communicated to the employees and hands-on practice should be implemented.
- Health surveillance is recommended to be established at least once a year for the operators exposed to Isopropyl Alcohol.

5.2.2 Recommendation on the CHRA

Upon conducting the assessment for three work units consisting of five chemicals, recommendation on the methods can be made. The general recommendations for the CHRA are :

- The Chemical Data Sheet (CSDS) should provide more information on the chemicals in order to make determination of the health and physical hazard more exact.
- In determining the Hazard Rating, chemical classification should not be made solely by looking at the Chemical Safety Data Sheet of the particular chemical due to the fact that some of the CSDS did not provide the adequate information.
- The method in determining frequency rating and duration rating need to be improved and stated more clearly. It is not appropriate for most of the working activities. An example is when a hazardous chemical is only used to touch up a material. It is not stated in the method which category it should fall under as the scope is too wide and general. Therefore, the table should be revised in order to obtain a more accurate and precise assessment.
- Develop a spreadsheet where the complete information of all hazardous chemicals, including risk phrases is provided in order to

reduce time on searching for additional information and also to avoid obtaining redundant information on certain chemicals.

- Person conducting CHRA should be well-exposed and have good experience in dealing with hazardous chemicals as it comes in handy especially while evaluating the degree of chemical absorbed and released. This evaluation is done by observing how the person handles the chemical. For example, a person who has bad eyesight might be working more closely to the chemicals compared to a person with better eyesight therefore increasing the degree of chemical absorbed by the person.

CHAPTER 6
REFERENCES

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CHAPTER 7

LIST OF APPENDICES

Questionnaire for Chemical Health Risk Assessment

This questionnaire is to obtain more information about the chemical usage in each work unit, which is already identified earlier during preliminary data gathering.

Section A : Introductory

A1. Please state your name : .....

A2. Badge No : .....

A3. Work Area : .....

A4. Gender : ☐ Male ☐ Female

A5. Job title : .....

Section B : Job description

B1. What is your work hour ?

☐ Normal (8 hours) ☐ Shift (12 hours)

B2. What is your task? (Please include process flow)

.....

.....

.....

Section C : Usage of chemicals

C1. Please list the chemicals that are being used in your work area, amount of usage and period of exposure

No	Chemical Name	Amount of usage	Period of exposure		
			Any work hour	Only for normal	Only for shift
1			One or more time per shift	< 1 hr/shift	< 1 hr/shift
			Greater than one time per week	1 to 2 hrs/shift	1 to 3 hrs/shift
			Greater than one time per month	2 to 4hrs/shift	3 to 6 hrs/shift
			Greater than one time per year	4 to 7 hrs/shift	6 to 10 hrs/shift
			Less than one per year	> 7 hrs/shift	10 to 12 hrs/shift
2			One or more time per shift	< 1 hr/shift	< 1 hr/shift
			Greater than one time per week	1 to 2 hrs/shift	1 to 3 hrs/shift
			Greater than one time per month	2 to 4hrs/shift	3 to 6 hrs/shift
			Greater than one time per year	4 to 7 hrs/shift	6 to 10 hrs/shift
			Less than one per year	> 7 hrs/shift	10 to 12 hrs/shift
3			One or more time per shift	< 1 hr/shift	< 1 hr/shift
			Greater than one time per week	1 to 2 hrs/shift	1 to 3 hrs/shift
			Greater than one time per month	2 to 4hrs/shift	3 to 6 hrs/shift
			Greater than one time per year	4 to 7 hrs/shift	6 to 10 hrs/shift
			Less than one per year	> 7 hrs/shift	10 to 12 hrs/shift

C4. What is the movement of the chemicals? (Please tick the one that applies)

☐ Supplier → ☐ Store → ☐ Safety Cabinet → ☐ Carousel →

☐ Minibank → ☐ Workbench → ☐ Hazardous chemical bin

C5.Is there any possibility of abnormal chemical exposure for each chemical, ie spillage? If yes, please state the details.

1. .....

.....

.....

2. .....

.....

.....

3. .....

.....

.....

4. .....

.....

.....

5. .....

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.....

6. .....

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.....

Section D : Control measures

D1. What are the existing control measures applied in your work area? Please circle the appropriate choice and state the specific type of control.

Engineering control measures :

a. Fume hood
b. Portable fume extractor
c. Exhaust fan
d. Others : .....

Personal protective equipment :

a. Glove : .....
b. Eye protection : .....
c. Apron
d. Face shield : .....
e. Respirator : .....
f. Others : .....

D2. Are you involved in the maintaining of these control measures? Please circle the appropriate response.

☐ Yes.

Please state the process and frequency of maintenance :

.....

☐ No.

Please state the person responsible for maintaining the control measures :

.....

Section E : Health Issues

E1. Is there any health effects experience by you after contacting the chemicals? If yes, please describe.

.....

.....

E2. Do you go for medical check-up every 6 months/year?

.....

E3. Is there any health effects caused by the usage of chemicals described in the report?

.....

.....

E4. Are you obliged to go for biological monitoring or health surveillance?

.....

Section F : Information, instruction and training

F1. Please list down the training that you have attended before and the frequency.

a. .....

b. .....

c. .....

d. .....

e. .....

F2. Are you informed of the location of nearest emergency controls? Please tick the one applies and state the location.

☐ Eye wash. Location : .....

☐ Shower. Location : .....

☐ First aid kit. Location : .....

F3. Are you equipped with the knowledge to use the above emergency controls?

.....

.....

F4. Are there any safe work practices in your work area?

.....

.....

F5. In case of spillage, do you know what are the procedures that you need to go through?

.....

.....

I, ... acknowledge that I have gone through the questionnaire with the Interviewer and ensure that the information given above are true to my knowledge.

Interviewee's Signature : .....

Date : .....

Interviewer's Signature : .....

Interviewer's Name : .....

Date : .....

Table 11: **Exposure Rating**

FREQUENCY RATING/ DURATION RATING	MAGNITUDE RATING (MR)				
	1	2	3	4	5
1	1	2	3	3	3
2	2	2	3	3	4
3	2	3	3	4	4
4	2	3	4	4	5
5	3	4	4	5	5

Significant risk arising from the use of chemical hazardous to health is to be controlled, in this following order :

- ✓ Elimination of chemical hazardous to health from the workplace;
  - ➢ Elimination of the chemicals hazardous to health includes the total removal of a hazardous chemical by the use of other processes not involving chemical hazardous to health.
- ✓ Substitution of chemical hazardous to health with a less hazardous chemical;
  - ➢ The substitution here is the substitution of a chemical hazardous to health with a less hazardous substitute such as the use of a water-based detergent instead of the neurotoxin n-hexane.
- ✓ Total enclosure of process and handling systems;
  - ➢ Totally enclosing the process and handling systems emitting chemical hazardous to health can prevent or minimize their release into the work environment.
- ✓ Isolation of the work to control the emission of chemicals hazardous to health;
  - ➢ This can be achieved by segregation, either by distance or physical barrier, of the hazardous work, process or chemical hazardous to health from workers.
- ✓ Modification of the process parameters;
  - ➢ Such as the use of lower operating temperature or pressure to minimize the release of chemical hazardous to health into the workplace environment.
- ✓ Application of engineering control equipment;
  - ➢ This is control through the application of engineering control equipment such as local exhaust system, general ventilation, and water spray.

- ✓ Adoption of safe work systems and practices that eliminate or minimizes the risk to health;
  - ➢ Safe work system and procedures that eliminate or minimize the risk to health can be adopted.
- ✓ Provision of approved personal protective equipment;
  - ➢ Provision of personal protective equipment and clothing includes the proper selection, correct fit, proper use, care and maintenance, and available replacement when required.

Suitability of control measures depends on :

- ✓ The toxicity of chemical
  - ➢ For high toxicity chemicals the use of local exhaust ventilation is suitable while the use of general ventilation is not
  - ➢ The use of job rotation is not suitable for chemical hazard
  - ➢ For personal protective equipment, the degree of protection must match the level of risk
- ✓ The physical and chemical properties of the chemical
  - ➢ The control equipment is designed to control the chemical in the physical form employees is exposed to.

    E.g. Use of dust mask is not suitable to protect against organic solvent vapor
- ✓ Nature of work
  - ➢ Suitable if the nature of work does not hinder the efficiency of the control measure or the control measure does not give rise to the potential for an accident or to another hazard
- ✓ Adaptability
  - ➢ Suitable if control measures are adapted to the work capacity and capability of the workers involved
- ✓ Route of entry
  - ➢ Control measures selected prevent entry of the chemical through the probable entry route.

By observing the following, the effectiveness of control measure can be assessed.

- ✓ In general
  - ➢ Minimal contamination of the air, work clothing, or work surfaces, odor or irritating sensation;
  - ➢ Minimal or no release or emission of chemical into the working environment;

- Minimal or no exposure or contact of workers to chemical;

✓ For local exhaust ventilation system (LEV)

- No accumulation of substance around the hood;
- Smoke tube test indicates food suction-smoke directed towards the hood;
- The capture velocity is within the recommended value for the specific contaminant; and
- The positioning of hood is such that it is very close to (within 1 hood diameter or enclosing the source).

✓ For personal protective equipment

- Use of correct type with adequate degree of protection;
- Properly worn – have undergone instruction or training session
- Correctly fitted – have been carefully chose and fit tested;
- Worn continuously at the designated work area – with constant supervision;
- Equipment still functioning properly – not defective or damaged or has not expired its shelf life
-

Maintenance of control equipment is an important aspect in ensuring that the health risks are continuously under control. This would entail the following :

✓ For engineering controls

- Periodic inspection, examination and testing to ensure effectiveness;
- Immediate repair when there is a breakdown in the equipment; and
- Re-testing of equipment effectiveness after any repair work.

✓ For personal protective equipment

- Available replacements for defective part(s) or ineffective equipment;
- Regular inspection and care of equipment; and
- Provision and use of proper equipment accommodation.

Table 12: RISK MATRIX

HAZARD RATING	EXPOSURE RATING (ER) 1	2	3	4	5
1	RR=1	RR=2	RR=2	RR=2	RR=3
2	RR=2	RR=2	RR=3	RR=3	RR=4
3	RR=2	RR=3	RR=3	RR=4	RR=4
4	RR=2	RR=3	RR=4	RR=4	RR=5
5	RR=3	RR=4	RR=4	RR=5	RR=5

RISK NOT SIGNIFICANT

RISK SIGNIFICANT

Category 1

Category 2

- ✓ C1 : Risk not significant now and not likely to increase in the future
  - ➢ If the assessment shows that a hazardous chemical is :
    - already controlled or can be readily controlled in accordance with the CSDS; and
    - there is not a significant risk to health
- ✓ C2 : Risk significant but already adequately controlled could increase in future
  - ➢ This conclusion applies to conditions where adverse health effects could increase in future, due to control measures failure or deterioration. Risks, while at present adequately controlled, could increase in future due to, for example :
    - Undetected deterioration in the efficiency of control measures;
    - Plant, equipment (including personal protective equipment) or system failure;
    - Changes in methods or rate of work;
    - A significant increase in the quantity of chemicals hazardous to health used.
- ✓ C3 : Risk significant now, and not adequately controlled
  - ➢ This conclusion applies to conditions where workers are at risk of adverse health effects since their exposure to the hazardous chemical is not adequately controlled.
- ✓ C4 : Uncertain about Risk : Insufficient Information
  - ➢ This conclusion is arrived at if there is insufficient information to determine the degree of hazard.
- ✓ C5 : Uncertain about Risk : Uncertain about degree and extent of exposure
  - ➢ This conclusion is arrived at if the level of exposure cannot be estimated with confidence.

For risk decision C1 the actions required are :

- ✓ end current assessment; and
- ✓ review assessment every five years or when there is a change in or as directed by DOSH (Department of Safety and Health).

For risk decision C2 the actions required are :

- ✓ determine precautions to maintain controls and minimize chances of higher exposure occurring;
- ✓ determine additional measures for regaining control if a high-risk event occurs, despite precautions;
- ✓ identify measure, procedures and equipment to prevent or control any accidental emission of chemical hazardous to health;
- ✓ determine if monitoring or health surveillance is required to check on effectiveness of controls; and
- ✓ review assessment every five years or when there is a change in circumstances or as directed by DOSH.

For risk decision C3 the actions required are :

- ✓ identify and implement immediate measures and procedures for preventing or controlling exposure;
- ✓ identify measures, procedures and equipment to prevent or control any accidental emission of chemical hazardous to health;
- ✓ establish the need to stop the process
- ✓ begin review of longer terms control equipments;
- ✓ re-evaluate exposure when the upgraded control measures are in place;
- ✓ determine if monitoring or health surveillance is required;
- ✓ determine if training and retraining of employees is required;
- ✓ review assessment every five years or when there is a change in circumstances or as directed by DOSH.

✓ **Form A : List of Chemicals**

Form A is to guide the flow of hazard rating determination and includes the following information :

- Name of chemical & indicator ingredient
- Physical form
- Source of information
- Classification of hazard
- Risk phrases
- Skin notation
- Hazard rating
- Chemical movement : storage, movement, handling and use, disposal

✓ **Form B : Work Unit Description**

Form B is used to capture information of the work unit. The information that form B require are :

- Work area;
- Job title and categories of employee(s);
- Working hours and work arrangements
- Brief process description
- Employee health feedbacks (to describe if any ill effects experienced by employees)
- Report on health effects (to summarize cases of health effects reported to employer)
- Worker with susceptible conditions (to describe conditions)
- Possibility of abnormal exposure (for other than during normal work or operation)
- Possibility of mixed exposure (if presence other chemicals affecting the same system/organ)
- Possibility of ingestion exposure (to describe exposure situations)

For risk decision C4 the actions required are :

- ✓ obtain additional information. Obtain specialist advise if necessary;
- ✓ meanwhile, implement good work practices to minimize exposure.

For risk decision C5 the actions required are :

- ✓ conduct a more detailed assessment. Obtain specialist advice if necessary.
- ✓ Meanwhile, implement good work practices to minimize exposure

✓ **Form C : Workplace Assessment**

Form C summarizes the findings of exposure evaluation. It includes the chemical name, task using the chemicals, frequency rating or duration rating, routes of entry, existing control and the suitability or efficiency, maintenance, testing and examination of engineering control, degree of chemical release and degree of chemical inhale as well as magnitude rating and exposure rating.

✓ **Form D : Workplace Assessment Result**

Form D guides the assessor to accurately determine the conclusion (C1, C2, C3, C4 or C5) for each assessment done. It includes

- Chemical hazardous to health
- Hazard rating
- Task
- Routes of exposure
- Risk decision
- Control adequacy
- Conclusion
- Actions to be taken

✓ **Form E : Risk Matrix**

The purpose of this form is to use hazard rating and exposure rating to find the risk rating for each chemical.

✓ **Form F : Action To Be Taken**

There are several information needed in this form as sated below :

- Technical measures : elimination/substitution
  Isolation/enclosure
  Ventilation
  Work practice/system of work
  Personal protection

- Maintenance of control equipment
- Monitoring of air contaminant
- Biological monitoring
- Health surveillance
- Information, instruction and training
- Emergency and first aid procedures

✓ **Summary form**

The summary form should be filled in and presented to the person in-charge of a company. The summary form includes the following :

- Name and address of company assessed
- Date of assessment
- Work area/department
- Work unit
- Number of workers in work unit
- Chemicals hazardous to health in work unit
- Assessment conclusions
- Recommendations