IMPLEMENTATION AND ANALYSIS OF CHEMICAL HAZARD RISK ASSESSMENT (CHRA) AT A PETROCHEMICALS COMPANY, MALAYSIA

Suziyana Mat Dahan, Mohd Yusof Taib, Nurhaizan Mohd Zainudin, Fadzida Ismail and Ahmad Nazif Noor Kamar
Faculty of Technology, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Kuantan, Pahang and Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang

ABSTRACT

Safety and health management system has started since last thirty years ago. At that time, the systems focused on protecting and informing workers with the assumption that workplace accidents were generally the result of individual unsafe acts. Safety standards were poor if compared with today, until the introduction of legislation in the 1970s. It was the first time, law placed responsibilities on employers and managements for ensuring the health and safety of the workers and the general public. Organizations management were started to view health and safety as an integral part of their business management and kept improving it by involving governmental and non-governmental organizations. Many organizations believed in effective health and safety management as one of the major factors for their profitability, not only contributing to reduce the cost of damage, down time and compensation, but also has significant effects on maximizing team and individual performance. An assessment known as Chemical Hazard Risk Assessment (CHRA) was carried out continuously for the purpose of safety and health improvement at workplace. In this paper, CHRA that was conducted in one of petrochemical companies in Malaysia is reported. Two work units have been chosen in which the workers were exposed to different types of chemical, duration of exposure and different mode of handling. The purpose of this assessment is to ensure that the workers are in safe workplace environment. In this assessment, hazards of every chemical were studied by referring to Material Safety Data Sheet or Chemical Safety Data Sheet which provided by chemical suppliers. Every task performed by workers was investigated to find out the safety work practice and degree of hazards released by the chemicals. Once the assessment was completed, actions required to control the risk at the workplace were determined. Results revealed that some work units were good at meeting the safety standards, but with CHRA, better safe workplace could be provided. More intensive enforcement by government agencies such as Department of Organization Safety and Health (DOSH) are required to ensure employers pursue relevant initiatives to meet the safety laws and regulations.

*Keywords:*workplace safety and health, Chemical Hazard Risk Assessment (CHRA)

BACKGROUND OF STUDY

INTRODUCTION

There are many dangerous substances used in a wide range of industrial and commercial activities and over the years many workers have contracted occupational diseases through exposure to such substances. This also included a petrochemical company in Malaysia where the workers were also facing the same issues. The potential for contracting an occupational disease varies according to the potential of harm and substances concerned of its form in solid, liquid, gas and dust. The types of chemical that used in the company are Nin Ethylene, Distearamide, Perhaxa, Trogoral, Normal Dodedyl and Mercapta. These substances are able to penetrate human body, thus the proper precautions must be taken by employer and personally by the workers. The dose received by employees relative to time of exposure is very important and should be investigated and also degree of the susceptibility to the substances. Some of the effects of hazardous chemicals are ranging from simple irritation to severe tissue destruction, systemic damage to internal organs and for some

chemicals with slow elimination rate from the body, they may persist in the body for a lifetime and cause deleterious effects [1]. The application of Personal Protective Equipment (PPE) is an effective method to minimize the risks of exposure and being contacted with the chemicals. Identification of appropriate PPE for a particular chemical is important to ensure the workers safety at workplace [2]. Thus, the aim of this study is to identify level of risk for each chemical that the workers are facing in their daily routine of work and to propose proper PPE for them.

CHEMICAL HAZARD RISK

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. To perform this duty, an assessment of all chemicals used in the workplace must be carried out in order to identify, evaluate and control any health risk associated with work activities involving the use of the chemicals.Under the Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) 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 an assessment has been conducted. The objectives of these regulations are to prevent harms resulted from the use of chemical at work place, to provide minimum standard on the safe use of hazardous chemicals and to stipulate the maximum allowable exposure standard [3].

Chemical Hazard Risk Assessment (CHRA) is an assessment method that can be conducted by competent assessor who certified by the DOSH. It 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 to protect the health of employees who may be exposed to hazardous chemicals at workplace. DOSH requirement on CHRA manual [3] can be used as a guideline to conduct an assessment of the health risks arising from the threat, handling, and storage or transporting of hazardous chemicals. This guideline refers to Use and Standard of Exposure of Chemical Hazardous to Health (USECHH) regulation 2000. There are two CHRA assessment methods: generic assessment and full assessment. However, only generic assessment was conducted for the purpose of this study.

CONCEPTS

Few basic concepts were regularly used and need to be understood in accordance with DOSH requirement as stated in 2nd Manual edition of recommended practice [3]. The basic concepts are:

Hazard, Exposure and Risk

Chemical health hazard is the potential of a chemical to cause harm or adversely affect health of people in the workplace. The adverse health effect ranges from fatality, disability and serious health impairment to mild skin irritation. Workers are considered as exposed to chemicals, if there is a possibility of the chemical is being breathed in; getting it on the eye or skin or absorbed through the skin; or being swallowed. A chemical may exert its effect either at the site of contact; or at a site away from the initial point of contact and takes place after it has entered the body through the various routes of entry. The risk of chemical substances to health usually increases with the severity of the hazard, the amount used, and the duration and frequency of exposure.

Rating of Hazard, Exposure and Risk

The approach adopted in [3] is qualitative assessment with rating system, in that the severity of hazard and the chance of overexposure are rated on five (5) scale of rating. Based on the rating, RR is the

Risk Rating ranging from1 to 5 where it indicates thelikelihood of injury or illness. HR is the Hazard Rating and again it is ranging from 1 to 5 which indicate the severity of adverse effects and ER is the Exposure Rating(1 to 5) indicating the chance of overexposure to the hazardous chemicals.

Material Safety Data Sheet (MSDS) and Chemical Safety Data Sheet (CSDS) were used to identify the possible hazards associated with each chemical. MSDS and CSDS must be provided by supplier under regulation 9(1) of the Occupational Safety and Health. The information recorded includes the following:

a) The composition of the ingredients that clearly identifies the hazardous chemical for the purpose of conducting a hazard evaluation.
b) Hazard identification
c) First-aid measures
d) Fire-fighting measures
e) Accidental release measures
f) Handling and storage
g) Exposure controls and personal protection
h) Physical and chemical properties

Basic PPE were applied by workers at the workplace where the study was conducted. The basic PPE required by DOSH were safety shoes, safety helmets, safety glass, ear plugs/muffs and NOMAX fire protection coverall.

CONTROL MEASURE SYSTEM

There were several important methods implemented in managing chemical hazard risks at workplace and meet the standard that has been established. Besides that, advisory input and recommendation from the published authoritative guidance was considered as one of the Control Measure System. A regime of control measure which reliably prevents any adverse health effects was drawn on hierarchy of measurement in order of preference as stated in Table 1.

Table 1: Control Measure

Hierarchy Order	Hierarchy Preference	Hierarchy Description
1	Elimination	Change the process or activity so that the hazardous substance is not used or is not generated
2	Substitution	Replace it with safer alternative
3	Isolation	Separate the hazardous substance from the workers
4	Engineering controls	Use physical measures to minimize workplace contamination
5	Administrative control	Use of safe work practices and procedure to minimize contamination.
6	Personal Protective Equipment	Provide proper PPE such as facemasks, gloves, protecting clothing

METHODOLOGY

METHODOLOGY OF CHRA

The approach adopted to determine hazard and the chances of overexposure in this study was qualitative assessment. Rating system of number 1 to 5 was implemented with an increasing order of magnitude represented increasing of risk, for example scale 1 represented low risk and scale 5 represented very high risk. Table 2 shows level of risk for the particular risk rating.

Table 2: Description of Level of Risk

Risk Rating	Level
5	Very High Risk
4	High Risk
3	Medium Risk
2	Low Risk
1	Very Low Risk

Risk imposed by each chemical was classified as either 'significant' or 'not significant' based on computation of the risk rating. Risk was classified as not significant if it was unlikely that the work exposure adversely affected the health of workers. Table 3 shows risk significant category for the particular risk exposure rating (ER) and risk Hazard Rating (HR).

Table 3: Risk Significant Category

		Exposure Rating (ER)				
		1	**2**	**3**	**4**	**5**
Hazard Rating (HR)	**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

Legend:

: Risk not significant

: Risk significant – Category 1 (to be controlled using PEL)

: Risk significant – Category 2 (risk priority to control higher than category 1)

Once completing the risk decision and the assessment of existing control measure at each work unit, final conclusion for this CHRA was summarized and the results were denoted by C1, C2, C3, C4 and C5. The description of notations is described below:

C1: Risks is not significant at that time and not likely to increase in future
The description is applied if the assessment shows the following situations:

- Already controlled or can be readily controlled in accordance with the CSDS and
- There is not significant risk to health then the assessment is complete.

C2: Risk is significant but already adequately controlled and could increase in future
This conclusion is made where the 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;
- Control measures not used properly;
- Human error, from lack of awareness, monitoring failure or inadequate training;
- Changes in methods or rate of work;
- A significant increase in the quantity of hazardous chemicals used

C3: Risks is significant at that time and not adequately controlled
This conclusion is made where the workers are at risk of adverse health effects since their exposure to the hazardous chemicals is not adequately controlled.

C4: Uncertain about risk - Insufficient information
This conclusion is arrived at if there is sufficient information to determine the degree of hazard.

C5: Uncertain about risk - Uncertain about degree and extent of exposure
This conclusion is arrived if the level of exposure cannot be estimated.

IMPLEMENTATION OF CHRA

First step of CHRA implementation in this study was to evaluate level of exposure to the particular chemical and classification of the chemical into work unit. Workers were assigned to different work units and evaluation of hazards was based on similar task. The similar task was defined as the workers have similar potential for being exposed to the chemical hazards. Besides that, the working unit identification was made by performing site visits to potential exposure area.

EVALUATION OF EXPOSURE AND CLASSIFICATION OF WORK UNITS

The work units that have been categorized in this study are as follows:

i) Work Unit 1: Polymerization Area/Process Operator & Polymerization Area/Supervisor
ii) Work Unit 2: Palletizing and Utility Operator

Table 4 shows identification for work unit with task description which performed by workers and the control measures.

Table 4: Identification of Work Unit

No	Working Unit	No. of Workers	Task Descriptions	Control Measure/Safe Work Practice
1	Polymerization area/ process operator	12	The task involves transferring chemical from drum to mixing tank, transferring chemical by using pipeline, and also transferring chemical in drum from chemical room to refill area by using forklift.	Emergency eye wash located at ground floor. Gas sensor located at plant site. PPE such as dust mask, safety shoes, semi leather glove and safety helmet are provided.
	Polymerization area/ process supervisor	4	Task of supervisor is to ensure that the process plant running smoothly. They are also doing plant checking for outside job, cleaning and etc. The assistant supervisor is to assist the outside job and collect 2 kinds of sample: Product sample - collected from V600 discharge valve and put into 50 ml bottle. Solvent recovery sample - collected from V620 discharge valve and put into 50 ml bottle	PPE such as dust mask, safety shoes, semi leather glove and safety helmet provided.
2	Palletizing and utility operator	12	Palletizing operator To top-up 20 kg of chemical into vibrator Arranging polystyrene strand Refill 20 ml chemical for water cleaning in water tank	PPE such as dust mask, safety shoes, semi leather glove and safety helmet provided. In-house training provided.

Table 5: Classification of Chemicals in Work Unit 1 and 2

a) Work Unit 1: Polymerization Area/Process Operator

Chemical	Hazard Classification	Skin Hazard (Y/N)
N,N Ethylene Distearamide	Harmful-inhalation Irritant-eye/skin	Y
Perhexa (IPC-I17)	Harmful-inhalation Irritant-respiratory tract/eye/skin	Y
Trigonox (IPC-I3)	Harmful-inhalation Irritant-respiratory tract/eye/skin	Y
Normal Dodedyl Mercaptan (IPC-J2)	Irritant-eye/skin/respiratory tract	Y
Irganox (IPC-A6)	Non hazardous	Nil

b) Work Unit 1: Polymerization Area/Supervisor

Chemical	Hazard Classification	Skin Hazard (Y/N)
Styrene Monomer	Harmful-inhalation Irritant-eye/skin/ingestion Possible carcinogen	Y
Ethylbenzene	Toxic-ingestion Harmful-inhalation/swallow Irritant-eye/skin/ingestion	Y
Polybutadiene Rubber	Non hazardous	Nil
Perhexa (IPC-I17)	Harmful-inhalation Irritant-respiratory tract/eye/skin	Y
Stearic acid (IPC-C4)	Irritant-eye/skin/respiratory tract	Y

c) Work Unit 2: Pelletizing and Utility Operator

Chemical	Hazard Classification	Skin Hazard (Y/N)
Polystyrene	Non hazardous	Nil
N,N Ethylene Distearamide	Harmful-inhalation Irritant-eye/skin	Y
Phophoric acid (Kurita S-3400)	Harmful-inhalation Irritant-eye/skin	Y
N-parafin oil	Harmful-inhalation Irritant-eye/skin	Y
Zincum (IPC-E7)	NA	NA

RESULTS AND DISCUSSIONS

Working Unit 1:
Polymerization Area/Process Operator & Polymerization Area/ Supervisor

Workers in this work unit were from storage yard and polymerization area. They were exposed to 10 types of chemicals, from which, 9 of the chemicals were found as hazardous. Survey found that workers in this unit were moderately exposed to under C2 classification and evaluation risk imposed by each chemical in this unit was regarded as ‘significant’ but the adequate controlled measure should be increased. Control measures have taken place in the work unit, whereby workers were provided with PPE such as chemical goggles, safety boots, cotton/semi leather gloves, helmets and dust mask. These PPE were applied according to risk listed in MSDS. Chemical respirators equipped with activated carbon and chemical gloves with chemical resistant were provided. This revealed that the control measures were considered as adequate. During the visit to this area, the survey found that there was lack of awareness on the need to use PPE among operators and supervisor. In future, the management should implement improvement plan such as organizing training to the workers. Thus, work unit 1 was concluded as C2: which is risk significant but already adequately controlled and could increase in future. Table 6 and Table 7 show the qualitative chemical health risk assessment for work unit 1. Meanwhile, Table 8 shows control measure for work unit 1.

Table 6: Qualitative Chemical Health Risk Assessment for Work Unit 1 - Polymerization Area/ Process Operator

QUALITATIVE CHEMICAL HEALTH RISK ASSESSMENT												
WORK UNIT 1: Polymerization Area/Process Operator												
Chemical Name	Task	D.o.H	HR	FR	DR	Chem. Release Presence	Degree of Chem. Absorb	MR	Mo	ER	RR	Conclusion
N,N Ethylene Distearamide (IPC-E1)	Arranging in pallet	2	2	3	1	M	M	3	Nil	3	3	C2
Perhexa ((ICP-I17)	Transfer chemical from drum to tank using air pump and transfer chemical from chemical room to charging area	3	3	3	2	M	M	3	Nil	3	3	C2
Luperox-DI (ICP-I3)		3	3	3	2	M	M	3	Nil	3	3	C2
Normal Dodedyl Mercaptan (ICP-J2)		3	2	4	1	M	M	3	Nil	4	3	C2
Irganox (ICP-A6)	Transfer chemical from bag to tank	-	3	3	2	M	M	3	Nil	3	3	C2
Item: *D.o.H: Degree of hazard* *FR: Frequency Rating* *MR: Magnitude Rating* *Mo: Modifying Factor* *ER: Exposure Rating* *RR: Risk Rating* *HR: Hazard Rating* *DR: Duration Rating*												

Table 7: Qualitative Chemical Health Risk Assessment for Working Unit 1 - Polymerization Area/Supervisor

QUALITATIVE CHEMICAL HEALTH RISK ASSESSMENT												
WORK UNIT 1: Polymerization Area/ Supervisor												
Chemical Name	Task	D.o.H	HR	FR	DR	Chem. Release Presence	Degree of Chem. Absorb	MR	Mo	ER	RR	Conclusion
Styrene Monomer	Collect RDM, Solvent sample from lab analysis	5	5	4	2	M	M	3	Nil	4	5	C2
Ethylbenzene		4	4	4	3	M	M	3	Nil	4	4	C2
Polybutadiene Rubber (PBB)		1	1	4	1	L	L	1	Nil	2	2	C2
Trigonox (IPC-I17)	Monitor operators routine job	3	3	3	2	M	M	3	Nil	3	3	C2
Stearic acid (IPC-C4)		2	2	4	2	M	M	3	Nil	4	3	C2
Item: *D.o.H: Degree of hazard* *FR: Frequency Rating* *MR: Magnitude Rating* *Mo: Modifying Factor* *ER: Exposure Rating* *RR: Risk Rating* *HR: Hazard Rating* *DR: Duration Rating*												

Table 8: Control Measure for Work Unit 1

Chemical Name	**Work Unit 1: Polymerization Area/Process Operator**			**Chemical Name**	**Work Unit 1: Polymerization Area/Supervisor**		
	Control Measure				**Control Measure**		
	Existing	**Maintenance (Y/N)**	**Adequate (Y/N)**		**Existing**	**Maintenance (Y/N)**	**Adequate (Y/N)**
N,N Ethylene Distearamide (IPC-E1)	PPE	Y	Y	Styrene Monomer	PPE	Y	Y
Perhexa ((ICP-I17)	PPE	Y	Y	Ethylbenzene	PPE	Y	Y
Luperox-DI (ICP-I3)	PPE	Y	Y	Polybutadiene Rubber (PBB)	PPE	Y	Y
Normal Dodedyl Mercaptan (ICP-J2)	PPE	Y	Y	Trigonox (IPC-I17)	PPE	Y	Y
Irganox (ICP-A6)	PPE	Y	Y	Stearic acid (IPC-C4)	PPE	Y	Y

Working Unit 2:
Utility and Palletizing Operator

Workers in this work unit consist of operators doing their job in extrusion process. Survey found that workers in this unit were moderately exposed under C2 classification and evaluation risk imposed by each chemical in this unit was regarded as 'significant' but the adequate controlled measure should be increased. The survey also found that polystyrene was not classified as 'hazardous' chemical. In terms of control measure implementation in the work unit, workers have been provided with PPE such as chemical goggles, safety boots, cotton/semi leather gloves, chemical gloves, helmets and chemical respirator. Assessment found that PPE used in this work unit were suitable for the risk that they were exposed to. In terms of maintenance, it was found that regular inspection on PPE and other protective measures were conducted. Therefore, work unit 2 was concluded as C2: Risk significant but already adequately controlled and could increase in future. Table 9 shows qualitative chemical health risk assessment for work unit 2.

Table 9:Qualitative Chemical Health Risk Assessment for Work Unit 2

QUALITATIVE CHEMICAL HEALTH RISK ASSESSMENT												
WORK UNIT 2: Utility and Pelletizing Operator												
Chemical Name	Task	D.o.H	HR	FR	DR	Chem. Release Presence	Degree of Chem. Absorb	MR	Mo	ER	RR	Conclusion
Polystyrene	Arranging the strand	-	-	5	1	L	L	1	Nil	3	Nil	Non-Hazard
N,N Ethylene Distearamide (IPC-E1)	Transfer chemicak from bag to tank	2	2	5	1	M	M	3	Nil	4	3	C2
Phophoric acid (Kurita S-3400)	Charge the chemical from pile to tank	2	2	4	1	M	M	3	Nil	4	3	C2
N-parafin oil (KP-32)	Taking data and transferring liquid	2	2	5	1	L	L	1	Nil	3	3	C2
Zincum (IPC-E7)	Charging the chemical into tank	2	2	4	1	M	M	3	Nil	4	3	C2
Item: *D.o.H: Degree of hazard* *FR: Frequency Rating* *MR: Magnitude Rating* *Mo: Modifying Factor* *ER: Exposure Rating* *RR: Risk Rating* *HR: Hazard Rating* *DR: Duration Rating*												

CONCLUSIONS

CHRA can save live and help to reduce health risks of employees who are exposed to hazardous chemicals in work place. It is mandatory for employers to create safer and healthier working environment for their employees. Management has the authority and resources to develop and carry out programs which spelling out of methods and procedures of safety and health in the use of chemicals at workplace. With the present commitment of management in Occupational Safety, Health and Environment (OSH & E), the consequences that may cause harm to personnel can be improved through the recommendation in Table 10.

Table 10: Recommendation Resulted from the Assessment

No.	FINDINGS	RECOMENDATION
1	Chemical Exposure Chemical present found that moderately exposure risk (RR=2, 3, 4) based on qualitative risk assessment.	Conduct exposure monitoring to measure and fully characterize the degree of exposure Carried out by DOSH registered hygiene technician in accordance with approved method.
2	Work Practice/ Work system Presently, SOP is available and adequate.	To monitor the implementation of SOP and need to be reviewed if there is any changes in operations.
3	Personnel Protective Equipment (PPE) A variety of PPE is maintained onsite and supplied to all employees. However, PPE programs are not formalized in terms of applicability, maintenance, and testing, training and medical fitness.	Maintain a formal PPE program. The program must be include with the following : Maintain a master list of identified chemicals and specify respirator for each chemicals (e.g. charcoal cartridge respirator for an organic solvent) Issue respirator for each person. Do not allow respirator sharing. Specify date issue, date of filter change and respirator maintenance procedures. All employees given PPE should receive training for proper wearing of PPE, its limitation and maintenance.
4	Hazard Communication and training Procedures have been developed for hazardous chemical handling at each process. Warning sign are posted at specific areas	Develop and implement hazard communication training. Training should be included with hazard of specific chemicals that workers are exposed to hazardous chemicals properties, interpretation of MSDS/CSDS and protective measures during handling. Training program should also include during emergencies such as fire, leaks or spills. Training should be specified to the operation/ chemicals used and are given in Bahasa Malaysia or English. Conducted at least once in 2 years or when there are any changes in hazard information, work practices, control measures or new task assigned. All trainings conducted should be documented and monitored to test their effectiveness.
5	Engineering Control Existing Local Exhaust Ventilation (LEV) at palletizing process	To demonstrate the LEV design, construction and testing accordance to approved standard and certified by Professional Engineer (PE). Maintain all documents pertaining to LEV design, testing, etc
6	Maintenance of control equipment, facility and fitting Location of eye wash and shower are at strategic points. All chemicals transferring from tankers to storage tank via pipeline are equipped with non-return valves. Usage of non-fire and non-explosive motor are also implemented in the plant. 7 units of Local Exhaust Limit (LEL) detectors are installed.	To ensure equipment in good condition. Ensure tanks for storage in good condition to avoid leakage, cracks or sip through in the future. To ensure and maintain the integrity of facility/fittings.
7	Emergency Response Preparedness (ERP) As petrochemical plant, which falls under non-major hazard installation (MHI), ERP/Safe Operation document has been prepared.	ERP is a life document and subject to review. Need to be tested on its effectiveness.

REFERENCES

Department of Occupational Safety and Health (2000) *Assessment of the Health Risks Arising from the Use of Hazardous Chemicals in the Workplace (A Manual Recommended Practice 2nd Edition)*. Available at: http://www.ibs.upm.edu.my/note/garispanduan27.pdf (Accessed: 5 April 2009).

Department ofOccupational Safety and Health(2001) *Guidelines on Control of Chemical Hazardous to Health.* Available at: http://www.dosh.gov.my/doshv2/phocadownload/guidelines/garispanduan18.pdf. (Accessed: 5 April 2009).

UNL Environmental Health & Safety(2003) *Toxicology and Exposure Guidelines*. Available at: http://ehs.unl.edu/chemicalinfo/tox_exposure_guidelines.pdf (Accessed: 5 April 2009).