Safety, Health and Environmental Committee (JKSHE):

Establishing Chemical Hazard Management

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Abstract

Most of the laboratories in Malaysian Nuclear Agency are using chemicals in their research activities. However, it is known that using of chemicals without proper knowledge especially on the material characteristics as well as safe handling procedure may cause great harm to the workers. Therefore, Safety, Health and Environmental Committee (JKSHE) sees the need to establish a good chemical hazard management to ensure that a safe and healthy workplace and environment is provided. One of the elements in chemical hazard management is to carry out Chemical Hazard Risk Assessment (CHRA). The assessment was done so that decision can be made on suitable control measures upon use of such chemicals, such as induction and training courses to be given to the workers and health surveillance activities that may be needed to protect the workers. For this, JKSHE has recommended to conduct CHRA for one of the laboratories at Secondary Standard Dosimetry Laboratory (SSDL) namely Film Dosimeter Processing Room (dark room) as the initial effort towards a better chemical hazard management. This paper presents the case study where CHRA was conducted to identify the chemical hazards at the selected laboratory, the adequacy of exisiting control measures and finally the recommendation for more effective control measures.

Keywords/Kata Kunci: Chemical, Hazards, Assessment, Chemical Hazard Risk Assessment (CHRA), Safety, Health, JKSHE, Laboratories.

INTRODUCTION

Chemicals are used widely in some of the laboratories in Malaysian Nuclear Agency for their research activities. However, it is known that using of chemicals without proper knowledge especially on the material characteristics as well as safe handling procedure may cause great harm to the researchers. This is due to some chemicals do pose certain threats to the safety and health of humans as well as the environment. Figures obtained from the Social Security Organization (SOCSO) Malaysia indicated an increase from 35 to 102 cases of occupational diseases that are associated with exposure to chemicals hazardous to health between the year 2007 and 2009. Compensations that were paid out to affected workers during that period were also significant as the amount increased from approximately RM 25,000 in 2007 to RM 260,000 in 2009.

Therefore, Safety, Health and Environmental Committee (JKSHE) sees the need to establish a good chemical hazard management to ensure that a safe and healthy workplace and environment is provided. One of the elements in chemical hazard management is to carry out Chemical Hazard Risk Assessment (CHRA). The assessment is conducted so that any occupational safety and health issues associated with chemicals can be minimized greatly through proper management and usage of chemicals. As the initial effort towards a better chemical hazard management, JKSHE has recommended to conduct a simple CHRA (Qualitative) for one of the laboratories at Secondary Standard Dosimetry Laboratory (SSDL) namely Film Dosimeter Processing Room (dark room). This paper would present the case study where CHRA (Qualitative) was conducted to identify the chemical hazards at these laboratories and followed by the recommendation.

OBJECTIVE

The objective of this paper is to present the case study where CHRA (Qualitative) was conducted at the selected laboratory of Secondary Standard Dosimetry Laboratory (SSDL), namely Film Dosimeter Processing Room (dark room). The case study would discussed the estimation of risk rating qualitatively, the adequacy of exisiting control measures and the recommendation. Through this case study also, Safety, Health and Environmental Committee (JKSHE) hopes to promote Chemical Safety Awareness among the fellow researchers.

ABOUT CHEMICAL HAZARD RISK ASSESSMENT (CHRA)

A 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.

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; and
e) To recommend further appropriate control measures to prevent or reduce risks.

A Full CHRA must be carried out by Registered CHRA Assessor and both Qualitative and Quantitative Assessment must be included. The Quantitative Assessment would involve the sampling of data by using measurement instruments to determine the magnitude of exposure to the workers.

A simple CHRA (Qualitative) however, could be done easily based on the CHRA Manual (Assessment of the Health Risks Arising from the Use of Hazardous Chemicals in the Workplace, 2000 DOSH).

BACKGROUND OF CASE STUDY

The Dark Room is used for film processing. During film processing, the chemicals involved are Photographic Developer Solution and Photographic Fixing Solution. Below is the flow chart for evaluation of film

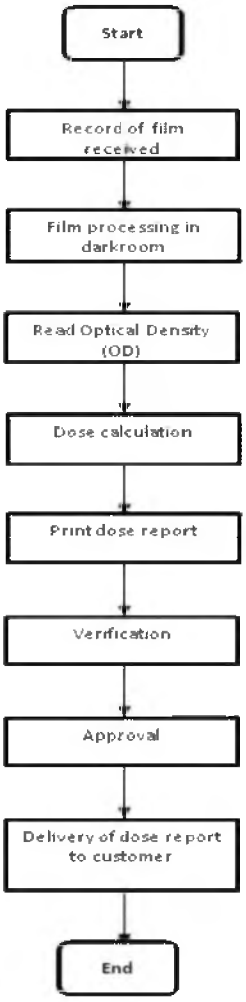
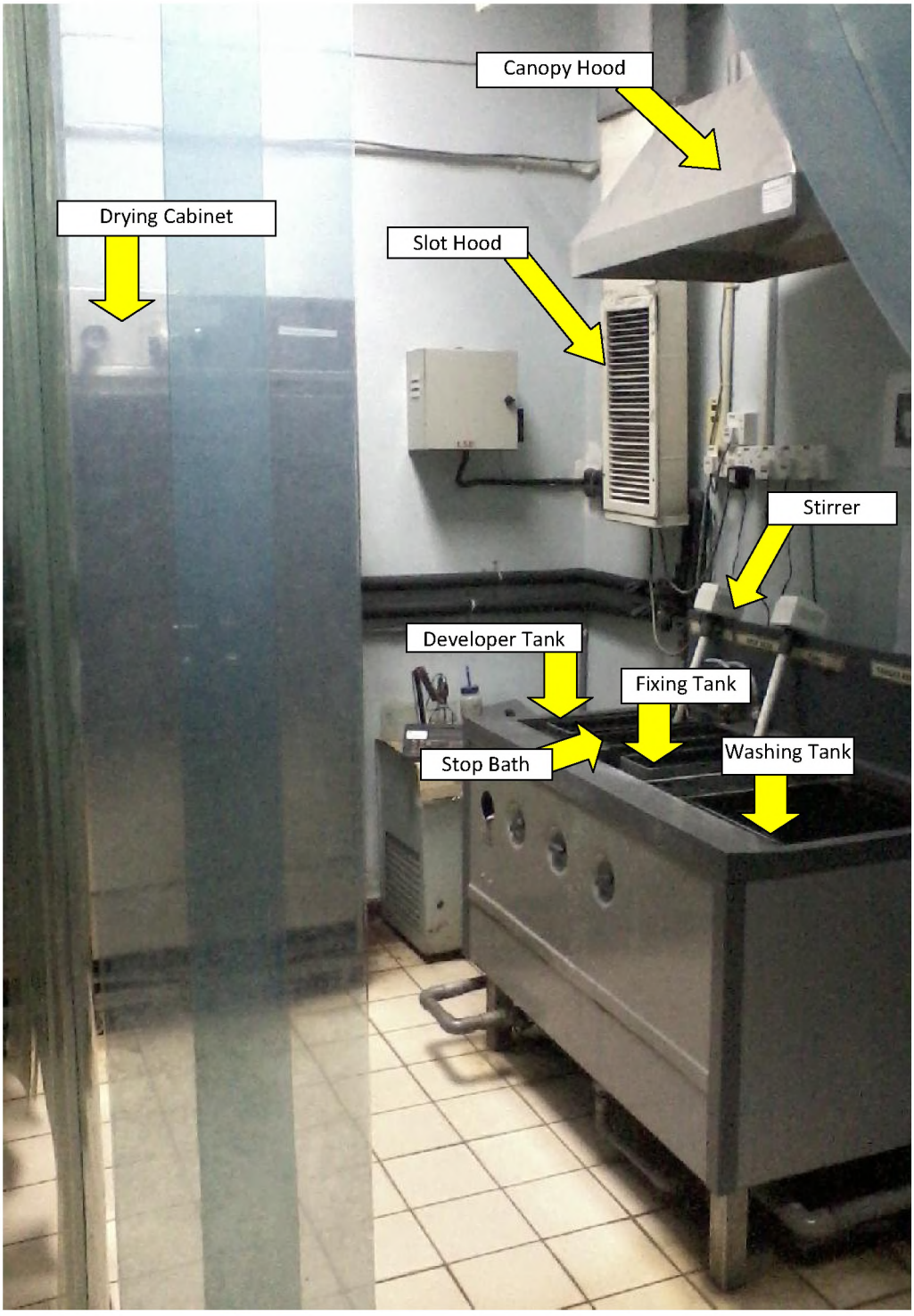


Figure 1: Flow Chart for Evaluation of Film Badge

The lab is equipped with two types of hood for LEV (Local Exhaust Ventilation System), i.e. Canopy and Slot type. This lab is also provided with 2 units of Split Air Conditioner. There is a Plastic Screen to divide the lab into Film and Chemical Solution Preparation Area, and Film Processing Area. The processing rack with films and the Darkroom's environment are as the pictures below:

Picture 1: Processing Rack with Films



Picture 2: Working Area of Film Processing in Darkroom

Below is the Film Processing Procedure:

No	Film Processing Work Process
1	Label with numbers on the envelopes of the films, according to the Processing Frame. Each frame can be fit with 60-65 of films.
2	Switch on the valve of the Film Washing Tank so that the water will keep running when the processing works are in progress
3	Lock the door of Dark Room
4	Insert the Stirrer into the Developer Solution Tank and Fixer Solution Tank and switch them on.
5	Switch off the room light and switch on the Safety Red Light. Wait for 5 – 10 minutes until the workers' eyes are adjusted to the dark room's environment
6	Take out the films from the envelopes and insert the films with sequence to the Processing Rack
7	Put the Processing Frame that is full with films into the Developer Solution Tank for 6 minutes. A maximum of 2 Processing Frames can be inserted into the Developer Solution Tank at once.
8	Take out the Processing Frame from the Developer Solution Tank after 6 minutes, and insert the Frame into the Stop Bath Tank. The Frame will stay there for 2 minutes so that the developing process can be stopped and the chemical solution of developer can be washed away from the films.
9	Move the Processing Frame from the Stop Bath Tank to the Fixer Solution Tank and stay there for 12 minutes.
10	After that, put the Processing Frame into the Film Washing Tank for 24 minutes. Make sure the water in the Washing Tank is running continuously
11	Move the Processing Frame into Drying Cabinet. Hang the Processing Frame inside the Cabinet for at least 2 hours within the temperature range of 50 – 60 deg C.

Table 1: Film Processing Work Process

There is a need to mention that LEV testing and examination has been conducted on that One (1) unit Canopy Hood on 10 Jan 2012. The Assessment based on the testing & examination result was done by Registered Hygiene Technician II. The Assessment Report has concluded that the LEV system is working below safety limit of specification. It was mentioned that the suction from the Canopy Hood is not sufficient enough to keep operator in safe breathing zone, with the possibility that the contaminant may escape from the hood.

ASSESSMENT CONCEPT

There are a few basic concepts that we must understand as below:

a) Hazard, exposure and risk

Hazard

Chemical health hazard is the potential of a chemical to cause harm or adversely affect health of people in the workplace. Adverse health effect ranges from fatality, permanent and serious health impairment to mild skin irritation at the other end. For example, the hazard of cyanides is that they are very toxic and a small quantity, if ingested, can cause death. Chemicals that can adversely affect the health of an exposed person is termed as chemicals hazardous to health. Under the USECHH Regulations 2000, a chemical hazardous to health is defined as any:

1) Chemical listed in Schedule I to USECHH Regulations 2000;
2) Chemical categorised under Part B of the CPL Regulations 1997; - those classified as very toxic, toxic, harmful, corrosive and irritant (and sensitising); and include carcinogens, mutagens, and teratogens.
3) Pesticide as defined under the Pesticides Act 1974; and
4) Scheduled waste listed in the First Schedule to the Environmental Quality (Scheduled Wastes) Regulations 1989.

Exposure

A worker is exposed to a chemical if there is a possibility of the chemical 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. Exposure through inhalation is most common, especially for airborne chemicals such as gases, vapours and particulate. Skin absorption is common for lipid soluble chemical especially in the form of liquid or mist. Ingestion is not as common as inhalation or skin absorption, but nevertheless through poor personal hygiene and work practices it could be an important route of exposure. Injection through the skin can also occur, for example, when syringes are used.

Risk

Risk is the likelihood that a substance will cause adverse health effects or illness in the conditions of its use. The risk to health usually increases with the severity of the hazard, the amount used, and the duration and frequency of exposure.

Mesch and Kugele (1992) have suggested a risk equation as follows:

Risk = [How x How Bad x How Much] -------- Equation (1)

Which proposes that health risk is a function of three (3) things, i.e.:

1) The likelihood of exposure or contact with the chemical (How);
2) The potential of the chemical to cause harm or its hazard (How Bad); and
3) The degree of exposure to the chemical (How Much).

Risk has also been defined as the probability of over exposure and the consequences of that exposure. This is so because a potentially toxic chemical may cause death or serious health effects if the exposure is substantial. Therefore the risk equation can also be defined as

Risk = Hazard x Exposure --------- Equation (2)

The hazard component will take into consideration the nature of hazard and the potential adverse health effects from the possible routes of entry or contact. The exposure component looks at the chance of overexposure occurring by taking into account the frequency of exposure, the duration of exposure, and the intensity or magnitude of exposure. Before any risk conclusion is made one has to take into account the work practices and personal factors including individual susceptibility.

b) Rating hazard, exposure and risk

The approach adopted by this manual is qualitative with a rating system, in that the severity of hazard and the chance of overexposure are rated on a five- (5) scale rating. To ensure that the risk rating value is consistent with the hazard or exposure rating, the above equation (2) is redefined thus:

RR = Ö (HR x ER) ---------- Equation (3)

Where

RR is the risk rating (1 to 5) indicating the likelihood of injury or illness;

HR is the hazard rating (1 to 5) indicating the severity of adverse effects; and

ER is the exposure rating (1 to 5) indicating the chance of overexposure to the chemical hazardous to health.

(Note the scale of 1 to 5 is in an increasing order of magnitude, i.e. a rating of 1 means very low and 5 means very high and 3 is medium)

ASSESSMENT METHOD

Risk Rating (Qualitative)

Risk is evaluated as either "significant" or "not significant".

In order to obtain the Risk Rating (RR), we must determine the Hazard Rating (HR) and Exposure Rating (ER).

a) Hazard Rating (HR)

For HR (Hazard Rating), we can determine it based on the information (Risk Phrases) from CSDS (Chemical Safety Data Sheet). Table below shows the Hazard Rating based on Risk Phrases.

EFFECT	ACUTE/ CHRONIC	ROUTES OF EXPOSURE					HAZARD RATING (HR)
		INH.	DERMAL SKIN	DERMAL EYE	ING.	NOT SPECIFIED	
Very Toxic	Acute	R26	R27		R28	R39	5
	Chronic	-	-		-	-	
Toxic	Acute	R23	R24		R25	R39	4
	Chronic	-	-		-	R48, R39	
Harmful	Acute	R20	R21		R22	R40	3
	Chronic	-	-		-	R48, R40	
Corrosive	Acute		R35				4
			R34				3
Irritant	Acute	R37	-	R41			3
		-	R38	R36			2
Sensitising	Acute	R42	-				3
		-	R43				2
Carcinogenic	Chronic	R49(1)				R45(1)	5
		R49(2)				R45(2)	4
		-				R40(3)	3
Mutagenic						R46(1)	5
						R46(2)	4
						R40(M2)	3
Teratogenic						R47(1)	5
						R47(2)	4
EXPOSURE ASSESSMENT REQUIRED		Inhala-tion	Skin	Eyes	Inges-tion	All Routes	

Table 2: Hazard Rating Table

b) Exposure Rating (ER)

For ER (Exposure Rating), we need to determine based on the Table of Exposure Rating below: Thus we need to obtain the Frequency Rating or Duration Rating, and Magnitude Rating.

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

Table 3: Exposure Rating

Frequency Rating (F):

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 4: Frequency Rating

Duration Rating (D):

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

***Note:** Total exposure duration per week (TD)
= (Number of exposure per week) x (Average duration of each exposure)

Table 5: Duration Rating

Magnitude Rating (MR):

There are two possible ways to estimate MR, either quantitatively or qualitatively. For the Simple CHRA, a qualitative estimate of exposure will be used in the absence of quantitative data.

Degree of Chemical Release of Presence:

DEGREE	OBSERVATION
Low	Low or little release into the air. No contamination of air, clothing and work surfaces with chemicals capable of skin absorption or causing irritation or corrosion.
Moderate	Moderate release such as a) Solvents with medium drying time* in uncovered containers or exposed to work environment; b) Detectable odour **of chemicals with odour thresholds exceeding the PELs. Evidence of contamination of air, clothing and work surfaces with chemicals capable of skin absorption or causing irritation or corrosion.
High	Substantial release such as a) Solvents with fast drying time* in uncovered containers; b) Sprays or dust clouds in poorly ventilated areas; c) Chemicals with high rates of evaporation exposed to work environment; d) Strong odour of chemicals with odour thresholds exceeding the PELs. Gross contamination of air, clothing and work surfaces with chemicals capable of skin absorption or causing irritation or corrosion.

Table 6: Degree of Chemical Release

Degree of Chemical Absorbed or Contacted:

DEGREE	OBSERVATION / CONDITION
Low	Low breathing rate (light work)* Source far from breathing zone Contact with chemical other than those described under "Moderate" and "High". Small area of contact with chemicals capable of skin absorption - limited to palm (intact skin). <2% or 0.04m^2 No indication of any skin conditions. Intact/normal skin No contamination of skin or eyes
Moderate	Moderate breathing rate (moderate work)*. Source close to breathing zone Contact with eye or skin irritants, sensitisers or chemicals capable of skin penetration, except those described under 'High'. Moderate area of contact- one or both hands up to the elbows. Skin area >2% or 0.04m^2 Skin dryness and detectable skin condition. Dry, red skin
High	High breathing rate (heavy work)*. Source within breathing zone. Gross contamination of eye or skin with skin or eye irritants, sensitisers or chemicals capable of skin absorption -skin soaked or immersed in chemical capable of skin penetration. Area of contact not only confined to hands but also other parts of body. Skin area>50% or 1m^2 Follicle rich areas. Skin damaged. Severe drying, peeling and cracking.

Table 7: Degree of Chemical Absorbed

Magnitude Rating:

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

Table 8: Magnitude Rating

Therefore we are able to conclude the Risk Assessment based on the Risk Decision:

Risk Matrix:

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

Table 9: Risk Matrix

To conclude for assessment:

RISK DECISION	ADEQUACY OF CONTROL MEASURES	CONCLUSION
Risk Not Significant	-	C1
Risk Significant	Adequate	C2
	Not Adequate	C3
Insufficient Information	-	C4
Uncertain about exposure	-	C5

Table 10: Conclusion Table

C1: Risks not significant now and not likely to increase in future
C2: Risks significant but already adequately controlled and could increase in future
C3: Risks significant now, and not adequately controlled
C4: Uncertain about Risk: Insufficient Information
C5: Uncertain about Risk: Uncertain about degree and extent of exposure.

ASSESSMENT AND RESULTS

Step 1: Determination of Hazard Rating (HR):

Based on the CSDS for Photographic Developer and Fixing Solutions, the highest Risk Phrases is R35 (Causes severe burns) and thus the Hazard Rating should be 4, Corrosive (Acute Effects) with notation of sk (corrosive to skin/eye).

HR = 4

Step 2: Determination of Exposure Rating (ER):

a) Frequency Rating (F)

We choose Frequency Rating instead of Duration Rating, because Frequency Rating is mainly used to assess the likelihood of acute effects (as we have identified that the chemicals used has higher risk of acute effects). Since the same worker will work two shifts (one time each in the morning and afternoon) per day, thus the potential of exposure can be classified as one or more time per shift or per day. According to Frequency Rating Table, that would give a Rating of 5 (Frequent).

F = 5

b) Magnitude Rating (M)

(i) Degree of Chemical Release of Presence:
There are complaints from SSDL Dark Room Operators that the odour of chemicals is detectable. Furthermore, the Chemical Component (Acetic Acid) of the solution is categorised as corrosive. Therefore, it is likely that the Degree of Chemical Release is Moderate.

(ii) Degree of Chemical Absorbed or Contacted:
As the source (immersion tank) is close to the breathing zone of the workers, and the contact area is consider moderate (one or both hands up to the elbows, skin area > 2%); it is likely that the Degree of Chemical Absorbed could be assigned as Moderate.

Based on the Magnitude Rating Table, therefore MR can be assigned with 3.

MR = 3

c) Exposure Rating (ER)

With F = 5, MR = 3, we could assign the Exposure Rating with 4; based on the Exposure Rating Table.

ER = 4

Step 3: Determination of Risk Rating (RR):

With Hazard Rating (HR) = 4, Exposure Rating (ER) = 4, Risk Rating (RR) = 4 with Category 1 (Based on Risk Matrix Table)

RR = 4

Step 4: Conclusion ofAsessment:

Since the Risk is significant, and current control measures are not adequate (LEV System below safety specification), therefore it is right to conclude that the Assessment Conclusion falls under denotation of C3.

C3: Risks significant now, and not adequately controlled

Step 5: Standard Actions to be Taken:

Based on the CHRA Manual, the standard actions required for risk decision C3 are:

(a) Identify and implement immediate measures and procedures for preventing or controlling exposure;
(b) Identify measures, procedures and equipment to prevent or control any accidental emission of chemical hazardous to health;
(c) Establish the need to stop the process;
(d) Begin review of longer terms control requirements;
(e) Re-evaluate exposure when the upgraded control measures are in place;
(f) Determine if monitoring or health surveillance is required;
(g) Determine if training and retraining of employees is required
(h) Review assessment every five years or when there is a change in circumstances or as directed by DOSH.

EVALUATION AND RECOMMENDATION

It is reminded that this Simple CHRA is done based on the Qualitative Measures (For Exposure Magnitude Rating) as per stated in CHRA Manual and this is not carried out by Registered CHRA Assessor. Therefore, this Assessment Result can only be treated as the Preliminary Result.

The estimated Risk Rating based on the current findings is categorized as 4 (Significant Risk) and concluded as C3 (Risks significant now, and not adequately controlled). It is likely that the Risk Rating will be similar if SSDL requested for Full CHRA. This is because the risk is evidently not adequately controlled (Failed LEV System).

In this case, I would recommend of the following actions:

1. Engineering Control Measure:

SSDL is recommended to repair the LEV System. This is because the usage of chemical solutions may continue up to another 3 – 4 years. It is a long period of exposure to the workers which may poses great risk of health. Furthermore, CSDS stated that ventilation should be sufficient so that any applicable occupational exposure limits are not exceeded. And there is no PPE recommended in CSDS to prevent the workers from chemical vapor inhalation. Apart from that, there is a strong chemical odor in the dark room which may indicate the strong presence of chemical vapor and perhaps exposure to the workers.

Please take note that it is mentioned in CSDS for Fixing Solution that Sulphur Dioxide may be set free in concentration well below the TLV and asthmatic individuals may be sensitive to even lower concentration. Meanwhile, for Developer Solution, the hazard is that it may produce allergic

reaction. One of its hazardous components, Hydroquinone is rated as R68 (European Directives), same as R40 (CPL Regulations, Malaysia) which may bring possible risk of irreversible effects (Effects that remain following the cessation of exposure, and may even progress. Cancer is a typical example of irreversible effects).

In Control Measure Hierarchy, application of Engineering Control Measure should always be given priority compare to Provision of PPE. However, reconsideration is allowed if there is an evident conclusion that the cost of risk mitigation through Engineering Control is greater than the severity of the risk and its' consequences.

2. Immediate Adoption of Safe Work Systems and Practices:

It will be good if we can reduce the Frequency Rating of Exposure, that's mean SSDL needs to relook into the workers' operating schedule. A proposal such as to schedule different operator in the morning and afternoon production will help to reduce the rating from Frequent to Probable. The current Working Instruction/ Procedure should be incorporated with the relevant safety instructions/ precautions/ emergency procedures.

3. Immediate Check on the Personal Protective Equipment (PPE):

According to CSDS, SSDL needs to provide workers with Chemical Resistant Gloves (Specified materials kindly refer to CSDS) and Safety Glasses for the hand and eye protection. For Acetic Acid with sk. Notation, means that skin exposure needs control regardless of absorbed dose. Therefore, SSDL needs to ensure that the Laboratory Clothing is provided and appropriate.

4. Full CHRA:

SSDL is suggested to go for Full CHRA but the Actions 2 & 3 above must be implemented immediately. Otherwise, SSDL can also opt for Full CHRA after the LEV System has been repaired.

CONCLUSION

The case study where CHRA (Qualitative) was conducted at Film Dosimeter Processing Room (Dark Room) has showed that there are rectification needs to be done in terms of Chemical Safety. JKSHE is aware of that and is willing to work towards a better chemical hazard management system. However, no matter how good system is, we still need the partnership and support from all levels of the organization in order to implement the system.

ACKNOWLEDGEMENT

The author would like to acknowledge and show his gratitude's towards the fellow colleagues who were involved whether direct or indirectly for their support for the completion of this case study.

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