Determining the Exposure of Benzene, Toluene, Xylene (in Condensate) in a Chemical Laboratory of Natural Gas Company by Chemical Health Risk Assessment (CHRA)

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Abstract

Introduction: Chemical risk assessment is needed to find out how high the hazard level of chemicals in the laboratory. This chemical health risk assessment will assess how often the chemical is exposed to workers, how much exposure it is so that the level of risk can be understood. The purpose of enabling decisions to be made on appropriate control measure, training of employees, monitoring and surveillance activities as may be required to protect the health of employees who may exposed by hazardous chemicals to health at work.

Methods: This research is research with a qualitative approach. Based on the data collected, this study is observational. This study uses the Chemical Health Risk Assessment (CHRA) method. This method is carried out by identifying chemicals, determining Hazard Rating, evaluating exposure, assessing the adequacy of the control measures that have been carried out, concluding the CHRA results, and identifying the efforts that need to be made.

Result: In this study, there are three work units, namely a wet laboratory, oil laboratory, and gas laboratory. The chemicals analyzed are benzene, toluene, and xylene in the condensate. The hazardous chemical have significant risk now and already adequately controlled could increase in future (C2) which mean that the employees are at risk due to hazardous chemicals and it adequately controlled but the risk can increase in the future.

Conclusion : Therefore, several steps can be taken to control the risk of health hazards from benzene, toluene, and xylene in the condensate, for example: determine precaution to maintain controls and minimize chances of higher exposure occurring; determine additional measures for regaining control if a high-risk event occurs despite precaution; identify measures, 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 the effectiveness of controls; and review assessment every five years or when is a change in circumstances.

Key words: *Hazardous chemicals, risk assessment, BTX, CHRA*

Introduction

Natural gas processing companies are one of the industries that have laboratory facilities to support their production. However, the laboratory is one place where various chemicals gather in one place. Chemical exposure can have the potential to cause health problems for workers. Chemical laboratory workers have a significant risk of exposure to hazardous chemicals[1].

This laboratory functions to maintain the quality of raw materials until the finished product is ready to be marketed. Some of the chemicals in the laboratory include benzene, toluene, and xylene in the condensate which is analyzed three times a day. Acute exposure to high concentrations of benzene can directly occur in the nervous system, skin, respiratory system, and digestive system[2]. Health effects due to exposure to toluene are divided into two categories[3]. Acute effects, trough

inhalation toluene can cause euphoria, drunkenness, dizziness, trembling, convulsions, respiratory disorders, and tremors. Trough ingestion toluene can cause oropharyngeal and digestive tract. On the eyes, it can cause lacrimation and corneal damage, while it may cause erythema and dry skin trough dermal exposure. Effects due to chronic exposure to toluene via inhalation are damage to the liver, kidneys, and nerves, while to the skin it may cause contact dermatitis and irritation. Refinery natural gas workers are exposed to significant levels of benzene, toluene, ethylbenzene, and xylene (BTEX)[4].

Chemical risk assessment is needed to find out how high the hazard level of chemicals in the laboratory. To carry out this risk assessment, all chemicals used must be identified, evaluated, and controlled against the hazards of chemicals that exist. This risk assessment is carried out as an effort to prevent health problems that may arise from exposure to chemicals. This chemical health risk assessment will assess how often the chemical is exposed to workers, how much exposure it is so that the level of risk can be understood.

Material and Method

This research is research with a qualitative approach. Based on the data collected, this study is observational. This study uses the Chemical Health Risk Assessment (CHRA) method. This method is carried out by identifying chemicals, determining Hazard Rating, evaluating exposure, assessing the adequacy of the control measures that have been carried out, concluding the CHRA results, and identifying the efforts that need to be made[5].

The procedure in carrying out a DOSH, 2000 Chemical Health Risk Assessment (CHRA) is consists of ten aspects below:

Chemical Identification and Hazard Rating (HR) Assessment

The results of chemical identification are used to classify chemicals based on the health impacts that each chemical can cause. The grouping results will be assessed using the Hazard Rating (HR). Hazard Rating has a rating scale of 1 to 5, with the understanding that the rating scale of 1 is a scale for chemicals that are not dangerous to the health of the workforce, up to a rating scale of 5 which is a scale for chemicals that are very dangerous to the health of the workforce. Hazard Rating in the analysis of health risks due to chemicals is used to determine priorities based on the potential health hazards caused by chemicals.

Duration of Exposure (Duration Rating / DR)

Identifying the duration of exposure is done to assess the effects of chronic or routine exposure to the chemical used. Chronic effects assessments can use the total duration of exposure. The total duration of exposure is the product of the number of exposures in one week and the average duration of each exposure.

Degree of Release or Occurrence of Chemicals

The degree of release or appearance of chemicals in the environment can be estimated from information, including the physicochemical information contained in the Chemical Material Safety Data Sheet, the characteristics of the work process in the description of the chemical process, the number of chemicals used, the method of chemical use, environmental conditions workplace.

Degree of Absorption or Contact with Chemicals

Chemicals that are absorbed through the skin include organic solvents and some pesticides. The assessment of the degree of absorption or contact with chemicals must be based on the results of observations on the chemical that has the highest degree.

Magnitude Rating (MR)

Qualitatively, the Magnitude Rate or the amount of exposure is assessed based on the estimated dose of chemicals that are absorbed through inhalation and absorption on the skin. The absorption of chemicals through the eyes and skin comes not only from direct contact with chemicals but also from contaminated air, smoke, or particulates.

Exposure Rating (ER)

Exposure Rating (ER) is assessed through cross-tabulation based on the duration of exposure or Duration Rating (DR) and the amount of exposure or Magnitude Rating.

Assessment of the Adequacy of Controls That Has Been Done

Assessment of the adequacy of the control measures are evaluated for each work unit. This assessment is carried out simultaneously with the assessment of chemical exposure. The adequacy of the control that has been carried out is assessed by examining the control measures that have been made, checking the air inspection records, biological monitoring, and checking the inspection records, as well as testing the control equipment used.

Risk Rating (RR)

Determination of the risk level or Risk Rating is used to conclude the results of the chemical risk assessment that has been carried out. The risk level assessment is carried out based on the results of the exposure level or Exposure Rating and Hazard Rating that have been done. The level of risk will be evaluated based on "significant" and "insignificant". The risk that is evaluated is "insignificant" if occupational exposure cannot cause health problems in the workforce

Conclusion of Risk Assessment Results

The conclusion of the chemical risk assessment results can be made after the Risk Rating has been assessed. Based on the results of the Risk Rating assessment and assessment of existing control measures, there are 4 types of conclusions that can be reached in this assessment. The four types of conclusions are denoted by C1, C2, C3, C4, and C5

Identification of Control Measures That Can Be Taken

The control measures that can be taken are identified based on the results of risk decisions resulting from the risk assessment that has been carried out. Some of these control efforts include:

a. Take appropriate measurements to control exposures that exceed safe limits.

b. Take measurements to eliminate intolerable risks.

c. End the assessment and set a new schedule to re-evaluate or review the assessment that has been done.

d. Decide whether exposure monitoring or health surveillance is more necessary.

e. Create a strategic long-term plan to control exposure to as low as reasonably practicable (ALARP).

f. Gather information or advice from specialists on a specific problem.

g. Maintain control equipment to keep working properly to implement a preventive maintenance program.

Result

In this study, there are three work units, namely a wet laboratory, oil laboratory, and gas laboratory. The chemicals analyzed are benzene[6], toluene[7], and xylene [8] in the condensate. In this assessment, the chemical hazard will identify the type of chemical, the degree of exposure, and the adequacy of existing control measures. Based on these parameters a conclusion can be formed so that it can be used as input for efforts to reduce the risk of hazardous chemicals. The results of the following qualitative assessments obtained from the MSDS are shown in tables 1, 2, 3, and 4 below.

Table 1. Duration Rating (DR)

No.	Work unit	Duration of Work	DR
1	Wet Laboratory	7am - 5pm	4
2	Oil Laboratory	7am - 5pm	4
3	Gas Laboratory	7am - 5pm	4

Table 2. Hazard Rating Determination of Benzene, Toluene, and Xylene in Condensate

No.	Name of Chemical	Determine the Degree of Hazard				
		Hazard Rating Based on Health Effect		Hazard Rating Based on Risk Phrases		
		Hazard Category	HR	Effect	Route of Exposure	HR
1	Benzene (in condensate)	Category 1 carcinogens, mutagens, and teratogens	5	Carcinogen and mutagen	R45 / R46	5
2	Toluene (in condensate)	Skin irritation	2	Toxic and harmful	R48 / R20	4
3	Xylene (in condensate)	Skin Irritation	2	Harmful	R20 / R21	3

Table 3. Exposure Rating of Determination of Benzene, Toluene, and Xylene in Condensate

No.	Name of Chemical	Evaluate Exposure				
		Duration Rating (DR)	Magnitude of Exposure			Exposure Rating
			Degree of Release	Degree of Absorption	Magnitude Rating	
1	Benzene (in condensate)	4	High	Moderate	4	4
2	Toluene (in condensate)	4	High	Moderate	4	4
3	Xylene (in condensate)	4	High	Moderate	4	4

Discussion

Table 4. Concluding the Assessment of Benzene, Toluene, and Xylene in Condensate

No.	Name of Chemical	Determining Degree of Hazard	Determining Degree of Exposure	Risk Rating	Risk Evaluation	Adequacy of Control Measure	Conclusion of Risk
		Hazard Rating (HR)	Exposure Rating (ER)				
1	Benzene (in condensate)	5	4	5	Risk Significant-Category 2	Adequate	C2
2	Toluene (in condensate)	4	4	4	Risk Significant-Category 1	Adequate	C2
3	Xylene (in condensate)	3	4	4	Risk Significant-Category 1	Adequate	C2

Based on the qualitative assessment results table above, it shows that the risk evaluation of benzene is included in the risk significant-category 2.Risk significant-Category 2 means that this hazard cannot be tolerated and must be eliminated, but if this is not possible, several efforts can be made such as the substitution of the hazardous chemical with a less hazardous chemical, total enclosure of process and handling system, or isolation of the work to control the emission of chemicals hazardous to health. Besides, the risk evaluation of toluene and xylene is included in the significant risk category-1. This means the risk has to be controlled to below permissible exposure limits or to as long as reasonably practicable (ALARP) where no limits are specified.

According to table 4, it shows that benzene, toluene, and xylene in condensate have a C2 conclusion, this means the risk is significant but adequately controlled. This conclusion applies to conditions where adverse health effects could increase in the future, due to control measure failure or deterioration; plant, equipment, or system failure; human error, from lack of awareness, monitoring failure or inadequate training; changes in methods or rate of work; and a significant increase in the number of chemicals hazardous to health used.

Conclusion

According to DOSH, 2000 the conclusion risk of Benzene, Toluene, and Xylene (in the condensate) is C2 which means the risk is significant but already adequately controlled could increase in the future. Therefore, several steps can be taken to control the risk of health hazards from benzene, toluene, and xylene in the condensate, for example: determine precaution to maintain controls and minimize chances of higher exposure occurring; determine additional measures for regaining control if a high-risk event occurs despite precaution; identify measures, 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 the effectiveness of controls; and review assessment every five years or when is a change in circumstances.

Control measures are a way to reduce exposure to chemicals in labor. Prevention efforts that are carried out include eliminating chemicals that are hazardous to health, substituting hazardous chemicals with less hazardous chemicals, using controlled engineering equipment, isolation of hazardous chemicals, conducts health surveillance of workers, rotates employees if needed, and last uses personal protective equipment. Every control effort is carried out following the control hierarchy and according to the priority of chemical hazards that can be caused.

Acknowledgements: Thank you to all parties that are involved in the research, especially to the Laboratory of Natural Gas Company which has allowed the data collection.

Ethical Clearance: The study was approved by ethical clearance certificate Number 301 / HRECC. FODM / VI / 2020 from the Faculty of Dental Medicine Health Research Ethical Clearance Commission Universitas Airlangga.

Conflict of Interest: There is no potential conflict of interest

Source of Funding: The source of this research costs from self

Reference

1. Abbas M, Zakaria A, Balkhyour M. Implementation of Chemical Health Risk Assessment (CHRA) program at Chemical Laboratories of a University. J Saf Stud. 2017;3(1):53.
2. Kartikasari D, Nurjazuli N, Rahadjo M. Analisis Risiko Kesehatan Pajanan Benzene Pada Pekerja Di Bagian Laboratorium Industri Pengolahan Minyak Bumi. J Kesehat Masy. 2016;4(4):892–9.
3. Sahri M, Widajati N. Evaluation of Toluene Exposure in Workers at Industrial Area of Sidoarjo , Indonesia by Measurement of Urinary Hippuric Acid. Asia Pacific J Med Toxicol. 2013;2(November):145–9.
4. Moridzadeh M, Dehghani S, Rafiee A, Hassanvand MS, Dehghani M, Hoseini M. Assessing BTEX exposure among workers of the second largest natural gas reserve in the world: a biomonitoring approach. Environ Sci Pollut Res. 2020;(group 1).
5. DOSH. ASSESMENT OF THE HEALTH RISKS ARISING FROM THE USE OF HAZARDOUS CHEMICALS IN THE WORKPLACE. 2nd ed. Vol. 2, Ministri of human resources of Malaysia.

2000. 81 p.

6. PubChem. Lembaran Data Keselamatan Bahan Benzene-D6. 2018;1253(1907):1–13.
7. PubChem. Lembaran Data Keselamatan Bahan Toluene. 2018;1253(1907):1–13.
8. PubChem. Lembaran Data Keselamatan Bahan Xylene. 2018;1253(1907):1–13.