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Inhalation Risk Assessment of Thinner Use in Furniture Painting Workers at Furniture X

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Abstract: The safety and health of workers in the furniture painting industry are a primary concern, given the increasing use of hazardous chemicals that can lead to various health issues. This study aims to analyze the inhalation risk associated with thinner use among furniture painting workers at Furniture X. Using a descriptive research method; the analysis focuses on inhalation exposure risks linked to thinner chemicals. Data were collected through a review of thinner Safety Data Sheets (SDS), field observations, and structured interviews, with the findings assessed using the Chemical Health Risk Assessment (CHRA) framework. The assessment considered Hazard Rating (HR), Exposure Rating (ER), and Risk Rating (RR) factors. The results indicate that thinner, which is mixed with paint for the painting process, contains chemicals such as toluene (CAS: 108-88-3), xylene (CAS: 1330-20-7), and acetone (CAS: 67-64-1), each with varying levels of risk (RR). One of the substances in thinner, xylene, was identified as having significant potential to cause respiratory irritation. The study concludes that the CHRA method applied to the furniture painting process at Furniture X revealed three hazardous chemicals in the thinner used, with xylene posing a notable health risk. These findings underscore the need to implement safe work procedures and ensure the appropriate use of personal protective equipment (PPE).

Keywords: Occupational Safety and Health, CHRA, Inhalation Risk, Furniture Painting

INTRODUCTION

The furniture painting industry faces significant challenges in ensuring the health and safety of its workers. Exposure to thinners containing volatile organic compounds (VOCs), such as toluene and benzene, is a significant risk in this sector. Studies show that 71.4% of workers fail to properly use personal protective equipment (PPE) properly, leading to exposure to hazardous chemicals at levels exceeding permissible thresholds (Erdinur et al., 2021). The increasing use of dangerous chemicals raises serious concerns, as these substances cause various health problems among workers.

Chemical emissions can enter the human body through inhalation, ingestion, dermal contact, and injection. Inhalation is the most common exposure pathway in workplaces and is associated with toxic substances in the form of dust/particles, gas, liquid, or vapor. When inhaled, these substances are absorbed into the bloodstream and distributed to target organs, potentially causing significant health risks (Usman & Mila Tejamaya, 2022).

According to the International Labour Organization (ILO), 6.71% of all deaths worldwide are work-related, with occupational diseases accounting for the vast majority, reaching 2.6 million deaths annually (ILO, 2022). Presidential Regulation No. 7 of 2019 of the Republic of Indonesia on Occupational Diseases defines conditions as those caused by workplace exposures, including organ-specific diseases, occupational cancers, and other health disorders. Chemical exposure is highlighted as one of the primary contributors to work-related diseases (Indonesia, 2019).

A notable concern in this sector is the high prevalence of workers failing to use PPE despite clearly identifying hazards. Furthermore, pollutant levels in workplace environments, such as dust and cadmium, often exceed safe limits, reaching 0.1538 $\mu g/m^3$ in specific locations (Erdinur et al., 2021). For instance, the furniture industry in Jepara demonstrates a similar trend, with workers frequently exposed to hazardous levels of thinner and wood dust (Caesar et al., 2023). These observations emphasize the urgent need for concrete measures to enhance occupational health risk management, including implementing control technologies, providing suitable PPE, and promoting workplace safety awareness.

This study aims to analyze the inhalation risk associated with thinner use among furniture painting workers at Furniture X. The study employs the chemical health risk assessment (CHRA) approach developed by the Department of Occupational Safety and Health (DOSH) Malaysia in 2018 (DOSH, 2018). The CHRA method is widely used to assess hazardous chemicals in workplace environments. This approach was chosen because it provides a systematic framework for identifying and evaluating health risks associated with hazardous chemical exposure and determining appropriate risk control measures.

METHODS

This descriptive study employing a case study approach was conducted at Furniture X. It focused on analyzing the level of inhalation exposure risk associated with thinner chemicals. Data were collected through a review of Safety Data Sheets (SDS) for thinners, field observations, and interviews with workers directly interacting with the chemicals under study.

The method used was the Chemical Health Risk Assessment (CHRA) introduced by the Department of Occupational Safety and Health (DOSH) Malaysia. This method involves assessments based on three key factors: Hazard Rating (HR), Exposure Rating (ER), and Risk Rating (RR). The Exposure Rating (ER) is determined by combining the frequency-duration rating (FDR) and magnitude rating (MR).

CHRA is a simple and user-friendly method (Taheri et al., 2020) designed to support decision-making regarding appropriate control measures, employee training, and health monitoring and supervision required to protect workers from potential chemical hazards in the workplace (DOSH, 2018).

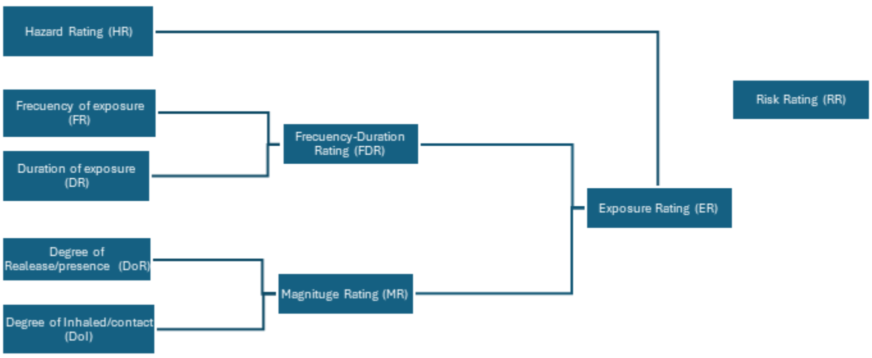

Figure 1. Inhalation Exposure Risk Rating Determination Scheme

The stages of the CHRA method include:

Identifying Chemical Properties and Determining Hazard Levels (Hazard Rating, HR)

The hazard level (HR) is assessed using a scoring scale ranging from 1 (low hazard) to 5 (high hazard) based on the potential health risks and chemical properties as outlined in the Safety Data Sheets (SDS) and relevant hazard classifications.

Table 1. HR of inhalation exposure based on hazard classification and H-Code

HR	*Hazard Classification*	*H-Code*
	Acute toxicity category 1 (inhalation)	*H330*
	Carcinogenicity Category 1A	*H350, H350i*
5	*Mutagenicity category 1A*	*H340,*
	Reproductive toxicity category 1A	*H360,H360D,H360F,H360FD,H360Fd,H360Df*
	Specific target organ toxicity – single-exposure category 1	*H370*
	Acute Toxicity Category 2 (inhalation)	*H330*
	Carcinogenicity Category 1B	*H350, H350i*
	Mutagenicity Category 1B	*H340*
	Reproductive toxicity category 1B	*H360,H360D,H36F,H360FD, H360Fd, H360Df*
4	*Effects on or via lactation*	*H362*

	Specific target organ toxicity – single-exposure category 2	*H371*
	Specific target organ toxicity – repeated exposure category 1	*H372*
	Respiratory Sensitization Category 1	*H334*
	Acute Toxicity Category 3 (inhalation)	*H331*
	Carcinogenicity category 2	*H351*
3	*Mutagenicity category 2*	*H341*
	Reproductive toxicity Category 2	*H361,H361f, H361d, H361fd*
	Specific target organ toxicity – repeated ex[posure category 2	*H373*
	Specific target organ toxicity – single exposure category 3 (respiratory tract irritation)	*H335*
	Acute toxicity Category 4 (inhalation)	*H332*
2	Specific target organ toxicity – single exposure category 3 (Narcotic effect)	*H336*
1	Chemicals not otherwise classified	*H333*

Determining the Frequency of Exposure (FR)
The exposure frequency level is assessed on a scale from 1 (improbable) to 5 (frequent).

Table 2. Inhalation Exposure Frequency (FR) Levels

Rating	*Description*	*Definition*
5	*Frequent*	*Exposure occurs one or more times per shift or per day*
4	*Probable*	*Exposure occurs more than once per week*
3	*Occasional*	*Exposure occurs more than once per month*
2	*Remote*	*Exposure occurs more than once per year*
1	*Improbable*	*Exposure occurs once per year or less*

Determining the Duration of Exposure (DR)
The exposure duration level is assessed on a scale from 1 (< 1 hour) to 5 (≥ 7 hours).

Table 3. Inhalation Exposure Duration (DR) Levels

Rating	*Duration of exposure per shift (x)*
5	*x ≥ 7 hours*
4	*4 ≤ x < 7 hours*
3	*2 ≤ x < 4 hours*
2	*1 ≤ x < 2 hours*
1	*x < 1 hour*

Determining the Frequency-Duration Rating (FDR)
The FDR value is determined by combining the Frequency Rating (FR) and Duration Rating (DR) on a scale from 1 (low) to 5 (high).

Table 4. Frequency-Duration (FDR) Matrix of Inhalation

FDR		***Frequency Rating (FR)***				
		1	**2**	**3**	**4**	**5**
Duration Rating (DR)	**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

Determining the Degree of Release (DoR)
A chemical's release degree is assessed based on field observations, SDS data, and a rating scale from low to high.

Table 5. Inhalation Degree of Release (DoR)

Degree	*Observation*
Low	*• Minimal release into the air. • No contamination of air, clothing, or work surfaces with chemicals. • Low volatility (boiling point >150°C at room temperature, 20°C). ** • Low dustiness (e.g., pellet-like solids with minimal dust formation).*
Moderate	*• Moderate releases, including: a) Solvents with medium drying time* in uncovered containers or exposed to the work environment. b) Detectable chemical odors (check odor threshold). • Medium volatility (50–150°C at room temperature, 20°C). ** • Medium dustiness (e.g., crystalline or granular solids that settle quickly). • Evidence of contamination of air, clothing, and work surfaces with chemicals.*
high	*• Substantial releases, including: a) Solvents with fast drying time* in uncovered containers. b) Sprays or dust clouds in poorly ventilated areas. c) Chemicals with high evaporation rates in the work environment. d) Detectable odor of chemicals with odor threshold at/above PEL/ OEL. • High volatility (boiling point <50°C at room temperature, 20°C). ** • High dustiness (e.g., fine powders forming persistent clouds). • Gross contamination of air, clothing, and work surfaces with chemicals.*

Determining the Degree of Inhalation (DoI)
The degree of inhalation of a chemical is assessed based on field observations, with the assessment scale ranging from low to high.

Table 6. Degree of Inhalation

Degree	*Observation*
Low	*• Low breathing rate (light work) * • Source is far from the breathing zone*
Moderate	*• Moderate breathing rate (moderate work) * • Source is close to the breathing zone*
High	*• High breathing rate (heavy work) * • Source is within the breathing zone*

The category of activity severity and respiratory rate is determined from observations in the table 7.

Table 7. Degree of Physical Activity and Respiratory Rate

Physical Activity	*Breathing Rate*
Light Work *Sitting, moderate arm and trunk movements (e.g., desk work, typing)* *Sitting, moderate arm and leg movements (e.g., hand soldering, QC inspection)* *Standing, light work at machine or bench, mostly using arms*	*Low*

Moderate Work *Sitting, heavy arms, and leg movement* *Standing, light work at machine or bench, with occasional walking* *Standing, moderate work at a machine or bench, some walking* *Walking, with moderate lifting or pushing (e.g., machine operation)*	*Moderate*
Heavy Work *Intermittent heavy lifting, pushing, or pulling (e.g., pick-and-shovel work)* *Sustained heavy work*	*High*

Determining Magnitude Rating (MR)

The magnitude rating is determined using a chemical's Degree of Release (DoR) and Degree of Inhalation (DoI) values. These values are applied to a matrix to calculate the level of exposure, or Magnitude Rating (MR), as shown in the table 8.

Table 8. Magnitude Rating (MR) Matrix for Inhalation Exposure

MR		Degree of Inhaled (DoI)		
		Low	***Moderate***	***High***
Degree of Release (DoR)	***Low***	1	2	3
	Moderate	2	3	4
	High	3	4	5

Modifying Factors for MR

Modifying factors can adjust the MR value by adding or subtracting 1, as outlined in the table below. The final MR value must not exceed five or fall below 1.

Table 9. Modifying Factors for MR

Modification	***Criteria***
+ 1 *(Maximum MR not to exceed 5)*	• *Poor work practices or personal hygiene allow chemical agents to remain on skin or clothing.* • *Reported cases of chemical exposure with biological monitoring results exceeding the BEI.* • *Widespread complaints of adverse health effects linked to chemical exposure.* • *Pre-clinical symptoms of chemical exposure reported among workers.* • *Presence of susceptible individuals in the work unit.* • *Cross-contamination of airborne chemicals.*
-1 *(Minimum MR not less than 1)*	• *Small quantities of chemicals used: solids (grams, packets/bottles) or liquids (milliliters, bottles).*

Determining Exposure Rating (ER)

The exposure rating is determined by comparing the Frequency-Duration Rating (FDR) and Magnitude Rating (MR) values in the matrix below.

Table 10. Exposure Rating (ER) Matrix

ER		***Magnitude Rating (MR)***				
		1	**2**	**3**	**4**	**5**
Frequency-duration Rating (FDR)	**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

Determining *Risk Rating* (RR)

The final step is to determine the risk level (RR) by comparing the hazard level (HR) and exposure level (ER) in a risk matrix, which can be represented by the following equation: **RR = HR x ER**

Table 11. Risk Rating Matrix

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

Low risk	RR = 1 to RR = 4
Moderate Risk	RR = 5 to RR = 12
High Risk	RR = 15 to RR = 25

Determining action priorities (Action Priority/AP)

The risk level category determines the priority actions to be taken.

Table 12. Action Priorities

Level of risk	*Adequacy of Control*	*Action Priority*
High *HR and ER could not be determined*	*Inadequate* *-*	*1*
Moderate/low	*Inadequate*	*2*
High/Moderate/Low	*Adequate*	*3*

There are three levels of action priority (Action Priority/AP), determined based on the Risk Rating (RR) value:

1. **Action Priority 1 (AP-1):**
   Criteria: RR ≥ 15, existing controls are inadequate, or HR/ER cannot be determined.
   Action: Following the hierarchy of controls, immediate improvements in control measures are required. Temporary control measures, such as safe work practices and personal protective equipment (PPE), must be implemented to reduce exposure until permanent controls are established. Work activities or processes may need to be temporarily suspended.
2. **Action Priority 2 (AP-2):**
   Criteria: Where RR ≤ 15, and existing controls are inadequate.
   Action: Control measures should be improved but with a lower priority compared to AP-1. Work activities or processes do not need to be stopped immediately.
3. **Action Priority 3 (AP-3):**
   Criteria: Existing controls are adequate, regardless of the risk rating.
   Action: Maintain existing control measures and ensure their continued effectiveness.

RESULTS AND DISCUSSION

Thinner is a mixture containing water and various solvents used in the painting process at Furniture X. Field observations and identification revealed that the thinner includes three primary chemicals: toluene (CAS: 108-88-3), xylene (CAS: 1330-20-7) and acetone (CAS: 67-64-1).

Chemical Properties and Hazard Rating (HR)
The inhalation's qualitative hazard rating (HR) is determined using Safety Data Sheet (SDS) information, including hazard classifications and H-codes.

Table 13. Inhalation Hazard Rating (HR)

Chemical Name	*H-Code*	*Hazard Classification*	HR
Toluene	H336	Specific target organ toxicity – single exposure category 3 (narcotic effect)	**2**
Xylene	H335	Specific target organ toxicity – single exposure category 3 (respiratory tract irritation)	**3**
Acetone	H336	Specific target organ toxicity – single exposure category 3 (narcotic effect) Causes severe eye irritation.	**2**

Frequency of Exposure (FR)
The frequency rating (FR) depends on field observations and worker interviews.

Table 14. Frequency Rating

Chemical Name	*Definition*	*Description*	*FR*
Toluene	*Exposure > once per week*	*Probable*	*4*
Xylene	*Exposure > once per week*	*Probable*	*4*
Acetone	*Exposure > once per week*	*Probable*	*4*

Duration of Exposure (DR)
The duration rating (DR) is assessed based on worker interviews and field observations.

Table 15. Inhalation Duration Rating

Chemical Name	*Duration of Exposure per Shift (x)*	*DR*
Toluene	4 ≤ x < 7 hours	*4*
Xylene	4 ≤ x < 7 hours	*4*
Acetone	4 ≤ x < 7 hours	*4*

Frequency-Duration Rating (FDR)
The FDR is calculated by comparing the FR and DR values using the FDR matrix.

Table 16. Frequency-Duration Rating

Chemical Name	FR	DR	FDR
Toluene	*4*	*4*	*4*
Xylene	*4*	*4*	*4*
Acetone	*4*	*4*	*4*

Degree of Release (DoR)
The DoR is evaluated based on SDS data and field observations.

Table 17. Degree of Release (DoR) Inhalation

Chemical Name	Observation	DoR
Toluene	*Evidence of contamination of air, clothing, and work surfaces with chemicals.*	*Moderate*
Xylene	*Evidence of contamination of air, clothing, and work surfaces with chemicals.*	*Moderate*
Acetone	*Evidence of contamination of air, clothing, and work surfaces with chemicals.*	*Moderate*

Determining the degree of inhaled (DoI)
The DoI is determined based on physical activity and breathing rate.

Table 18. Degree of Inhalation (DoI)

Chemical Name	*Physical Activity*	*Breathing rate*
Toluene	*Moderate Work*	*Moderate*
Xylene	*Moderate Work*	*Moderate*
Acetone	*Moderate Work*	*Moderate*

Determining Magnitude Rating (MR)
The MR is calculated by comparing DoR and DoI values.

Table 19. Magnitude Rating

Chemical Name	DoR	DoI	MR
Toluene	*M*	*M*	*3*
Xylene	*M*	*M*	*3*
Acetone	*M*	*M*	*3*

Exposure Rating (ER)
Using the exposure level matrix, the ER is derived from the FDR and MR values.

Table 20. Exposure Rating

Chemical Name	FDR	MR	ER
Toluene	*4*	*3*	*4*
Xylene	*4*	*3*	*4*
Acetone	*4*	*3*	*4*

Risk Rating (RR)
The RR is determined by multiplying HR and ER.

Table 21. Inhalation Risk Rating

Chemical Name	HR	ER	RR
Toluene	2	*4*	*8*
Xylene	*3*	*4*	12
Acetone	2	*4*	*8*
Low risk	**RR = 1 to RR = 4**		
Moderate Risk	**RR = 5 to RR = 12**		
High Risk	**RR = 15 to RR = 25**		

Action priorities (AP)
Action priorities are assigned based on risk level and control adequacy.

Table 22. Action Priority

Chemical Name	*Risk Level*	*Control Adequacy*	*Action Priority*
Toluene	*Moderate*	*Inadequate*	2
Xylene	*Moderate*	*Inadequate*	2
Acetone	*Moderate*	*Inadequate*	2

Painting is applying liquid paint to an object to create a thin layer that hardens into a durable coating. The primary function of painting is to provide a protective layer that enhances the object's longevity (Irmasari, 2018). Paint is a liquid material used to coat surfaces with the objectives of improving the appearance (decorative), strengthening the object (reinforcing), and offering protection (protective) (Khasib, 2017).

Thinner is a solution comprising solvents, gloss enhancers, and volume additives, which also function as evaporators to accelerate the drying process of paint (Lorensia, 2018). Thinner quality is crucial, as the specified ratios on product packaging do not always produce the desired results. Some thinners also lack the solvents to dissolve specific paint compositions (Habibie & Anwar, 2014).

The CHRA results show that the risk ratings (RR) for the chemicals used include scores of 8 for toluene, 12 for xylene, and 8 for acetone, all of which fall into the Moderate Risk category. Although xylene is categorized as having a moderate hazard level (HR) with a score of 3, indicating potential respiratory irritation, its exposure level (ER) is considered high, with a score of 4 (Dahan et al., 2012).

Xylene, an aromatic hydrocarbon, is a chemical compound with a high boiling point and solubility in various organic solvents. These characteristics make xylene widely used in industries such as paint manufacturing. Xylene is a solvent in paint production due to its ability to enhance paint quality and achieve desirable results. Its volatility allows products to dry quickly and last longer. However, this same volatility contributes to xylene's categorization as a respiratory irritant (category 3). This differs from other chemicals like toluene and acetone, which are not classified as respiratory irritants (El-Harbawi, 2020).

The inhalation hazard rating (HR) and exposure rating (ER) are critical factors in determining the overall risk rating (RR) for chemical inhalation exposure. In CHRA, inhalation hazard refers to the potential for inhaled chemical exposure to cause health disorders or diseases in workers. Inhalation exposure is defined as the amount of chemical that can be inhaled, while inhalation risk reflects the likelihood that a chemical could lead to health issues or diseases (Marquart et al., 2008).

The Moderate Risk category requires prioritized actions for controlling chemical hazards. According to Table 2.10, this falls under Action Priority (AP-2), indicating that work activities do not need to cease immediately, provided safe work practices are implemented until permanent risk control measures are applied (Haryanto et al., 2021). The primary goal of risk control is to minimize workers' exposure to the lowest reasonably practicable level or as low as reasonably practicable (ALARP).

Control measures include eliminating highly hazardous chemicals, substituting them with less dangerous alternatives, or implementing engineering controls such as local exhaust ventilation (LEV) or automated chemical handling systems. Additional strategies involve reducing exposure duration and frequency through worker rotation. The final hierarchy of controls involves personal protective equipment (PPE) tailored to the specifications outlined in the SDS for each chemical. Recommended PPE includes chemical-resistant gloves, full-face respirators with cartridges suited to specific chemicals, chemical-resistant protective clothing, and routine maintenance of PPE. Future assessments should incorporate quantitative risk evaluations through environmental monitoring and worker exposure measurements to enhance the accuracy of chemical risk assessments in the workplace (Usman & Mila Tejamaya, 2022).

CONCLUSION

Based on the findings and the inhalation risk assessment of thinner use among furniture painting workers at Furniture X using the Chemical Health Risk Assessment (CHRA) method, three chemicals were identified in the thinner: toluene (CAS: 108-88-3), xylene (CAS: 1330-20-7), and acetone (CAS: 67-64-1). These chemicals were classified as moderate risk. The risk assessment revealed Hazard Ratings (HR) variations, with toluene and acetone scoring HR 2 while xylene scoring HR 3. These differences highlight varying levels of inhalation hazards and potential health effects. Additionally, all three chemicals were associated with high Frequency Ratings (FR) and Duration Ratings (DR), indicating frequent and prolonged daily exposure for workers.

The Exposure Rating (ER) for all three chemicals was determined to be 4, reflecting a high level of exposure. Risk Ratings (RR) were calculated as 8 for toluene and acetone and 12 for xylene. Notably, xylene was categorized as a moderate hazard (HR 3), capable of causing respiratory tract irritation due to its high volatility and potential for inhalation exposure. This characteristic sets xylene apart from toluene and acetone, which are not classified as respiratory irritants.

All three chemicals were placed in Action Priority 2 (AP-2), which indicates that while immediate cessation of work is not required, the existing control measures are inadequate and need improvement to minimize worker exposure. These findings underscore the importance of implementing safe work practices and ensuring all workers use appropriate personal protective equipment (PPE), as specified in the Safety Data Sheets (SDS) for each chemical. Such measures are critical to reducing risks and protecting worker health in furniture painting.

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