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Assessment of the effects of organic solvent to the health of workers in Printer - case study of Fuji Seal Vietnam Company, in VSIP II industrial park, Binh Duong province

by ***Truong Quoc Minh, Nguyen Hien Than (****Thu Dau Mot University, Vietnam)*

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Corresponding author: minhtq@tdmu.edu.vn (Truong Quoc Minh M.A.)
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ABSTRACT

The study was conducted at Fuji Seal Vietnam Co., Ltd. to examine the exposure and health risks of workers working in the printing and ink phase area when exposed to solvent vapor through the respiratory apparatus Toluene, Methyl Ethyl Ketone, Ethyl Acetate, Isopropyl Acohol. The results show that: During the monitoring period from July to November 2016, the amount of solvent vapor in the printing area and ink phase is quite high, at the highest Toluene printing area, it was 2.63 times higher than the standard equal to the health risk HQ male is 2.61 and HQ female is 3.37; Ethyl Acetate exceeded the highest of 4.34 times equal to the male HQ risk ratio of 4.29 and female HQ equal to 5.53; MEK exceeds 8.43 times equal to the health risk HQ male is 8.36 and HQ female is 10.79; Isopropyl Acohol exceeds 8.4 times equal to the health risk HQ male is 8.33 and HQ female is 10.75; At the inking area, MEK exceeds 8.43 times equal to the health risk HQ male is 8.36 and HQ female is 10.79. From the calculated data - analysis, found that the health of workers working in the printing and inking areas had high risks, the ability of workers suffering from diseases such as headache, dizziness, skin damage,... and especially respiratory failure.

Key words: *Fuji Seal Company, health risks, solvent vapor*

1. Introduction

Currently, the printing industry is an industry that contributes to regional economic development. Compared to the beginning of the printing industry, technology in the printing industry is now much more developed with many modern printing techniques to overcome the limitations of the old printing technology such as the production of fast products. More, better ink quality of printing products is also standard. However, it is inevitable that the level of toxicity of printing materials and ink-based solvents (in particular ink). In the ink, there are organic solvents such as Toluen, Ethyl acetate, Isopropyl Acohol, MEK ... People who come into contact with these toxins often can suffer from diseases such as dermatitis, respiratory, cardiovascular, eye, and may even cause cancer (Ministry of health, 2011).

From the above issues, the topic: "Assessing the effect of organic solvent vapor on workers' health in the printing factory, case study of Fuji Seal Vietnam Company, Binh Duong province" selected as the research topic for graduation essays. The results of the study will quantitatively assess the risk of the effect of solvent ink on workers' health, thereby suggesting solutions to minimize the impacts and prevent health risks to workers in printing industry.

2. Materials and methods

***Materials*:** Research data were collected from environmental monitoring data at the Company from July to November in 2016. The number of monitoring points is four points: printer area (location VT1), in the print chamber 6 - printer 2 (location VT2), at printer output 2 (location VT3), station area 7 - printer 2 (location VT4).

***Methods*:** Health risk assessment method $D = (C \times IR \times EF)/BW$

In which: D: Absorption amount (mg/kg.day); C: Pollution concentration (mg/m^3); IR: Rate of absorbing pollutants (m^3/day); EF: Exposure factor; BW: body weight (kg) (ATDSR, 2005)

TABLE 1. Default air absorption rate

Object	Air volume (m^3/day)
Children <1 year old	4,3
Children (6-11 years old)	14,4
Teenagers (12-19 years old)	15,8
Adults (20-65 years old)	15,8

Method of calculating health risk factors: Health risks are calculated using the following formula: HQ= CDI / RfD. In which: HQ: The risk ratio; CDI: The daily intake dose (mg/kg.day); RfD: Reference dose (mg/kg.day) (Budihardjo, 2007).

Reference dose: For solvent solvents Toluen, Ethyl Acetate, Metyl Ethyl Keton, reference dose is calculated according to the formula:

$$RfD_i = \frac{RfC \times IR \times ED \times F}{ARL \times AT \times 365 \times BW}$$

In which: ARL is an acceptable level of risk (In this study, ARL is equal to 1) (Oregon Department of Environmental Quality, 2017). Reference concentration is taken according to VSL Standard (Decision No. 3733/2002/ QD-BYT) - Limited value of chemicals in the work zone air (average 8 hours).

TABLE 2. Concentration and reference dose

Agent	RfC (mg/m^3)	RfD$_i$ (mg/kg/ngày)
Toluen	100	2,283
Etyl Acetate	500	11,414
Metyl Etyl Keton	150	3,424
Isopropyl Acohol	350	7,99

3. Results

3.1. Evaluation of solvent vapor exposure

In order to assess the amount of exposure from which the health risks of Workers at Fuji Seal, the authors based on survey results measured at the location of solvent vapor emission. Since then, calculate the Exposure Amount (CDI) and health risks of workers (HQ) at Fuji Seal Company. CDI and HQ calculation results are presented in the following tables:

TABLE 3. Results of calculation of workers' exposure at Fuji Seal Limited Company

Location	Period	CDI Toluen		CDI MEK		CDI Etyl Acetate		CDI Isopropyl Acohol	
		Male	Female	Male	Female	Male	Female	Male	Female
VT1	29/07/2016			26.64	34.36				
	12/9/2016			28.63	36.94				
	19/09/2016			3.33	4.30				

	10/11/2016			18.23	23.52				
	23/12/2016			0.82	1.05				
VT2	29/07/2016	5.96	7.69					66.60	85.91
	12/9/2016	4.26	5.49	28.63	36.94			55.50	71.59
	10/11/2016	0.25	0.32					0.57	0.73
	23/12/2016							0.82	1.05
VT3	29/07/2016					24.46	31.56		
	12/9/2016					48.93	63.12		
	10/11/2016					4.08	5.26		
VT4	19/09/2016	0.850	1.097	1.663	2.145				

TABLE 4. Result of calculating health risks of workers at Fuji Seal Company

Location	**Period**	**HQ Toluen**		**HQ MEK**		**HQ Etyl Acetate**		**HQ Isopropyl Acohol**	
		Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
VT1	29/07/2016			7.78	10.04				
	12/9/2016			8.36	10.79				
	19/09/2016			0.97	1.26				
	10/11/2016			5.33	6.87				
	23/12/2016			0.24	0.31				
VT2	29/07/2016	2.61	3.37					8.33	10.75
	12/9/2016	1.87	2.41	8.36	10.79			6.95	8.96
	10/11/2016	0.11	0.14					0.07	0.09
	23/12/2016							0.10	0.13
VT3	29/07/2016					2.14	2.76		
	12/9/2016					4.29	5.53		
	10/11/2016					0.36	0.46		
VT4	19/09/2016	0.372	0.480	0.486	0.627				

3.2. Assessment of worker health risks due to exposure to solvent vapor of each position

VT1: Printer area

Compared to the risk limit, it can be seen that workers working at VT1 have a very high risk of health because they are infected with MEK. During the period from the beginning of the year to the end of the year before the solvent vapor treatment equipment was installed, the amount of solvent vapor at the emission location was quite large, the health impact was quite high (in the public sector, South Korea was low). the highest is 5.33, the highest HQ is 8.36, the lowest female worker is 1.26 and the highest is 10.79). However, at the end of the

year, the solvent vapor treatment system is applied, so the amount of solvent released to the working environment is very small and does not affect workers working in the area (HQ < 1; Male HQ = 0.24, female HQ = 0.31).

TABLE 5. Average results of exposure and health risks in VT1

Period	CDI MEK		HQ MEK	
	Male	**Female**	**Male**	**Female**
29/07/2016	26.64	34.36	7.78	10.04
12/9/2016	28.63	36.94	8.36	10.79
19/09/2016	3.33	4.30	0.97	1.26
10/11/2016	18.23	23.52	5.33	6.87
23/12/2016	0.82	1.05	0.24	0.31
Average year	***15.53***	***20.034***	***4.536***	***5.854***
Max	**28.63**	**36.94**	**8.36**	**10.79**
Min	**0.82**	**1.05**	**0.24**	**0.31**

VT2: In the print chamber 6 - printer 2

***** *Toluen:*

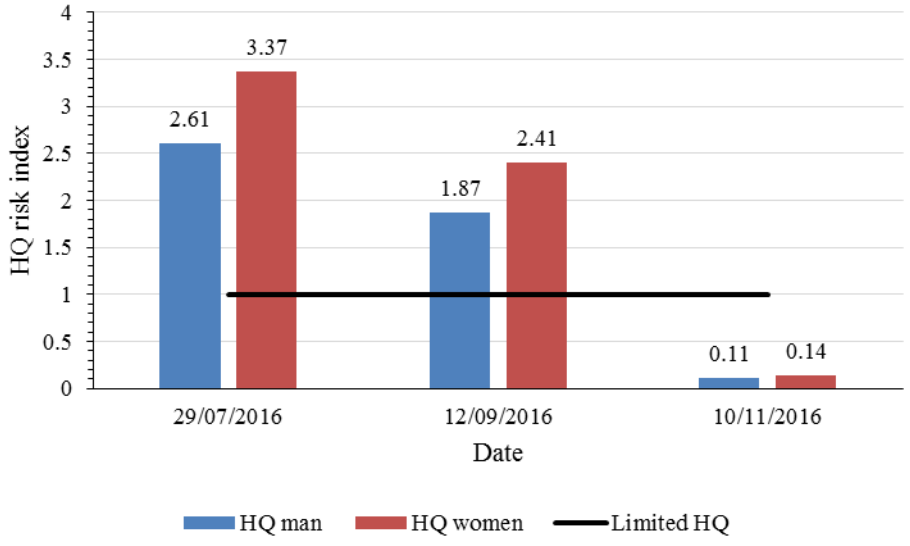

Figure 1. *Results of worker health risk developments in VT2*

The variation in the dose of exposure will affect the risk of health risks for workers. The risk calculation period in July shows the health risk level at the safe level (HQ > 1) as

HQ in men is 2.61 mg/kg.day and HQ in women is 3.37 mg/kg.day. However, at the end of the year (November), the risk is no longer high and the risk is low (HQ < 1), because the exposure of Toluen to exposed workers is greatly reduced.

** MEK:*

TABLE 6. Results of calculating exposure and health risks when exposed to MEK

Period	CDI MEK		HQ MEK	
	Male	Female	Male	Female
12/9/2016	28.63	36.94	8.36	10.79

At VT2, high MEK exposure leads to a high risk of health for exposed workers. Compared to VT1, the health risk of exposed workers at VT2 is equal to the risk at VT1 and is at high risk (at the same time in September).

** Isopropyl Acohol:*

TABLE 7. Results of calculating exposure and health risks when exposed to Isopropyl Acohol

Period	CDI Isopropyl Acohol		HQ Isopropyl Acohol	
	Male	Female	Male	Female
29/07/2016	66.60	85.91	8.33	10.75
12/9/2016	55.50	71.59	6.95	8.96
10/11/2016	0.57	0.73	0.07	0.09
23/12/2016	0.82	1.05	0.10	0.13
Average	***30.8725***	***39.82***	***3.8625***	***4.9825***
Max	***66.6***	***85.91***	***8.33***	***10.75***
Min	***0.57***	***0.73***	***0.07***	***0.09***

The workers' average of Isopropyl Acohol exposure for a year is quite high, compared with Toluen exposure in this position, the amount of Isopropyl Acohol exposure for workers in the area is very high, on average CDI in the south equal to 30.8725 mg/kg.day longer in women CDI 39.82 mg/kg.day. But with high CDI, the risk of workers' health will also be high (HQ > 1), which will lead to long-term exposure (inhalation) of Isopropyl Acohol by workers to be susceptible to diseases such as headache, nausea, hypotension, etc. and especially severe depression.

VT3: At printer output 2

TABLE 8. Results of calculation of exposure and health risks of workers in VT3

Period	CDI Ethyl Acetate		HQ Etyl Acetate	
	Male	Female	Male	Female
29/07/2016	24.46	31.56	2.14	2.76
12/9/2016	48.93	63.12	4.29	5.53
10/11/2016	4.08	5.26	0.36	0.46
Average	***25.82***	***33.31***	***2.26***	***2.92***
Max	***48.93***	***63.12***	***4.29***	***5.53***
Min	***4.08***	***5.26***	***0.36***	***0.46***

The average Etyl Acetate exposure factor of workers in VT3 is quite high, leading to an average annual health risk of workers due to exposure to Ethyl Acetate exceeding the permitted limit. However, in terms of batches, the calculated results show that the highest average risk in the period in September HQ = 5.53 above the limit, and the lowest risk in the period in November, HQ = 0.46 within the limit. Compared with VT1 and VT2, the level of toxic gas exposure in VT3 is much lower.

VT4: Station area 7 - printer 2

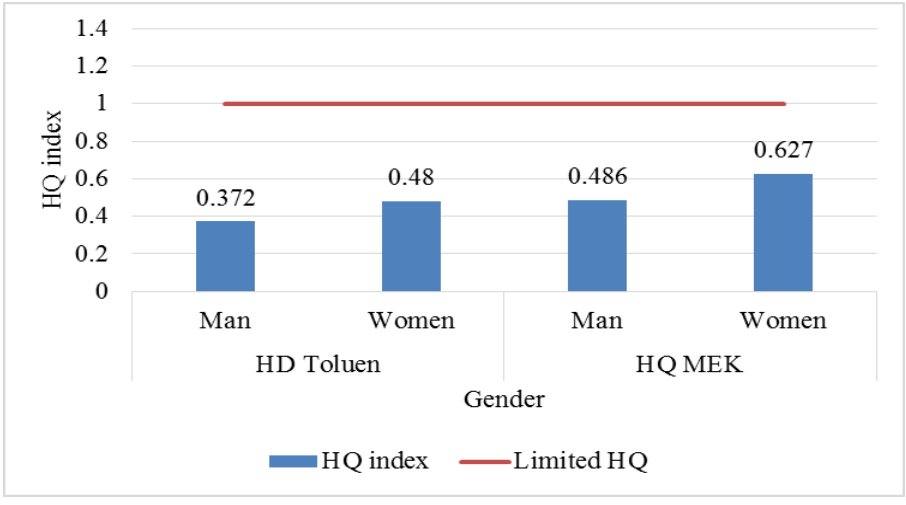

Figure 2. Changes in worker risks due to exposure to Toluene and MEK at VT4

The results of the calculation and the above chart (Figure 2) show that the health risks of workers due to exposure to Toluene and MEK are very low.

Toluen: Compared to VT2, the risk of Toluene exposure in VT4 is very low, below the risk limit, in man HQ = 0.372 and women HQ = 0.480. This shows that at Station 7 area of printer 2 is less affected by this toxic gas.

MEK: Like Toluen, compared to VT2, at VT4 the risk of worker health in the area is very low. However, it can be seen from the calculation that the amount of MEK exposure in the area is higher than Toluen exposure, but both are within risk limits and do not affect workers' health in the area.

***General assessment**:*

Through the results of measurement, analysis and calculation of toxic vapors at locations (VT1, VT2, VT3, VT4), it is found that: most of them are unsatisfactory and have a high risk of health risks with exposed workers. However, the risk of health risks only occurs in the first months to mid-2016, at the end of 2016, the calculation results show that the risk has decreased and it seems that the working environment at the location of gas generation Poison no longer affects the health of workers. The fact that the Company has installed a system to extract toxic gas from the printers has contributed to creating a more open work space and health for workers in the area safer.

4. Discussion

Research with the objective of assessing the effect of organic solvent vapor on public health using methods of assessing respiratory exposure due to exposure to solvent vapors thereby giving conclusions about health risks workers in the area are as follows:

In the printing areas (VT2, VT3, VT4), through analysis and calculation, it can be seen that the amount of solvent generation is quite large in the monitoring months at the beginning to the end in 2016 like Toluen reaching 263 mg/m^3 exceeding 2.63 times higher than regulation at VT2, MEK at VT2, which is 8.43 times higher than regulation, Isopropyl Acohol exceeds 8.4 times in VT2 and Etyl Acetate by 4.32 times in VT3. With the amount of toxic gas and solvent has led to the health risks of workers in the area is high, according to the calculation, the highest health risk level in the substances is HQ = 10.79 due to exposure. MEK infection, this is a substance that can be fatal due to respiratory failure if exposed for a long time.

In the ink preparation area (VT1), according to the calculation of exposure dose and health risks by MEK during the period from July to November in 2016, the highest CDI is 36.94 mg/kg.day leads to a very high health risk HQ = 10.79.

The working environment in the printing industry on plastic film provides a high level of health risk. From the results of the project, to minimize the level of risk and prevent environmental pollution, the author has the following recommendations: (1) Binh Duong needs to conduct periodic inspection of the working environment here, (2) Regularly remind business owners to treat solvent vapor in the production area and equip labor safety tools for workers directly involved in the production area, (3) It is necessary for Binh Duong People's Committee to implement the health protection program for workers in industrial park.

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