

# Determination of Safe Benzene Concentration in Tank Car Crew at PT Pertamina Patra Niaga

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## Abstract

Benzene is a compound that can cause carcinogenic effects in humans. The purpose of this study was to determine the level of health risk due to exposure to benzene through inhalation on tank car crews at Pertamina Patra Niaga. This type of research is a descriptive, observational and cross sectional study. The population in this study were all the Tank Car Crew (AMT) who worked in Pertamina Patra Niaga, amounting to 8 people. The sampling technique is the total population, so the sample is 8 workers. Data analysis used quantitative data to determine the safe concentration of (C) benzene in workers from animal body weight of white rats (W animals), body surface of experimental animals (BSA animals), body weight (W), height of workers (h), worker body surface area (BSA), worker respiratory rate (BR), working time (t), benzene (C) concentration, animal km. Human km, NOAEL and safe dose toxin limit (SHD).

The results showed measurements of benzene concentration at PT. Pertamina Patra Niaga is 0.26 mg / m<sup>3</sup> (0.08 ppm), which means the concentration of benzene is still below the Threshold Value (NAB) according to Minister of Manpower Regulation No. 13 / MEN / X / 2011 at 0.5 ppm. Based on the calculations that have been done, the safe limit value is 0.02 ppm. This value if according to the Minimum Risk Level (MRL) of 2007 ATSDR exceeds that which is set at 0.009 ppm daily for acute effects and 0.003 ppm daily for chronic effects, so that control efforts are needed to be protected from the adverse effects of benzene on the health of workers. Control recommendations are to consume CYP2E1 enzyme contained in beef liver and salmon which serves to reduce benzene levels in the body, use Personal Protective Equipment (PPE) in the form of mask respirators and plant a number of ornamental plants that can absorb and reduce benzene concentrations such as Boston and Golden Photos<sup>1</sup>

**Keywords :** Benzene, safe concentration, workers of PT Pertamina Petra Niaga

## Introduction

Industrial progress and development requires the availability of adequate transportation so that it can meet economic needs and development. According to data from the Central Statistics Agency (BPS) since 2014-2016 there has been an increase in the number of vehicles in Indonesia by 5-6% per year.<sup>2</sup>

Increasing the number of vehicles will support the economy of the community, but on the other hand it can cause air pollution and energy needs which continue to increase every year.<sup>3</sup>

PT Pertamina Patra Niaga is one of the motorbike fuel terminals which is in charge of distributing fuel in Central Java. In fuel distribution activities, workers called the Tank Car Crew (AMT) must come in contact with benzene.

Benzene is a compound that can cause carcinogenic effects in humans. Benzene can enter the human body through 3 pathways, namely breathing, inhalation and skin. Prolonged exposure to benzene in the work environment such as fuel terminals can cause an increased risk of nervous system disorders, blood pressure, headaches and loss of consciousness.<sup>4</sup>

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Based on observations made at Pertamina Patra Niaga, it was found that tank crews did not use personal protective equipment (PPE) such as masks and gloves to protect themselves from exposure to gasoline vapors containing benzene and many workers who smoke also added to the risk of benzene exposure.

Based on the background described, the researchers wanted to conduct a study that aimed to determine the level of health risk due to exposure to benzene through inhalation on tank car crews at Pertamina Patra Niaga.

**Research Method**

This study was a descriptive, observational and cross sectional study. The population in this study were all the Tank Car Crew (AMT) who worked in Pertamina Patra Niaga, amounting to 8 people.

The research design begins with the collection of secondary data related to work processes which include chemicals in the work area and the number of workers involved. Furthermore, primary data collection was carried out related to the concentration of benzene in the workplace air, length of work time, and worker body weight. In addition, primary data collection was also carried out on experimental animals, namely the weight of white mice. Data on the concentration of benzene in the air was obtained by direct measurement using Coconut shell charcoal and analyzed by Gas Chromatography (GC), referring to the NIOSH 1501 method.

The research variables were benzene concentration in the workplace, worker body weight, worker height, respiration rate of workers, length of day working, body surface area, weight of white mice, body surface of white mice, highest dose of toxin without effect on experimental animals (NOAEL), Km factor in animals (Animal Km), factor Km in workers (Human Km), safe dose limit for toxins for workers (SHD), and benzene concentration in safe air for workers (C is safe).

Data analysis in this study was carried out by using quantitative data analysis manually to determine the safe concentration of benzene for tank car crews at PT Pertamina Patra Niaga.

**Findings**

**A. Characteristics of Try Animals and the Surface Area of Try Animals (White Mice)**

In general, the toxicity of compounds is interpreted

by the potential of chemicals that can cause damage when it enters the human body. In general, the response of the human body qualitatively to toxic substances is similar to the response of animals, so this becomes the basis of extrapolation from animal to human data.

Table 1 shows the characteristics of experimental animals in the form of white rat body weight.

**Table 1. Distribution of Characteristics of Try Animals (White Mice)**

Try Animals (White and White)	W (kg)	BSA (m <sup>2</sup> )
1	0,1405	0,024165
2	0,1405	0,024165
3	0,1410	0,024223
4	0,1410	0,024223
5	0,1395	0,024050
6	0,1415	0,024165

Based on the data of white rat body weight, the body surface of the white mouse can be calculated using the following formula:

$$BSA \text{ animal} = 0,09 W^{0,67}$$

Description :

BSA : Body Surface Area / body surface area (m<sup>2</sup>)

W : Weight / weight (kg)

**B. Worker Characteristics, Worker’s Body Surface Area and Worker’s Respiratory Rate**

The surface area of the worker body

$$BSA = \sqrt{W.h/3600}$$

Description :

BSA: Body surface area (m<sup>2</sup>)

W: Weight / weight (kg)

h: Height / Height (cm)

**C. Occupational respiratory rate**

$$BR = 5,3 \ln W - 6,9 / 24$$

Description:

BR: Breathing Rate ( $\text{m}^3 / \text{hr}$ )

W: Weight / Weight (kg)

**Table 2. Worker's Body Surface Area, Worker's Respiratory Rate and Characteristics of Workers**

Workers	Wb (kg)	h (cm)	BSA ( $\text{m}^2$ )	t (hour/day)	BR
1	56	171	1,63	8	0,60
2	69	160	1,75	8	0,64
3	71	169	1,82	8	0,65
4	75	159	1,82	8	0,65
5	79	161	1,88	8	0,67
6	69	155	1,72	8	0,64
7	50	166	1,52	8	0,57
8	56	167	1,61	8	0,60
Total	525	1308	13,75	64	5,02
Average	65,62	163,5	1,72	8	0,63

The characteristics of the workers in this study included the body weight and working time of 6 workers in the Tank Car Crew area at PT Pertamina Patra Niaga. Based on Table 2, it is known that the highest body weight is 79 Kg, the lowest weight is 50 Kg, and the average weight is 65.62 Kg. The duration of work in a day is 8 hours. Whereas the highest height is 171 cm, the shortest is 155 cm with an average height of workers that is 163.5 cm. The results of the analysis of the calculation of body surface area and worker respiratory rate according to table 2 show that the average body surface area of workers is 1.72  $\text{m}^2$  and the average respiration rate of workers is 0.63  $\text{m}^3 / \text{hour}$ .

#### D. Benzene Concentration

**Tabel 3. Benzene Concentration**

Measurement Location	Results of Benzene Measurement	
	(mg/m <sup>3</sup> )	Ppm
Tanks In PT Pertamina Patra Niaga	0,26	0,08

Based on the results of air measurements of the work environment at PT Pertamina Patra Niaga where the results of these measurements showed a concentration of Benzene of 0.08 ppm or 0.26  $\text{mg} / \text{m}^3$ . Based on the Minister of Manpower and Transmigration Regulation No.Per.13 / MEN / X / 2011 concerning the threshold values of physical factors and chemical factors in the workplace for 0.5 ppm Benzene concentration so that

benzene concentrations in the Tank Car Crew at PT Pertamina Patra Niaga Benzene concentration values below NAB<sup>5</sup>

#### E. Animal Km dan Human Km

Determination of safe dosage of toxin for workers begins with the calculation of Animal Km and Human Km.

Animal Km and Human Km.

1. Animal Km

$$Animal\ Km = \frac{W\ animal}{BSA\ animal}$$

Description :

Animal Km = Km factor in animals

W = experimental animal body weight (white mouse)

BSA = Body surface area can be tried

**Tabel 4.** Animal Km

Workers	Animal Km = W/BSA
1	5,81
2	5,81
3	5,82
4	5,82
5	5,80
6	5,86
<b>Total</b>	34,93
<b>Average</b>	5,82

The results of the Animal Km calculation are shown in table 4, with the average Animal Km in the experimental white rat being 5.82

2. Human Km

$$Humal\ Km = \frac{W\ Human}{BSA\ Human}$$

Description :

Human Km = Km factor on workers

W = worker weight

BSA = Worker's body surface area

**Tabel 5.** Human Km

Workers	Human Km = W/BSA
1	34,36
2	39,43
3	39,01
4	41,21
5	42,02

6	40,12
7	32,89
8	34,78
<b>Total</b>	303,82
<b>Average</b>	37,98

The results of the Human Km calculation are shown in table 5, with an average Human Km in labor force of 37.98.

F. NOAEL

One of the objectives of research activities in the field of toxicology is to be able to evaluate the safety of a substance. To determine the safe limit of the concentration of a chemical begins with a toxicity test determining the highest dose without causing effects on experimental animals or *No Observed Adverse Effect Level (NOAEL)*.

$$NOAEL\ Benzene\ (mg/m^3) = \frac{3 \times 0,00013 \times 8}{0,1405} = 0,022\ mg/kg$$

Swaen et al. (2010) research results state that benzene NOAEL is 3.0 mg / m<sup>3</sup> or equivalent to 0.022 mg / kg obtained from the calculation of the formula above.

G. Safe Human Dose

Safe dosage of toxin for workers or Safe Human Dose (SHD) is found to be initiated using the following formula from Shaw et al. (2007) :

$$SHD = \frac{NOAEL \times Animal\ Km}{Human\ Km} = \frac{0,022 \times 5,82}{37,98} = 0,003\ mg/kg$$

Description :

SHD: Safe Human Dose (mg / kg)

Animal Km: Km factor in animals

Human Km: Km factor in humans

$$\begin{aligned}
 &= 0,07 \text{ mg/m}^3 \\
 \text{C safe (ppm)} &= \frac{\text{#mg/m}^3 \times 24,5 \text{ ppm}}{\text{BM}} \\
 &= \frac{0,07 \times 24,5}{78,11} \\
 &= 0,02 \text{ ppm}
 \end{aligned}$$

#### H. Safe Limit for Benzene Concentration

Determination of safe limits of Benzene concentration in the working environment of the Tank Car Crew uses the following formula<sup>1</sup> :

$$\text{C safe} = \frac{(SHD)(W)}{(\delta)(BR)(t) \text{ mg/m}^3}$$

Description :

C safe: concentration of toxin in the air that is safe for workers (mg / m<sup>3</sup>)

SHD: Safe Human Dose (mg / kg)

W: Weight (kg)

δ: % of substances absorbed by the lungs

BR: Human respiratory rate (m<sup>3</sup> / hour)

t: Working time (hours)

MW: Molecular Weight / Molecular Weight

Based on the above formula, the results of calculating the safe concentration of benzene at PT Pertamina Patra Niaga are obtained from the SHD value, average worker weight, percentage of substance absorption, average worker respiratory rate and average length of work time is:

$$\begin{aligned}
 \text{C safe (mg/m}^3) &= \frac{(SHD)(W)}{(\delta)(BR)(t) \text{ mg/m}^3} \\
 &= \frac{0,003 \times 65,62}{50\% \times 0,6 \times 8} \\
 &= \frac{0,19}{2,4}
 \end{aligned}$$

The results of the calculation of safe limits in the air for workers above can be used to: predict the concentration of toxins in the air a safe work environment for workers if there is no determination of the Threshold Limit Value (NAV), and to be compared with the NAV determined by various institutions either by Ministry of Manpower and Transmigration, National Standardization Agency, ACGIH, NIOSH and OSHA.<sup>1</sup>

#### CONCLUSION

The results of the measurement of benzene concentration in PT Pertamina Patra Niaga were 0.26 mg / m<sup>3</sup> (0.08 ppm). Based on Permenakertrans No. 13 / MEN / X / 2011 Threshold Value The benzene limit is 0.5 ppm. From the measurement results when compared to the NAB, it is still below the set threshold value.

While based on the 2007 ATSDR Minimum Risk Level (MRL), daily benzene concentration of 0.009 ppm can have an acute effect and 0.003 ppm every day for chronic effects, so that the concentration of benzene in the work environment of PT Pertamina Patra Niaga

has the potential to provide health effects for workers. Thus control efforts are needed so that workers are protected from the adverse effects of benzene on the health of workers.

Control recommendations are to consume CYP2E1 enzyme contained in beef liver and salmon which serves to reduce benzene levels in the body, use the appropriate Personal Protective Equipment in the form of half mask respirator with organic vapor cartridge to minimize benzene exposure, and plant a number of ornamental plants that can absorb and reduce the concentration of benzene such as Boston and Golden Pothos<sup>1</sup>

**Conflicts of Interest:** all authors have no conflict interest to declare.

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

**Ethical Clearance:** The study was approved by the institutional Ethical Board of the Public Health, Airlangga University.

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