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Occupational Health Risk Assessment for Benzene and hydrogen Sulfide-Exposed Posts at a Crude Oil Depot

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ABSTRACT

The purpose of this study is to investigate the hazard status of benzene and hydrogen sulfide in a crude oil depot and evaluate the occupational health risk level, so as to provide countermeasures for risk control. In this study, the comprehensive index method was used to evaluate the occupational health risk level of exposure to benzene and hydrogen sulfide in the pump room, valve group, control room and tank metering port. The results show that the metrology workers are exposed to benzene and hydrogen sulfide in the process of operation of pump room, valve group, control room and tank metering port. Sanitary engineering protection measures are mainly closed operation, and set up ventilation fan in the pump room, personal protective equipment is mainly anti-static work clothes, oil-resistant gloves, respiratory protective equipment is gas masks, but they are not weared daily. The occupational health management system is complete. The working time of each shift is 12h, with a maximum of four shifts per week for 48h and a maximum of 12h per shift for exposure to chemical hazardous agents. Benzene and hydrogen sulfide were tested for 11 samples each, and the detected exposure concentration was not exceeding the standard. The hazard levels of benzene and hydrogen sulfide were grade 5 and grade 4, respectively, and the exposure level was 1.62. The risk index of exposure to benzene and hydrogen sulfide was 3, and the risk level was medium. The protective measures for the crude oil depot are effective, but the on-site monitoring of benzene and hydrogen sulfide concentration should be strengthened to prevent acute poisoning accidents and reduce occupational health risks.

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Crude oil depot is an important place for the storage and turnover of crude oil. The trace evaporation of crude oil in the daily storage process may cause a certain degree of occupational health hazard to workers. Crude oil contains benzene, hydrogen sulfide and other chemical hazardous agents. Benzene belongs to grade one carcinogen [1]. Long-term inhalation of benzene will affect the nervous system of the victim. Hydrogen sulfide is an acute poison that can be fatal in a short time if inhaled in small amounts and in high concentrations. Low concentrations of hydrogen sulfide affect the eyes, respiratory system and central nervous system. In view of the high harm of benzene and hydrogen sulfide and the large stock of crude oil depot, it is necessary to evaluate the occupational health risk of benzene and hydrogen sulfide in crude oil depot. Occupational health risk assessment is a process of qualitative or quantitative assessment of occupational health risk level through comprehensive and systematic identification and analysis of workplace risk factors and protective measures, so as to adopt corresponding risk control countermeasures [2,3]. In order to understand the occupational health risk status of the crude oil depot staff's exposure to benzene and hydrogen sulfide, this study intends to use the comprehensive index method to carry out a semi-quantitative assessment of the occupational health risk of an crude oil depot, so as to provide a basis for the corresponding risk control measures.

Research objects and methods

Research objects & Crude Oil Depot

Methods

Occupational health survey

Occupational hygiene survey was carried out on the crude oil depot, including the working position, working shift system, exposure to benzene and hydrogen sulfide, protective facilities for sanitary engineering, personal protective equipment and occupational health management measures.

Detection of chemical hazardous agents

Time weighted average concentration (C_{TWA}) of benzene in the air of crude oil depot was measured by sampling according to the requirements of GBZ159-2004 "Sampling Standard for Monitoring Hazardous Substances in Workplace Air" and GBZ/T 160.33-2004 "Determination of Sulfide in Workplace Air Toxic Substances". In accordance with the requirements of GBZ/T 300.66-2017 "Determination of Toxic Substances in Workplace Air - Part 66: Benzene, Toluene, Xylene and Ethylbenzene", samples were taken to determine the maximum concentration (C_M) of hydrogen sulfide in the air of the crude oil depot. According to GBZ 2.1-2019 "Occupational exposure limits for hazardous factors in the workplace - part 2: chemical hazardous factors", the permissible concentration-time weighted average of benzene (Occupational exposure limit (OEL)) is 6.00mg/m^3, and the maximum allowable concentration of hydrogen sulfide (Occupational exposure limits)

is 10.00mg/m^3.

1.2.3 Semi-quantitative risk assessment by comprehensive index method [4]. The Exposure index (EI) was determined by considering the hazard characteristics, hazard control measures, Exposure time and Exposure level of benzene and hydrogen sulfide. The Exposure risk (ER) was calculated according to formula (1), and the risk level (risk, R) was calculated according to formula (2) [GBZ/ t298-2017]. In this study, when R value is 1, 2, 3, 4, and 5, R is negligible risk, low risk, medium risk, high risk, and very high risk , respectively.

$$ER = [EI_1 \times EI_2 \cdots \times EI_n]^{1/n} \quad (1)$$

Where: ER - exposure level;
EI - exposure index is divided into 5 levels according to the increase of exposure dose;
n - number of exposure factors

$$R = \sqrt{HR \times ER} \quad (2)$$

Where: R - risk level; HR -- hazard level; ER - level of exposure.

The results of the study

Basic situation

The crude oil depot is mainly engaged in loading, unloading and storage of crude oil. The metrology work mainly includes starting and stopping of pump and inspecting operation, inspecting operation of valve group and pipeline, monitoring operation of control room and inspecting operation of storage tank. The working time of each shift is 12h, with a maximum of four shifts per week and a maximum of 48h. The time of exposure to chemical hazardous agents in each shift is 12h. Workers are exposed to benzene and hydrogen sulfide mainly through respiratory exposure, with occasional skin exposure. The crude oil is transported in closed pipelines and stored in closed tanks. The pump room is equipped with a ventilator for ventilation and normal operation; Personal protective equipment is mainly anti-static work clothes, oil-resistant gloves, respiratory protective equipment is a gas mask, but do not wear daily; The occupational health management system is complete.

Hazard identification

The main chemical hazardous agents of volatile components of crude oil are benzene and hydrogen sulfide. Crude oil volatilizes slowly in the valve and pump room of the pipeline. When the tank metering port of the storage tank is opened, the crude oil vapor in the storage tank volatilizes into the air along the tank metering port. This can lead to exposure of site operators to benzene and hydrogen sulfide hazards.

Hazard characteristic assessment

According to the toxicity of the chemicals, the harm of benzene and hydrogen sulfide was classified, and the hazard levels were rated as grade 5 and grade 4 respectively.

Exposure assessment

Detection results

The concentrations of benzene and hydrogen sulfide were detected in four places: pump room, valve group, control room and tank metering port. A total of 11 samples were tested for benzene, with the detection range of detected exposure concentration ranging from 0.03 to 1.6mg/m^3, and the C_{TWA} of the pump room, valve group, control room and tank metering port were 0.67, 0.03, 0.03 and 1.05mg/m^3, respectively, with no places exceeding the standard. Hydrogen sulfide was detected in 11 samples, with the range of detected exposure concentration ranging from 0.53 to 1.81mg/m^3, and the detected exposure concentration (C_M) of hydrogen sulfide in the metrometer was 0.74, 0.53, 0.53 and 1.32mg/m^3, respectively. The detection results of meterobenzene and hydrogen sulfide is shown in table 1.

Table 1: detection results of benzene and hydrogen sulfide in a crude oil depot workplace

chemical hazardous agents	Sample numbers	detected exposure concentration (mg/m^3)			Number of exceeded samples
		range	C_{TWA}	C_M	
benzene					
pump room	3	0.6~0.7	0.67	-	0
valve group	3	0.03	0.03	-	0
control room	3	0.03	0.03	-	0
tank metering port	2	0.5~1.6	1.05	-	0
hydrogen sulfide					
pump room	3	0.53~0.92	-	0.74	0
valve group	3	0.53	-	0.53	0
control room	3	0.53	-	0.53	0
tank metering port	2	0.83~1.81	-	1.32	0

Exposure ratio

The exposure concentration (E) was estimated according to the exposure time of 48h per week, and E was compared with the corresponding Occupational exposure limit (OEL, the permissible concentration-time weighted average of benzene, and the maximum allowable concentration of hydrogen sulfide). The exposure ratio of benzene and hydrogen sulfide (E/OEL) was calculated respectively. The results of the exposure ratio calculation are shown in table 2.

Table 2: contact ratio of exposure to benzene and hydrogen sulfide of metrology workers

chemical hazardous agents	Weekly exposure frequency(d/w)	Time per exposure(h/d)	detected exposure concentration (mg/m^3)	Weekly working hours(h/w)	E(mg/m^3)	OEL	E/OEL
benzene							
pump room	4	3	0.67	48	0.28	4.69	0.06
valve group	4	2	0.03				
control room	4	6.5	0.03				
tank metering port	4	0.5	1.05				
hydrogen sulfide							
pump room	4	3	0.74	48	0.73	10	0.07
valve group	4	2	0.53				
control room	4	6.5	0.53				
tank metering port	4	0.5	1.17				

Note 1: The personnel in the pump room, valve group, control room and tank metering port are all metrology workers. The weekly exposure concentration of metrology workers is the sum of the weekly exposure concentration of the four sites;

2. The occupational exposure limit of benzene is a permissible concentration-time weighted average , which is multiplied by a reduction factor

Exposure index classification

The exposure index is mainly determined by the vapor pressure of the chemical hazardous agents, the exposure ratio (E /OEL), the occupational-disease-inductive measures, the amount used and the exposure time. See table 3.

Table 3: exposure index classification of exposure to benzene and hydrogen sulfide

chemical hazardous agents	vapor pressure	E/OEL	Hazard control measures					weekly amount	weekly exposure time	ER
			sanitary engineering protection	emergency rescue facility	personal protective equipment	Emergency rescue measures	management system			
benzene	1	1	1	1	5	1	1	3	5	1.62
hydrogen sulfide	1	1	1	1	5	1	1	3	5	1.62

Note; The content of benzene and hydrogen sulfide in crude oil is very small, so the exposure index of vapor pressure is 1

Description of risk characteristics

According to the hazard level and exposure level of benzene and hydrogen sulfide, the risk index was calculated and the risk level was determined. The decision results are shown in table 4.

Table 4: occupational health risk levels of metrologers in a crude oil depot

chemical hazardous agents	HR	ER	risk index	risk level
benzene	5	1.62	3	medium risk
hydrogen sulfide	4	1.62	3	medium risk

Discussion

In this study, the occupational health risk assessment of benzene and hydrogen sulfide in crude oil depot was conducted by comprehensive index method. The personnel exposed to benzene and hydrogen sulfide hazards in the pump room, valve group, control room and inspection port are all metrologists, so the occupational health risks of the above four positions were assessed in combination.

The results show that the concentrations of benzene and hydrogen sulfide are not exceeding the standard. The reason may be that the pipelines and storage tanks in the crude oil depot are well sealed, and the evaporation amount of benzene and hydrogen sulfide in the crude oil component is also low. The detected exposure concentration of the pump room and the inspection port is relatively high, because the pump room is an indoor environment, and the oil pump is less dense than the oil pipeline, and the crude oil evaporation is relatively large. The metering port leads to the tank, and the crude oil vapor above the original oil level in the tank has a high concentration. When the measuring port is opened, the crude oil vapor diffuses outward, resulting in a high detection concentration of benzene and hydrogen sulfide. Although none of the test results in this study exceed the standard, it is not excluded that the airtight degree of oil pumps, pipelines, valves and other facilities is reduced during use, resulting in higher exposure concentration, and under special circumstances, the crude oil vapor in the storage tank rapidly diffuses through the metering port, resulting in benzene or hydrogen sulfide concentration exceeding the standard.

In recent years, more and more risk assessment techniques have been applied to risk control and management in the workplace [5-7]. Risk assessment includes the analysis and assessment of inherent risk factors and risk offsetting factors [8]. The hazard of benzene and hydrogen sulfide mainly depends on its toxicity, exposure route, and so on. This is the inherent risk factor of chemical harmful factor, cannot eliminate commonly. However, the risks can be eliminated or reduced by means of sanitary engineering protection, occupational-disease-prevention articles, emergency rescue measures and occupational health management. The operation process of the crude oil depot has a high degree of sealing, good protection of health engineering, and a sound emergency rescue plan and occupational health management system are formulated, which can eliminate or reduce occupational health risks to a certain extent. This study result shows that the measurement of workers exposure to benzene and hydrogen sulfide occupational health risk level is moderate, but due to lack of personal respiratory protective equipment, under the condition of the engineering protection failure, may cause the heavier occupational health risks, especially hydrogen sulfide can also cause acute poisoning accident. Since there is a certain risk management weaknesses, it is suggested metrologers should carry gas mask and portable hydrogen sulfide concentration detector, in order to avoid acute poisoning accident and reduce occupational health risks.

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