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Research Article

Investigation of Occupational Hazards in Transport Wharf of Liquid Chemicals

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Abstract: Occupational health management of liquid chemical transport wharf is still in its infancy, to grasp the occupational health status of employees in the industry and improve the occupational health management level of employees, taking the liquid chemical transport wharf of an enterprise as the investigation object, according to the relevant domestic occupations. Hygiene standards, using the combination of on-site occupational hygiene survey and workplace occupational hazard factors detection, identify the occupational hazard factors of the wharf and detect the degree of hazard. The survey results show that the overall occupational health of the wharf is basically good, but the noise index is slightly exceeded. It is suggested to further improve the occupational health management level of the wharf by improving the protection technology and strengthening the administrative management.

Keywords: *wharf; occupational health; identification of hazard factors; liquid chemicals*

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0 Preface

Liquid chemicals are widely used and inextricably linked to economic development. In recent years, with the rapid development of the economy, the liquid chemical production industry has developed rapidly. There are certain environmental and safety problems in the process of transport, loading and unloading, which may pollute the atmosphere, soil, groundwater, etc., and contacts which may be at risk of poisoning. This survey will target a liquid chemical transport wharf of a petrochemical enterprise.

Occupational health originated in Europe and developed in developed countries, especially in the United States, Britain, and Japan. Hofmann and Burke analyzed the development trend of occupational safety research from individual laborer safety protection, safety training, safety culture, etc.[1]. Turof identifies occupational safety risks based on pre-established analysis systems and supports the reduction of operational accidents[2]. Antão *et al.* defined a set of environmental performance indicators applicable to the port area through occupational health, safety, and environmental analysis[3]. Rauno Pääkkönen and Milja Koponen use Finland as an example to assess and describe the future status and prospects of occupational health[4].

This survey will focus on the investigation of occupational hazards of employees in liquid chemical transport wharfs, identify occupational hazards, detect hazards, and explore protective countermeasures and management measures to provide a basis for further industry-related work.

1 Survey object

Taking the liquid chemical transport wharf of a petrochemical enterprise as the investigation object, to analysis and evaluate the occupational disease hazard factors and the degree of damage to the wharf and the health of the wharf employees, the occupational disease hazard protection facilities and effects, emergency rescue, occupational disease protection products for personal use, and occupational health examinations.

The total throughput of the wharf is 559,000 tons/year, including 250,000 tons/year of ethylene glycol, 80,000 tons/year of methyl tert-butyl ether (MTBE),

40,000 tons/year of C9 (carbon nine), 120,000 tons/year of butadiene, and 11,000 tons of ethylene. In the transport of liquid chemicals, there are mainly two transport processes:

a) Liquid chemical shipment process. The liquid wharf is mainly responsible for the ethylene liquid chemicals entering the factory. Judging from the throughput, the loading process of MTBE, C9, butadiene, and ethylene glycol is the main shipping process. The chemical product enters the process pipeline from the storage tank through the special pipeline to the wharf, the process pipeline is connected with the loading and unloading arm, and finally, the connection is made by the connection of the loading and unloading arm and the transporting ship.
b) Sweeping process before and after loading and unloading. Before loading, the butadiene purges the pipeline with nitrogen and connects the oil delivery arm in a nitrogen shield atmosphere. After the loading and unloading are completed, the chemical in the pipeline is purged with nitrogen to the cabin. After each loading and unloading of various products, the nitrogen gas should be inserted into the pipeline through the nitrogen valve of the valve chamber platform. After the residual liquid in the pipeline is purged to the cabin, the valve is closed, and the pressure relief valve at the top of the loading arm is opened for pressure relief. After that, the loading arm can be removed.

There are 16 employees involved in the above-mentioned transport operations, including four dispatchers and twelve loadings and unloadings (four team leaders and eight general loading and unloading workers).

2 Survey methods

This survey mainly relies on on-site occupational hygiene investigation and testing methods.

2.1 On-site occupational hygiene survey

The survey investigates the wharf transport process, occupational disease hazard factors and their distribution, the setting of the occupational disease hazard protection facilities and their effects, the personal protective equipment, the occupational health guardianship, and the occupational health management and understands the main transport processes. The process identifies the occupational hazards that exist during the operation.

2.2 Test and inspection method

The test method is as follows:

2.2.1 Selection of sampling points

According to *Specifications of Air Sampling for Hazardous Substances Monitoring in the Workplace*, representative positions were selected for testing[5], in which two total detection points for hydrocarbons, two detection points for ethylene glycol, and two for butadiene. For each detection point, the noise is set to two detection points.

2.2.2 Sampling basis

Toxic substances are detected according to the determination of toxic substances in workplace air[6], and the noise intensity is detected according to the workplace noise measurement quality control specification[7]. Occupational exposure limits and testing standards for occupational hazards are shown in Tables 1 and 2.

In Table 1, MAC is the maximum allowable concentration, permissible concentration (PC)-time-weighted average is the time-weighted average contact allowable concentration, and PC-short-term exposure limit (STEL) is the short-time contact allowable concentration. For chemical substances that have not been formulated with PC-STEL, excessive fluctuations in the short-time contact level of the super-value multiple control period are used.

2.2.3 Sampling method

The detection of chemical harmful factors is performed according to occupational exposure limits for hazardous agents in the workplace Part 1 and determination of toxic substances in workplace air according to the short-time contact allowable concentration and the time-weighted average allowable concentration detection requirement. In the case of full-load production, representative positions and sample them were selected in separate time periods, including the highest concentration of harmful substances in the air. Physical factors are detected according to Occupational Exposure Limits for Hazardous Agents in the Workplace Part 2: Physical Agents and Measurement of Physical Agents in Workplace Part 8: Noise. Carry out testing according to the physical factor testing requirements in the workplace, and select representative positions when the equipment is at full-load.

Table 1. Occupational exposure limits and testing standards for toxic chemicals

Occupational disease factor	Occupation exposure limit(mg/m^3)			Value multiple	Testing standard	Judging criteria
	MAC	PC-TWA	PC-STEL			
Butadiene	-	5	-	2.5	GBZ/T160.39-2007	GBZ2.1-2007
Total hydrocarbon	-	300	-	1.5	GBZ/T160.40-2004	GBZ2.1-2007
Ethylene glycol	-	20	40	--	GBZ/T160.48-2007	GBZ2.1-2007
PC-TWA: Permissible concentration-time-weighted average						

Table 2. Physical factors occupational exposure limits and testing standards

Occupational disease risk factors	Occupation exposure limit	Testing standard	Judging criteria
Noise	85 dB	GBZ/T189.8-2007	GBZ2.2-2007

3 Site survey results

3.1 Process analysis

The shipping process is as follows:

a) MTBE shipping process
   MTBE storage tank → MTBE pipeline → wharf MTBE process pipeline → MTBE loading arm → ship.
b) C9 shipping process
   C9 storage tank → C9 pipeline → wharf C9 process pipeline → C9 loading and unloading arm → ship
c) Butadiene shipment process
   Butadiene storage tank → butadiene pipeline → wharf butadiene process pipeline → butadiene loading arm → ship.
d) Ethylene glycol shipment process
   Ethylene glycol storage tank → glycol line → wharf glycol process line → glycol loading arm → ship.

The sweeping process is as follows:

a) Butadiene sweeping process
   Before loading the butadiene, purge the pipeline with nitrogen and connect the oil delivery arm in a nitrogen shield atmosphere. After the loading and unloading are completed, the chemical in the pipeline is purged with nitrogen to the cabin.
b) Butadiene into the tank process
   Butadiene gas phase → wharf butadiene gas phase process line → butadiene storage tank.
c) Other pipeline sweeping process
   After each loading and unloading, the nitrogen gas should be inserted into the pipeline through the nitrogen valve of the valve chamber platform. After the residual liquid in the pipeline is purged to the cabin, the valve is closed, and the pressure relief valve at the top of the loading arm is opened to relieve the pressure, then the loading arm can be removed.

It can be seen from the analysis of the process flow that two important positions are required to complete these two tasks: The overall dispatch (dispatching) and the loading and unloading operations (team leader and loader). Due to the relatively long working time in the work process, the work intensity is large, and the possibility of contact with toxic and harmful substances is large, which may cause occupational diseases.

3.2 Identification of occupational hazards

By looking at the catalog of raw materials and products, combined with the analysis of the main process technology, and referring to the *Classification Catalog of Occupational Disease Hazard Factors*, the possible occupational hazards factors of the liquid wharf are 1,3-butadiene, MTBE, and ethylene glycol., ethylene, noise, visual fatigue, low back pain, carpal tunnel syndrome, neck and shoulder wrist syndrome [Table 3]. The main occupational hazards are total hydrocarbons, butadiene, ethylene glycol, and noise.

3.3 Occupational disease hazard protection measures

There are eleven flammable gas concentration detection probes in the wharf, which are distributed in five barges, four platforms, and two emergency shut-off valves. The equipment of the wharf is preferred to select new low-noise equipment to meet the requirements of noise occupational exposure limits.

3.4 Personal protective equipment

The wharf has developed a personal occupational disease protection product distribution system to

Table 3. Post setting and exposure to occupational hazards

Position/ work	Number of worker	Workplace	Working hour (h/d)	Occupational hazard factors of exposure	Personal protective equipment	Operation of protective facilities
Scheduling	4	Control room	8 h	Visual fatigue, lower back pain, carpal tunnel syndrome, neck and shoulder syndrome	Safety helmets, overalls, anti-smashing shoes, etc.	Normal operation
Team leader	4	Wharf unloading arm area, duty room	12 h per shift, each on-site loading operation lasts approximately 2 h	1,3-butadiene, MTBE, ethylene glycol, ethylene, noise, etc.	Safety helmets, overalls, anti-smashing shoes, anti-noise earplugs, respirator, goggles	Normal operation
Loader	8					

provide workers with protective equipment such as dust masks, noise-proof earplugs, protective gloves, eye protection, protective boots, protective clothing, helmets, and safety ropes.

3.5 Occupational health monitoring

There were 16 people in the wharf who were exposed to occupational hazards. Entrusted units with occupational health supervision qualifications conducted occupational health examinations for all personnel. No occupational disease patients or occupational contraindications were found at present.

3.6 Emergency rescue measures

The wharf formulated the emergency response plan for occupational disease hazards and set up corresponding emergency response procedures and prepared corresponding emergency response plans, for example, emergency disposal plan for metal hose burst and oil spill and emergency disposal plan for low-temperature ethylene long-distance pipeline leakage.

3.7 Occupational health management

The enterprises affiliated to the wharf set up specialized health-care institutions and occupational health management departments, equipped with 20 health-care personnel and 2 full-time health management personnel, formulated occupational disease prevention and control plans, and established occupational health files. The enterprises affiliated to the wharf have established and improved occupational health rules and regulations, occupational disease hazard factor monitoring system, construction project occupational disease hazard evaluation system, and occupational health education and training system. All employees in the wharf industry have participated in industrial injury insurance and medical insurance. Employees who are exposed to occupational disease hazards are regularly organized annually for occupational health examinations.

4 Occupational disease test results

4.1 Test results of toxic chemicals

There are two hydrocarbon detection points, two ethylene glycol fixed-point detection points, and two butadiene fixed-point detection points, the detection rate is 100%, the detection points are reasonable, and the on-site sampling methods and procedures are in line with Chinese occupational health standards. The concentration of toxic chemical substances at each test point meets the requirements. The test results are shown in Table 4.

4.2 Physical factor test results

There are two noise detection points, the detection rate is 100%, the detection points are distributed reasonably, and the on-site sampling methods and procedures are in line with Chinese occupational health standards. The noise value of the pumping ship is slightly exceeded. Currently, the company is equipped with anti-noise earplugs (SNR of 31 dB and noise reduction of 18.6 dB). The test results are shown in Table 5.

5 Conclusion

Through the analysis of the transport process and staff of the liquid chemical transport wharf of a petrochemical enterprise and using on-site investigation and testing, the main occupational hazards in the wharf work site were identified, analyzed, and quantitatively evaluated. Occupational hazards were found to be

Table 4. Test results of all toxic chemical substances (sites) in the workplace

Inspection location	Occupational disease risk factor name	Test results (mg/m^3)			Overrun multiple	Result determination
		C-MAC	C-TWA	C-STEL		
Wharf operation room	Total hydrocarbon	-	3.09	3.40	0.01	Qualified
Dock pump ship	Total hydrocarbon	-	23.33	25.33	0.09	Qualified
Wharf operation room	Ethylene glycol	-	-	-	-	Qualified
Dock pump ship	Ethylene glycol	-	-	-	-	Qualified
Wharf operation room	Butadiene	-	<0.60	<0.60	-	Qualified
Dock pump ship	Butadiene	-	<0.60	<0.60	-	Qualified

Table 5. Workplace noise (fixed point) test results

Occupational disease risk factors	Inspection location	Test results dB (A)	Occupation exposure limit dB (A)	Suggestion/Judgment result
Noise	Pump ship	85.2	85	Must wear noise-proof earplugs
Noise	Control room	82.9	85	Selectively wear noise-proof earplugs

mainly chemical poisons (hydrocarbons, ethylene glycol, and butadiene), noise, etc. From the field test results of major occupational hazards, they basically met the relevant Chinese standards. At the same time, the enterprises affiliated to the wharf set up a more comprehensive occupational health management institution, established a sound occupational health management system, and formed a relatively complete set of wharf operation methods for wharf transport stations. In general, the employees of the transport wharf have good occupational health, and the protective measures and management measures have achieved the protective effect of occupational hazards. However, the test results show that the noise value is slightly exceeded. This working point is located at the dock pumping ship and belongs to the high noise area (≥85 dB). It is recommended that the wharf pumping and loading and unloading be listed as the key control point, although the worker contact time is short, wear noise-proof earplugs as required during operation to minimize contact time. In addition, training on noise hazards should be strengthened to increase workers' awareness of self-protection and reduce the impact of noise on health.

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