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Analysis of Occupational Hazard Factors and Countermeasures for Prevention and Control in a Vacuum Pump Maintenance and Cleaning Factory in Xi'an City, China

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Abstract: In order to understand and detect occupational hazards in a vacuum pump repair and cleaning plant in Xi'an City, and to propose preventive and control countermeasures to protect workers' health. We carried out On-site testing at the plant from December 2022 to January 2023 according to relevant Chinese standards and requirements, and the results were evaluated and analyzed. Resultly, the maximum permissible concentration of potassium hydroxide in the cleaning area of a vacuum pump repair and cleaning plant in Xi'an is less than 0. 009mg/m3, and the test results comply with the limit values; the time-weighted average permissible concentrations of other dusts in the disassembling area, sanding area and assembling area of the plant are 0.8, 0.2 and 0.2mg/m3 respectively, and the test results comply with the limit values; the disassembling area, cleaning area, sanding area, assembling area, testing area, molecular pump testing room and equipment room of the plant are 0.8, 0.2 and 0. 2mg/m3 respectively. The 8h equivalent sound level of staff contact noise in the dismantling area, cleaning area, grinding area, assembly area, testing area, molecular pump testing room and equipment room are 78.1, 80.1, 69.4, 54.5, 66.3 and 71.6 dB(A) respectively, and the test results are in line with the limit value requirements. Thus, the concentration of potassium hydroxide, other dusts and noise intensity contacted by workers during the production period of a vacuum pump maintenance and cleaning plant in Xi'an meet the requirements of national regulations.

1. Introduction

With the development of society, occupational diseases have become a major factor affecting the health of workers in China [1]. Occupational diseases can cause the loss of human resources and increase the burden on the national economy, thus affecting the sustainable development of the economy. A vacuum pump repair and cleaning plant in Xi'an City is mainly engaged in the work of

a company's flash chip project vacuum pump cleaning and repair services, and its production can reach an annual cleaning and repair of 650 sets / sets of vacuum pumps. The main raw and auxiliary materials in the production of the plant are CLEAN292 metal cleaner, RP880 rust remover, alcohol, helium, special lubricant and nitrogen, and there are more occupational hazards in the maintenance and cleaning work. For the sake of the human health of the staff of the plant, we conducted an on-site investigation of the plant with December 2022-January 2023 to assess the occupational hazard factors and propose corresponding countermeasures for the prevention and control of occupational hazard factors.

2. Objects and Methods

2.1. Objects

A vacuum pump repair and cleaning plant in Xi'an dismantling area, cleaning area, polishing area, assembly area, testing area, molecular pump testing room and equipment room.

2.1.1. Major equipment

The main equipment of a vacuum pump maintenance and cleaning plant in Xi'an includes dismantling benches, double-track cranes, pre-cleaning machines, industrial water purification equipment, sandblasting machines (wet), cleaning pools, sanding machines, helium gas detectors, circulating water refrigeration units, air compressors, compressed air tanks and fire-fighting pumps.

2.1.2. Production process

The returned vacuum pumps first pass through the dismantling area, which is mainly responsible for dismantling the products to be repaired. When dismantling, the oil in the repaired products is filtered out through the oil filter, and then outsourced to qualified professional units for processing. The disassembled vacuum pump parts are sent to the pre-cleaning machine by hand with a trolley to clean the dirty surface. The disassembled and pre-cleaned parts are sent from the pre-cleaning machine to the wet sand blasting cleaning machine for grinding and cleaning to remove the surface rust and stains, followed by ultrasonic cleaning. The cleaned parts and pumps, leak detector shell and intact parts and purchased new parts of the instrument into the combination area for assembly, through the pressurized bed and other equipment and tools will be pumps and leak detector parts pressure mounted on the instrument to ensure that the assembly of the precise in place. The assembled vacuum pump enters the test room, the test time lasts for 8 hours, and finally the maintenance workers will transport the qualified vacuum pump to the finished pump area for outsourcing and shipment. See Figure 1.

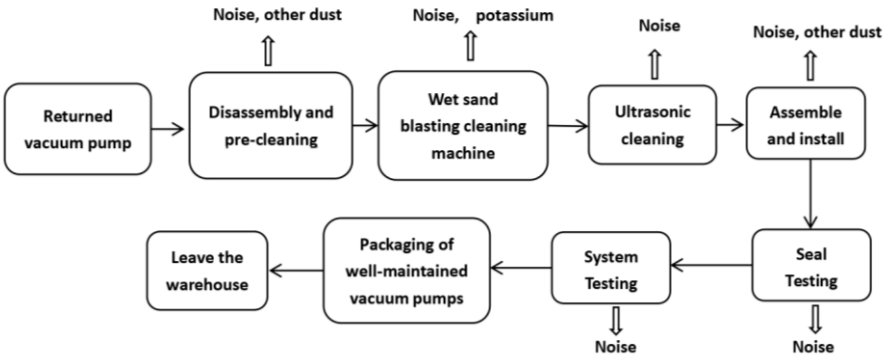

Figure 1: Production process flow of a vacuum pump repair and cleaning plant in Shaanxi, China

2.2. Methods

2.2.1. Basis of evaluation

According to the Law of the People's Republic of China on Prevention and Control of Occupational Diseases [2], Provisions on Management of Occupational Hygiene in Workplaces [3], Classification of Occupational Disease Hazardous [4], GBZ2.2-2007 Occupational Exposure Limits for Hazardous agents in the Workplace Part 2:Physical agents [5], GBZ/T192.1-2007 Determination of Dust in the Air of Workplaces Part 1: Total Dust Concentration [6], Technical Specifications for Occupational Health Surveillance [7], and other national laws and norms, we assessed the factors of occupational hazards of a vacuum pump repair and cleaning plant in Xi'an and put forward the corresponding preventive and control countermeasures.

2.2.2. Scope of evaluation

Based on the on-site investigation, it was determined that the scope of this test was the disassembly area, cleaning area, polishing area, assembly area, testing area, molecular pump testing room and equipment room of a vacuum pump repair and cleaning plant in Shaanxi.

2.2.3. Detection methods

According to GBZ/T 189.8-2007 Measurement of Physical agents in Workplaces Part 8: Noise [8], GBZ 2.1-2019 Occupational Exposure Limits for Hazardous agents in the Workplaces Part 1: Chemical Hazardous agents [9], GBZ/T300.21-2017 Determination of Toxic Substances in Workplaces air Part 21: Potassium and its Compounds [10], GB/T18204.1-2013 Examination Methods for Public Places Part 1: Physical Parameters [11], GBZ 159-2004 Specification of Air Sampling for Hazardous Substances Monitoring in the Workplaces [12] and other Chinese national standards, we tested the occupational disease hazards of the enterprise. Then we put forward the corresponding prevention and control countermeasures.

3. Results

3.1. Exposure of workers to occupational hazards

Table 1: Exposure of workers to occupational hazards in a vacuum pump repair and cleaning plant in Xi'an, China

Workshop/ location	Job category	Working position	Occupational disease exposure hazardous factors	Exposure time	Number of people exposed
disassembly zone	dismantler	disassembly station	other dust, noise	6h/d, 5d/w	2
cleaning zone	washer	cleaning station	Potassium hydroxide, noise	6h/d, 5d/w	2
grinding area	polisher	grinding position	other dust, noise	1h/d, 5d/w	2
assembly area	assembler	assembly station	other dust, noise	1h/d, 5d/w	2
test area	tester	test position	noise	6h/d, 5d/w	3
molecular pump test room	operator	molecular pump test station	noise	5h/d, 5d/w	1
equipment room		equipment room inspection position	noise	1h/d, 5d/w	

According to the identification of occupational disease hazards in the workplace, combined with the requirements of relevant Chinese national standards and norms, the main occupational disease

hazards such as chemical hazardous factors potassium hydroxide and other dusts, physical hazardous factors noise and other major occupational disease hazards contacted by laborers in the workplace of a vacuum pump repair and cleaning factory in Xi'an City were detected by on-site investigation. See Table 1.

3.2. Test results and analysis

3.2.1. Test results of chemical hazardous factors in workplace air

The content of potassium hydroxide and other dusts, which are chemically harmful factors to which laborers are exposed in the workplace of a vacuum pump repair and cleaning plant in Xi'an City, was tested, and the results of the testing of laborers in each position met the exposure limits according to the time of exposure. See Table 2.

Table 2: Test results of chemical hazardous factors in the air of a vacuum pump maintenance and cleaning plant in Xi'an, China

Workshop/ location	Job category	Exposure time	hazardous factor	Test results		exposure limit			Judgment results
				typology	calculation result (mg/m^3)	typology	RF (discount factor)	Judgment limit (mg/m3)	
disassembly zone	dismantler	6h/d, 5d/w	other dust	C_{TWA}	0. 8	PC-TWA	/	8	√
				C_{PE}	1. 1	PE	/	24	
cleaning zone	washer	6h/d, 5d/w	Potassium hydroxide	C_{ME}	＜0. 009	MAC	/	2	√
grinding area	polisher	1h/d, 5d/w	other dust	C_{TWA}	0. 2	PC-TWA	/	8	√
				C_{PE}	2. 0	PE	/	24	
assembly area	assembler	1h/d, 5d/w	other dust	C_{TWA}	0. 2	PC-TWA	/	8	√
				C_{PE}	1. 7	PE	/	24	

Notes: C_{TWA}-Time-weighted average concentration; PE-Peak Exposure Concentration; PC-TWA-Time-weighted average allowable concentration; C_{PE}-peak concentration value; C_{ME}-Instantaneous (short-term) concentration; MAC-Maximum permissible concentration;√-comply with requirements.

3.2.2. Test results of physical hazardous factors in the workplace

Table 3: Detection results of physical hazardous factors in the workplace of a vacuum pump maintenance and cleaning factory in Xi'an City, China

Workshop/location	Job category	Point of detection	Exposure time	Measure-ment results [dB(A)]	LEX,8h [dB(A)]	exposure limit [dB(A)]	Judge-ments
disassembly zone	dismantler	disassembly station	6h/d,5d/w	79. 3	78. 1	85	√
cleaning zone	washer	cleaning station	6h/d,5d/w	81. 3	80. 1	85	√
grinding area	polisher	grinding position	1h/d,5d/w	78. 4	69. 4	85	√
assembly area	assembler	assembly station	1h/d,5d/w	63. 5	54. 5	85	√
test area	tester	test position	6h/d,5d/w	67. 5	66. 3	85	√
molecular pump test room	operator	molecular pump test station	5h/d,5d/w	71. 4	71. 6	85	√
equipment room		equipment room inspection position	1h/d,5d/w	76. 5			

Notes: $L_{EX,8h}$-8-hour equivalent A sound level; √-comply with requirements.

The 8-hour equivalent sound level of noise for workers in each position in the employing

organization was calculated, and the results of the calculations were all in line with the Occupational Exposure Limits for Hazardous agents in the Workplace Part 2:Physical agents(GBZ 2. 2-2007). See Table 3.

4. Discussions

The analysis of this test found that the main occupational hazards in the workplace of a vacuum pump repair and cleaning plant in Xi'an are noise, potassium hydroxide and other dusts. The test results show that the noise, potassium hydroxide and other dusts exposed to workers in the workplace of a vacuum pump repair and cleaning plant in Xi'an meet the occupational exposure limits.

China is the country with the most serious dust hazard in the world [13]. Dust, as an occupational hazard factor, may cause a variety of hazards to workers, including (1) respiratory problems: long-term inhalation of dust may lead to respiratory problems, such as respiratory tract irritation, bronchitis, and inflammation of the lungs, etc. ; (2) occupational lung diseases: dust in some workplaces may contain toxic substances or chemicals, such as coal dust and silica, and long-term exposure may lead to occupational lung diseases, such as pneumoconiosis, silicosis, etc. ; (3) Allergic reactions: some people may have allergic reactions to specific types of dust, triggering symptoms such as allergic rhinitis and allergic asthma. This can affect the efficiency and productivity of workers; (4) Eye and skin irritation: certain dusts may cause eye and skin irritation, leading to redness, swelling, itching and inflammation; (5) Increased risk of accidents: in some industries, dusts may lead to reduced visibility at the workplace, increasing the risk of accidents, especially in work environments that require precision operations or the movement of heavy machinery.

Noise is also one of the occupational hazards that should not be ignored, and its hazards to workers include hearing damage, health problems, communication disorders, increased risk of accidents, psychological effects, and impact on productivity [14].

5. Suggestions

(1) Prolonged exposure to noise can cause damage to workers' nervous systems, resulting in dizziness, headaches, insomnia, fatigue, poor concentration, memory loss, emotional anxiety and other symptoms. Employers need to strengthen the maintenance and management of equipment to avoid abnormally high noise caused by insufficient lubrication or poor operation of vibration-damping facilities, and strengthen the inspection and maintenance of old equipment to ensure the normal operation of equipment.

(2) Chemical poisons can enter the human body through respiration, skin, digestive system, mucous membranes, etc., and cause damage to the internal organs and nervous system of the human body. It is recommended that employers turn on protective facilities in a timely manner during the production process and supervise employees to wear anti-virus masks correctly to minimize the hazards [15].

(3) Dust is mainly inhaled into the lungs through the respiratory tract, which is harmful to the human body and causes lung diseases. In order to prevent dust from causing harm to the human body, it is recommended that employers pay attention to maintaining air circulation at their posts, regularly checking and maintaining dust removal facilities to ensure their effectiveness in removing dust, and supervising workers to wear protective gear correctly, so as to avoid inhaling dust into the nasal cavity.

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