The Analysis of c-silica Dust Content in Respirable Dust in the Ceramic Industry

Analisis Kandungan Debu c-silika dalam Debu Respirabel pada Industri Keramik

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ABSTRACT

Introduction: Exposure to hazards in the work environment in the ceramic industry includes silica dust and heat temperatures. The purpose of this research was to analyze the respirable dust and c-silica dust, in addition to calculate c-silica dust in respirated dust. In addition, an evaluation of the results of dust measurements was also carried out by comparing it to the threshold value. **Method:** This was a descriptive study by testing samples of respirable dust and c-silica dust in the work place. The research was conducted at one of the ceramic industries in East Java. Data collection was carried out on all workers in the production division of 39 peoples. The measurement method for respirable dust analysis used the gravimetric method based on NIOSH method (NMAM 0600, 1998), while the analysis of c-silica dust used XRD equipment in accordance with the NIOSH method (NMAM 7500, 2003). **Results:** The results of the measurement of respirable dust in 39 respondents obtained a range of values of 0.019 - 0.0563 mg/m3 with an average of 0.19 mg/m3, while for c-silica dust, the results were at the range of 0.0020 - 0.3129 mg/m3 with an average of 0.07 mg/m3. The percentage of c-silica dust content in the ceramics industry in residential dust is different by 5 - 74.3% with the average of 34.89%. **Conclusion:** Evaluation of the results of measurement of respirable dust found that all samples were below the threshold value, while for c-silica dust, there were 27 samples with values above the threshold. On the average, there is 34.89% level of c-silica in respirable dust in the ceramic industry.

Keywords: ceramic industry, c-silica, respirable dust

ABSTRAK

Pendahuluan: *Paparan bahaya yang ada di lingkungan kerja pada industri keramik diantaranya debu silika dan suhu panas. Debu silika merupakan bahaya yang paling tinggi tingkat risikonya karena silika merupakan salah satu bagian dari bahan baku keramik yang dapat menyebabkan terjadinya silikosis.Untuk menganalisis debu respirabel dan debu c-silika, serta menghitung kandungan debu c-silika dalam debu respirabel. Selain itu juga dilakukan evaluasi hasil pengukuran debu tersebut dengan cara membandingkan dengan nilai ambang batas.* ***Metode:*** *Jenis penelitian ini merupakan penelitian deskriptif dengan melakukan pengujian sampel debu respirabel dan debu c-silika di lingkungan kerja. Penelitian dilakukan pada salah satu industri keramik di Jawa Timur. Pengambilan data dilakukan pada semua pekerja di bagian produksi yang berjumlah 39 orang. Metode pengukuran untuk analisis debu respirabel menggunakan metode gravimetri berdasarkan metode dari NIOSH (NMAM 0600, 1998) sedangkan untuk analisis debu c-silika menggunakan alat XRD sesuai dengan metode NIOSH (NMAM 7500, 2003).* ***Hasil:*** *Hasil pengukuran debu respirabel pada 39 responden didapatkan kisaran nilai 0,019 – 0,0563 mg/m3 dengan rata- rata 0,19 mg/m3, sedangkan untuk debu c-silika didapatkan hasil dengan kisaran 0,0020 – 0,3129 mg/m3 dengan rata-rata 0,07 mg/m3. Persentase kandungan debu c-silika pada industri keramik dalam debu respirabel berkisar antara 5 – 74,3 % dengan rata-rata 34,89 %.* ***Simpulan:*** *Evaluasi hasil pengukuran debu respirabel didapatkan semua sampel masih dibawah nilai ambang batas sedangkan untuk debu c-silika terdapat 27 sampel dengan nilai diatas ambang batas. Rata -rata terdapat 34,89 % kadar debu c-silika didalam debu respirabel pada industri keramik.*

Kata kunci: *c-silika, debu respirabel, industri keramik*

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INTRODUCTION

Exposure to hazards in the work environment in the ceramic industry includes silica dust and heat temperatures. Silica dust is the highest risk level because silica is one part of ceramic raw material that can cause silicosis. The heating process in the production process will cause changes in the fraction

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of silica including quartz, tridymite and cristobalite which are more dangerous (MNOSHA, 2012).

There are three main ingredients used to make classical ceramic products, namely clay, feldspar, and sand. Clays are not-so-pure aluminum silicate hydrates that are formed as a result of weathering from raw materials containing feldspar as one of the important native minerals for ceramic raw materials. The process that must be carried out to make a ceramic product are material processing, forming, drying, combustion and glazing.

Based on the raw materials and ceramics making process above, it can be seen that in the ceramic production process, dust is often found in the work environment. This is because the main raw material for ceramics is mashed clay and the process of making ceramics uses high temperatures aiming that the ceramics produced have high strength and are durable. High temperatures will make the clay powder become very dry so that the spread of dust in the work environment can occur.

The most common exposure to hazards in the ceramics industry includes silica dust, total dust and heat. Silica dust is the dominant danger in the ceramic industry because silica is a part of ceramic raw materials. In the process of heating in the production process, silica will change into other fractions of silica, including quartz, tridymite and cristobalite. Exposure to silica dust entering the respiratory air and entering the lungs has long been known to cause pneumoconiosis called silicosis. Occupational exposures to silica are associated with the development of silicosis, lung cancer, pulmonary tuberculosis, and airway diseases (Cauda et al., 2013). Silicosis usually occurs on workers who work in companies that produce stones for buildings, granite companies, coal mines, ceramic companies, tin mines, iron mines and in the sandblasting process. The incubation period for silicosis is 2-4 years depends on the amount of dust and free silica levels. The more free silica, the shorter the incubation period (Suma'mur, 2013).

Crystalline silica is one of the minerals most commonly found on earth, with extensive exposure in the work environment and ambient environment (ATSDR, 2017). Crystalline silica is also produced in a number of industrial processes such as gold, iron, tin, granite, sand, slate mining, metal casting, cement manufacturing, ceramics, and glass (Liao et al., 2015a). Exposure to silica dust which then enters the respiratory air and then the lungs has long been known to cause pneumoconiosis called silicosis (ATSDR, 2017). Some serious illnesses and increased mortality have occurred related to exposure to crystalline silica so that it becomes a priority in public health. Exposure to silica dust in the workplace and health effects for working communities are important issues for developed and developing countries. Some reports indicate that more than 23 million workers were exposed to crystalline silica in China and more than 10 million in India. An assessment of the level of risk performed on workers exposed to c-silica dust in the ceramic industry is 63.8% with an unsafe risk level (Sahri, et al ., 2019).

The National Institute for Occupational Safety and Health's Centers for Disease Control and Prevention said several epidemiological studies indicated that the current silica dust standard values are not sufficient to be used as guidelines to protect and prevent chronic silicosis. Epidemiological studies of workers in the United States Epidemiological studies carried out by Mazurek et al. (2017) with studies between 1999 - 2015 found that there were 55 people died at the age of 15-44 years due to suffering from pneumoconiosis due to silica dust exposure which was determined as a cause of death, while 38 (69%) suffered from pneumoconiosis due to exposure to silica dust. Pneumoconiosis case due to silica dust exposure occurs in several types of infrastructure and manufacturing industries.

Ministry of Manpower Republic Indonesia, 2018 concerning occupational safety and health in the work environment states that the threshold value for silica dust is set at 0.025 mg/m^3, while respirable dust is at 3 mg/m^3 (Kementrian Ketenagakerjaan, 2018). Considering the risk of exposure to silica dust is quite high so that the threshold value issued by the Ministry of Manpower becomes tighter, which was previously 0.05 mg/m^3 to 0.025 mg/m^3.

Silicosis is still a difficult disease to cure. Silicosis is progressive and there is no specific therapy to cure or change the course of silicosis even if the exposure is stopped. For this reason, an analysis of the risk of exposure to silica dust needs to be carried out as early as possible to determine the level of risk of silicosis in workers so that preventive measures can be immediately carried out effectively and efficiently.

Based on this background, the researcher wanted to know the respirable dust levels and c-silica dust levels as well as the percentage of c-silica dust content in respirable dust in the work environment in the production section of the ceramic industry.

This research can be used as a basis for analyzing the risk of c-silica dust exposure and to determine the appropriate control measures that can be taken to reduce the risk of health problems.

METHOD

The type of this research was a descriptive study by testing samples of respirable dust and c-silica dust in the work environment. The research location is one of the ceramics industries in East Java. Data collection was performed on all workers in the production section starting from processing raw materials to packaging, amounting to 39 people. The measurement method for respirable dust analysis used gravimetric method based on the method from NIOSH NMAM 0600 (National Institute for Occupational Health and Safety, 1998) while c-silica dust analysis used XRD tools in accordance with the NIOSH NMAM 7500 method (National Institute for Occupational Health and Safety, 2003).

Air samples were taken using an aluminum cyclone with a flow rate of 2.5 liters per minute. Air samples containing free silica would be adsorbed in a 37 mm diameter polyvinyl chloride filter. The aluminum cyclone is mounted on workers using a personal sampler connected to a flow meter and suction pump. PVC filters before and after use are weighed. Weather conditions, temperature, air pressure and humidity at the sampling location need to be observed. After the air sampling, the samples were prepared in the laboratory. The PVC filter was burned for 2 hours until it turned to ash. A 2-propanol solution was added to the ash until the total volume of the solution became 15 ml. The solution was stirred with an ultrasonic bath until there were no lumps in the solution. The solution was filtered into a 25 mm diameter silver membrane filter through a glass funnel with a vacuum. The mouthpiece was rinsed several times with 2-propanol until the maximum filtrate volume was 20 ml. The silver membrane filter was dried and placed on the sample holder to be measured by XRD.

Measurements with XRD were carried out on a horizontal axis of 2 theta angles ranging from 10o to 80o in the XRD software. The results of free silica concentrations were expressed in unit of percent (%) or unit of μg/m^3. The concentration of free silica (SiO2) was formulated as follows:

$$C = \frac{I_x \cdot f(t) - b}{m \cdot V} \quad (\mu g/m^3)$$

where:

V : the air volume sample

M : slope of the line from the calibration graph (counts/g)

b abscissa of the line from the calibration graph

Ix : intensity of the peak sample

f (t) : absorption correction factor

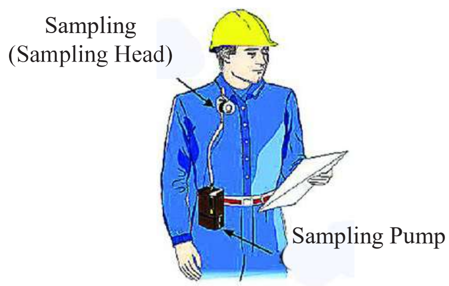
The analysis of respirable dust concentration was carried out using gravimetric method, namely weighing the weight of dust retained on the filter surface (the difference in filter weight after and before sampling). Filter blanks and sample filters were weighed using the same analytical scales so that the weight of the blank filter and filter samples were B2 (mg) and W2 (mg), respectively. The filter weight weighing data were further processed to obtain respirable dust concentration. The calculation steps were as follows:

Calculating the volume of air at the time of sampling

$$C = \frac{(W2-W1)-(B2-B1) \times 10^3 \text{ mg/m}^3}{V}$$

Sumber : https://www.sgsgalson.com/silica/

Figure 1. Personal dust sampler



Source: (Ji et al., 2016)

Figure 2. How to install personal dust sampler device on the worker

Where:

V: volume of air at the time of sampling (liters)

F: velocity of air flow at the time of sampling (liters / minute)

T: sampling time (minutes)

Calculating respirable dust concentration (mg / m3)

Where:

C: respirable dust concentration (mg / m3)

W1 : sample filter weight before sampling (mg)

W2 : sample filter weight after sampling (mg)

B1: weight of the blank filter before sampling (mg)

B2: weight of the blank filter after sampling (mg)

V: volume of air at the time of sampling (liters)

Table 1. The Results of Measurements of Respirable Dust Content and c-silica Dust in ceramic industry of PT. X Mojokerto 2018

Statistic Parameters	Value		
	Respirable Dust	c-silica Dust	% c- silica Dust
Mean	0.1906	0.0712	34.89
Median	0.1608	0.05	26.63
Standard deviation	0.1254	0.0704	20.6
Variance	0.016	0.005	424.87
Range	0.5457	0.3109	69.31
Min	0.0191	0.0020	5
Max	0.5639	0.3129	74.3

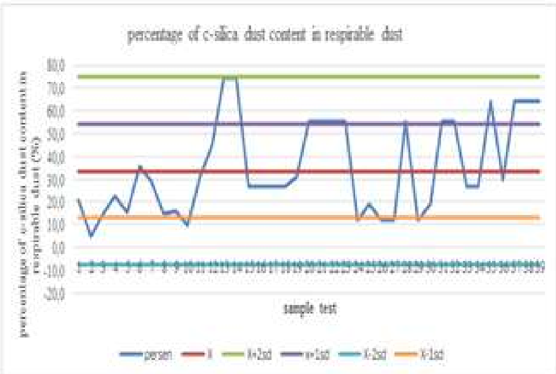


Figure 3. The Quality Control Chart Proportion of c-silica Dust Percentage in Respirable Dust.

RESULTS

The content of respirable dust in the work environment was measured using a personal dust sampler with the gravimetric method installed on each respondent with the aim to determine the level of respirable dust on each respondent. Based on the Regulation of Ministry of Manpower, number 5 of 2018 concerning occupational safety and health in the work environment, the threshold value for respirable dust is 3 mg/m^3.

The results of respirable dust test conducted on 39 respondents and comparing with the threshold value resulted that the measured dust level was still below the threshold value. The level of c-silica dust in the work environment where the respondent worked was measured using a personal dust sampler installed on each respondent with the aim to determine the exposure of c-silica dust from each respondent. After sampling, the sample in the form of a PVC type filter was analyzed for the c-silica concentration using XRD (x-ray diffraction). Based on the Regulation of the Ministry of Manpower, number 5 of 2018 concerning occupational safety and health in the work environment that the threshold value for c-silica total dust was 0.025 mg/m3. From the results of testing the total c-silica dust concentration conducted on 39 respondents and comparing with the threshold value, it can be seen that there were 27 respondents who were exposed to c-silica dust exceeding the threshold value.

Based on the analysis results of respirable dust testing and silica dust, it was known that the percentage of c-silica dust content in respirable dust was 34.89% on the average.

The measurement results of respirable dust, c-silica dust and the percentage of silica dust in respirable dust is in table 1.

The existing air temperature in the work environment was measured by using a heat stress monitor in the production section resulting to the average temperature of the environment with a range of 32.9 ^oC at the range of 31.3 - 36.6 ^oC and an average humidity level of 66.8%.

The distribution of the proportion of c-silica dust content in respirable dust can be seen on the quality control chart as shown in Figure 3. The Limitation ± 2 SD of the percentage of c-silica dust proportion in respirable dust was still in the upper and lower limits, which means that they were still in stable condition according to the measurement method.

DISCUSSION

According to Soeripto M (2008), dust is a solid particle emitted/produced by natural processes or mechanical processes such as splitting, grinding, blasting, cutting and destroying materials. In the effort to apply industrial hygiene, the first thing to understand is the production process within the company.

The production process of making ceramics starts from body preparation, pressing, biscuit firing, glaze preparation, glaze application, glost firing, sorting and packaging. The production process in the ceramic industry is a mechanical process that can form dust in the work environment. The production process is carried out in the same building and the conditions are closed so that the distribution of c-silica dust is evenly distributed throughout the room of the production building. The source of c-silica dust in the production section comes from raw materials in the form of clay and silica sand containing free silica which functions to form ceramics to make them harder and stronger. The process of heating (firing) in the production process to temperatures up to 1200 ^{o}C, will form another fraction of c-silica dust which is more reactive and more dangerous.

According to Suma'mur (2014), dust in the workplace can be assessed from the physical condition of the production process that is the use of raw materials that have the potential to cause dust into the workplace air so that it is necessary to measure and analyze both qualitatively and quantitatively to determine certainly the cause of pneumoconiosis. The effects of health problems due to exposure to particles as chemicals are caused by various factors, such as the physical properties of the particles, chemical properties, port of entry, and factors of the workers themselves. Factors of the workers themselves include age, habituation (adjustment), endurance (tolerance), and the degree of health of the body. The older the person, the more dust that enters and accumulates in the lungs as a result of daily inhalation of dust.

Ceramic industry is one of the industries that has dust potential because the basic material used is clay. Respiratory dust testing conducted on 39 samples obtained respirable dust concentration ranged from 0.019 to 0.056 mg/m^3 with an average of 0.19 mg/m^3. Based on (Kementrian Ketenagakerjaan, 2018), it was stated that the threshold value for respirable dust was 3 mg/m^3, so when compared to the results of respirable dust testing in this study the results of all respondents were below the required threshold value. Although the results of the evaluation of respirable dust were still below the threshold value, it did not mean that it was not risky, so it was necessary to further analyze the amount and type of dust that was in the respirable dust.

The raw material used in the ceramic industry is clay which contains a lot of free silica. In addition, in the production process of making ceramics, high temperatures are used, so that the most dominant dust is c-silica dust. Therefore, this study not only tested the respirable dust, but also the c-silica dust content, because c-silica dust is dust that can cause pneumoconiosis called silicosis. The c-silica dust level in 39 respondents obtained a range of 0.002 - 0.3129 mg/m^3 with an average of 0.0712 mg/m^3. The test results in this study found that 27 samples had exceeded the threshold value (NAB c-silica: 0.025 mg/m^3). In research Liao et al. (2015a), it showed that the concentration of c-silica dust in the working environment of the ceramic industry ranged from 0.0046 – 1.763 mg/m^3. The results of the study Chen et al. (2012a) showed that the concentration of silica dust that can be inhaled ranged from 0.12 - 0.3 mg/m3 in Chinese earthenware factories (ATSDR, 2017). The silica dust levels test in the ceramics industry showed the concentration of c-silica dust ranged from 0.007 - 0.4 mg/m^3 (Sahri, 2018). The range of c-silica dust test results in this study was within the range of studies conducted by other researchers in the ceramics industry. This show that the results of this study support previous research on the concentration of c-silica dust in the ceramic industry. The results of dust measurements in this study are included in the dust group that enters the respiratory tract which can cause health problems for workers if the workers do not wear masks that are appropriate to the size and type of dust.

Long-term exposure to silica dust is related to mortality rates for workers in China. The cause of death is not only due to respiratory disease and lung cancer but also due to cardiovascular disease (Chen et al., 2012b). To reduce the level of risk in workers exposed to c-silica dust in the ceramic industry, one way that can be done to reduce the level of risk is by controlling dust in the work environment to the limit of 0.012 mg/m^3. A study mentioned that by controlling c-silica dust at a maximum limit of 0.012 mg/m^3 with exposure to the next 25 years, most workers have a safe risk level based on the characteristics of workers who are the subject of research (Sahri, 2018).

Silicosis is one of the occupational lung diseases due to long-lasting exposure to silica dust which forms fibrotic tissue in the lungs and is irreversible. Hundreds of millions of workers worldwide are currently working in unsafe conditions and can cause health problems (Salawati, 2017). Research conducted by Anlar et al. (2018) has found an increase in DNA damage in peripheral lymphocytes and complete blood, MN frequencies in buccal epithelial cells and plasma 8-oxodG levels of ceramic workers. This is related to an increase in genotoxicity in workers in the ceramic industry.

The temperature used in the production process will also affect the convection and radiation of the temperature rise in the work environment. The working environment temperature ranges from 31.3 - 36.6^{o}C which makes c-silica dust drier and lighter so it is easily carried by the air flow in the workspace and can expand the spread of dust.

The concentration of c-silica dust in a working environment in a ceramic factory ranged from 0.0046 to 1.763 mg/m^3. Research conducted by Mohamed, El-Ansary and El-Aziz (2018) obtained results that silica dust measurements in the ceramic industry obtained an average of 0.51 mg/m3. The concentration of c-silica dust inhaled 8 hours daily ranged from 0.002 to 0.8 mg/m^3 in the British earthenware plant (Liao et al., 2015a). The concentration of silica dust that could be inhaled ranged from 0.12-0.3 mg/m^3 in Chinese earthenware factories. The measured c-silica dust content levels in this study were within the range of previous studies with the same type of industry (Chen et al., 2012b). Research conducted by Liao et al. (2015b) showed the results of silica dust measurements in the ceramic industry based on the work area obtained the highest results in the granulation section which is part of processing raw materials.

Silicosis was still found in workers who died due to exposure to silica dust between 0.05 - 0.1 mg/m^3. Thus, there are recommendations that the working environment exposure limits for inhaled c-silica (especially alpha-quartz) should be lowered from the current level. In 2000, ACGIH reduced its TLV for quartz from 100 to 50 μg/m^3. It was recommended (Chen et al., 2012a) that TLV should be reduced to 5 μg/m^3. If the risk of lifetime silicosis is below 1 in 1000 (the criteria used by OSHA) for a lifetime of exposure for 45 years, then the average Chinese total dust concentration must be lower than 0.14 mg/m^3 (or lower than 0.005 mg/m^3 of inhaled crystalline silica). Ceramic workers are likely to get synergistic effects from quartz dust and iron dust in their work environment because there is a significant increase in both levels after going through the combustion process (Moroni et al., 2014).

The results of the percentage analysis of the proportion of c-silica dust in respirable dust in this study ranged from 5 - 74.3% with an average of 34.89%. This happened because basically the main raw material for ceramics is clay which contains a lot of silica dust. In the ceramic industry, silica content of 0.22 - 33.04% was found. Research conducted by (Mohamed, El-Ansary and El-Aziz, 2018) showed the results of silica dust content analysis in respirable dust an average of 26.03%. Research conducted on the cement industry resulting the analysis of free silica with XRD showed that the concentration of free silica contained in respirable dust was between 0.67 and 92.92 μg/m^3 with an average value of 20.42 μg/m^3 while the percentage of free silica was between 0.63 and 17.81% with an average value of 4.38% (Suhariyono, 2015).

Based on a cohort study collected by Mannetje et al. (2002), in four groups namely diatomaceous earth workers, Vermont granite workers, sand industry workers in the U.S., and gold miners in South Dakota, among those workers were reported 170 deaths due to silicosis. The estimated risk of death from silicosis until the age of 65 years old after 45 years of exposure to 100 μg/m^3 of silica is 13 per 1000, while the risk of death at 50 μg/m3 is estimated to be 6 per 1000.

The higher body temperature (fever), the faster the frequency of breathing. In a hot environment, the body will experience an increase in metabolism to maintain a stable temperature so the body must sweat more in order to lower body temperature. This activity requires energy generated from the oxidation event using oxygen so that more oxygen will be needed by breathing faster. If the room temperature increases, the respiratory frequency will also be faster so that the dust entering the respiratory air is also more. Research that has been carried out related to the risk assessment of c-silica dust exposure in workers in the ceramic industry, stated that in the working period of more than 20 years the risk will increase if prevention is not carried out (Sahri, 2018).

Technical control can be done, among others by installing local ventilation on the biscuit molding machine, on the kiln or on a machine that has the potential to remove dust to be sucked and collected in the dust collector. Separation of the production process is also important to do to prevent contamination of other parts that should not be dusty by installing room dividers or isolating places or process units that have high dust levels. Wet process can also be done to minimize the spread of dust in the work environment.

Administrative control can be carried out by rotating workers in the production section whose work period is more than 20 years, especially in the processing of raw materials. Health checks as prevention efforts need to be done, including special health checks for workers in the production section by prioritizing routine lung anatomical and pulmonary examinations. For workers who are indicated by silicosis, other examinations should be done in addition to the radiological examination of the thorax, including tuberculosis and lung function checks.

Based on the previous research Sahri (2018), as an effort to prevent health problems due to silica dust exposure from the calculation results of the risk management strategy of the most possible safe and logical way to do is to reduce the concentration of risk agents in this case the concentration of c-silica dust in work environment up to the safe limit in accordance with the calculation of the risk management strategy. The safe limit for c-silica dust concentration was calculated from each worker and then the median or median value of the safe concentration was taken at 0.012 mg/m^3. Based on a simulation calculation of risk analysis for the next 30 years for c-silica dust exposure with a concentration of 0.012 mg/m^3, there will be an increased risk of unsafe after exposure for 25 years. At 30 years of exposure, it was found that 46.8% of respondents will be at risk of insecurity and control had to be taken immediately.

The use of personal protective equipment in accordance with the characteristics and types of risk agents in this case c-silica dust is needed. Personal protective equipment that can be used is a mask with the aim of reducing dust, especially those under 5 micrograms. Personal protective equipment is a last resort alternative if technical or administrative control is no longer possible. Types of masks that can be used to reduce dust entering the lungs include N-95, N-99 and N-100 masks, which means that the mask is able to filter harmful particles to efficiency greater or equal to 95%, 99% and 99, 97% of particles with a size of 0.3 microns and not resistant to particles containing oil.

In summary, the advice that can be given from the results of this study to prevent occupational diseases is as follows. First is choosing a more modern production machine so that the production process is more environmental- friendly. Second is isolating the raw material processing room so that dust does not enter the main production room and so that it is easy to control the source of dust. This is installing cover along the conveyor that transports the ceramics so that the dust left over the ceramic biscuits does not enter the work environment. Fourth is isolating and installing the local exhaust in the kiln which serves to heat the ceramic biscuits because in this heating process, c-silica dust will form another fraction that is more reactive and more dangerous due to heating.

Fifth is designing effective ventilation in accordance with the needs of the room aiming to reduce the temperature of the room so that workers feel comfortable in working because hot temperatures can accelerate the rate of respiration of workers so that more c-silica dust is inhaled.

Sixth is maintaining health by always paying attention to the nutritional status of employees so that the body's immune system is always maintained for example modification of the diet and pay attention to the number of calories that must be consumed so that the worker's weight remains ideal. Seventh is conducting periodic and special health checks on production workers in accordance with the types of hazards that exist in the workplace, in this case anatomical and pulmonary examination, kidney function and tuberculosis examination considering silicosis and tuberculosis have similarities radiological features of the thorax.

Health examination before work need to be done, especially pulmonary tuberculosis examination, chronic bronchitis, bronchial asthma, obstructive pulmonary disease so as not to place prospective workers to work in places that have the risk of danger of free silica dust. Before returning from work, the work clothes should be placed in the workplace and not brought home because to prevent contamination and protect family members from exposure to c-silica dust sticking to work clothes. Perform job rotations on workers who have a level of risk of insecurity and on employees who are found indications or symptoms of specific health effects associated with exposure to c-silica dust.

Periodic workplace monitoring is also needed to ensure that working environment conditions are still in accordance with the standard work environment guidelines used and also to evaluate work environment control programs. Education and training, promotion of occupational health and safety related to preventive and promotive efforts against occupational diseases caused by working environment conditions, especially in the production department such as training on the correct use of PPE and education about hazards that exist in the work environment and how to prevent them need to be carried out. Occupational health surveillance needs to be performed as well in the ceramics industry so that diseases caused by c-silica dust exposure can be detected early and make it easy to prevent and protect employees.

Workers need to always use a mask that suits the type of pollutant in this case is a special mask to reduce respirable dust containing silica with N-95 or N-100 type masks because the respirator is able to filter harmful particles up to 0.3 microns in size, particles that are the highest level of penetration or the most difficult to catch.

According to Mazurek et al. (2017), the main prevention in cases of pneumoconiosis due to silica dust exposure depends on eliminating or controlling priorities more effectively on the guidelines of niosh. An effective surveillance strategy can also be seen in Health Safety and Administration and the Centers for Disease Control and Prevention.

CONCLUSION

The results of respirable dust testing is conducted using a personal dust sampler on 39 samples obtaining test results of 0.019 - 0.0563 mg/m3, an average of 0.19 mg/m3. The results of c-silica dust testing conducted using personal dust sampler and analyzed using XRD on 39 samples obtains test results of 0.002 - 0.31 mg/m^3, with an average of 0.07 mg/m3. In respirable dust levels measured in the ceramic industry, there is a c-silica dust content at the range of 5 - 74.3% with an average of 34.89%.

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