HAZARD IDENTIFICATION OF WELDING IN CONFINED SPACE OF THE CEMENT PRODUCTION COMPANY

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ABSTRACT

Introduction: Maintenance of a electrostatic precipitator cooler machine involving welding activities in confined spaces, so the company of cement production need to understand the existing hazard by conducting hazard identification. Welding are related with physical, chemical, mechanical, and electrical hazards that can cause accidents and occupational illnesses. When the welding is carried out in confined spaces, it can increasing the hazards include chemical hazards in the air, configuration of the building structure, poor airflow, or any combination of existing hazards. **Methods:** This research aimed to conduct hazard identification on welding activities in confined spaces. The research design used a descriptive observational with cross sectional approach. The research population was the workers who repair the electrostatic precipitator cooler machines. Sample of this research were selected using the Purposive sampling method, 2 welders in the rapping bar and 1 safetyman. Primary data was collected by conducting observation and interviews using checklist sheet, secondary data was obtained by collecting company profile and daily safety reports. **Result:** The results of the analysis showed that the identified hazards of welding activities in confined space are 5 of mechanical hazards, 4 of atmospheric hazards, 5 of ergonomics hazards, 5 of falling hazards, 6 of physical hazards, 5 chemical hazards, and 4 electrical hazards. **Conclusion:** The conclusion of this research was the dominant potential hazard come from physical hazards consisting of inadequate light, welding sparks, optical radiation, noise, high pressure gas and hoses. Some hazards inflict accidents and illness due to work on welding in confined space are welding sparks, fume, oxygen and asitelyn gases, as well as toxic and carcinogenic substance i.e. cement and coal dust.

Keywords: confined space, hazard identification, welding

INTRODUCTION

Working in confined spaces almost exist in every industry where the underground areas such as pipelines, tunnels and sewers, while the other areas are storage tanks, silos, machines, and similar structures. Based on Occupational Safety and Health Administration of United State, confined space is sufficient work area for workers to enter and work in it, have limited access to entry, and it is not designed for routine work (Burlet-Vienney *et al.*, 2015). The work carried out by workers in confined space is maintenance of the machine if there is any damage or other problems.

Maintenance has important role to ensure the operation of the machine and the equipment used in the production process runs well because the machine can be damaged any time. Basically, maintenance is divided into two types of activities, preventive maintenance which carried out before the damage occurs and corrective maintenance which carried out after the damage is known. Preventive maintenance can be done by conducting inspections area whereas if damage has occurred then corrective maintenance needs to be done by means of machine repair. Machine repair always involves welding activities in the process of connecting metal materials (Wiryosumarto and Okumura, 2010).

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Welding activities are not only related to the work steps, but the operation of tools, maintenance of welding equipment, attitude of the workers, personal protective equipment, and environment. Based on the research conducted by (Ambarani and Tualeka, 2017), welding activities are always related to physical, chemical, mechanical, and electrical hazards that can cause accident if the workers and management neglect work safety. Maintenance activities that involve welding in confined spaces increase occupational safety and health risks so they require proper planning and supervision.

Confined space is one of the high risk workspace because it has hazards that can cause workers to be trapped in confined space due to chemical hazards content in the air, configuration of building structures, poor air flow, or combination of the existing hazards (Burlet-Vienney *et al.*, 2015). This is also supported by the National Institute for Occupational Safety and Health, the result of the survey and investigation of Fatality Assessment and Evaluation Control (FACE) in Confined Space stated that the hazards in confined space are specifically determined by the type of material stored in it, work processes that can be done, and environmental condition.

Based on Census of Fatal Occupational Injuries (CFOI) in 2015, total accident cases in confined spaces caused 136 workers to experience fatality (Bureau of Labor Statistics US Department of Labor, 2017). Research conducted at the Douglas N. Higgins, Inc. and McKenna Contracting, LLC fatality cases that occurred in confined space caused three workers died when entering a manhole containing hydrogen sulfide gas and carbon monoxide (Rekus, 2018). As the result of the accident in Douglas N. Higgins, Inc. and McKenna Contracting, LLC lost US $ 119.507 for not conducting hazard analysis in the workplace where there could be chemical hazards, hazardous gas detectors were not calibrated before use, did not have work permit in confined space, did not conduct training or tool box meetings for workers who will work in confined spaces, and don not provide emergency equipment.

Research conducted by (Wulandari, 2017) stated that there are six cases of work accidents in a month that occurred on welding process in confined space of PT DUMAS Tanjung Perak Shipyards Surabaya. The accidents resulted in a worker experienced burns on the hand and blister, two workers were hit by gram grains in the eye, a worker suffered from burns on the face, and two others got burn on the arm.

Every work done in a confined space has potential hazards that need to be understood by every company, especially for welding activities which is included in hot work. Therefore, the company must apply regulations by applying work permit, welder qualifications, hazards identification, procedures in case of emergencies; controlling poor air flow in confined space; and choosing a responsible supervisor (Burlet-Vienney *et al.*, 2015). Based on the standard of (ISO - The International Organization for Standardization, 2009) hazard identification become part of the risk assessment stage in risk management. In the process of hazard identification, there are several hazard determination techniques carried out by the company in the scope of its work and these can be assessed more detail in the ISO 31010 standard (International Organization for Standardization, 2009). Appropriate hazard identification instruments at the planning stage are important to increase awareness of hazards in the workplace, the possible failure of work equipment, and the level of likelihood of accidents which have an impact on work safety. The result of hazard identification serves as a consideration for companies in controlling hazards by applying appropriate occupational safety and health regulations.

PT X Tuban is a general contractor, supplier, mechanical, civil, engineering and maintenance company at PT Semen Indonesia Tuban which carries out routine contracts for the utility, routine and non-routine maintenance. PT X Tuban often gets non-routine maintenance project for machine repair which always involve welding activities. PT Semen Indonesia as the holding company always determined the target and working time for subcontractors project, so the aspects of the occupational safety and health are not given due attention. This is supported by work accident report related to welding at PT Semen Indonesia Tuban in 2013, there was one fatality case and seven workers suffered burns with 50% rate due to the explosion of asitelyn and oxygen cylinders gas used in welding of the hopper section, in 2014 there was one case of work accident due to damage of welding equipment which caused serious burn to welders, four accident cases in 2018 included one person was exposed to welding sparks in the eye, one person suffered burns in the arm, and two people exposed to sparks in the arm to the head.

Confined space of the rapping bar section has the highest risk of welding activities because the workers relate to the rapper system that moves when adjusting the plate in the right place, working in a narrow area, inadequate light, dusty environment, there are other workers at the top of the machine (*top box*) and the bottom of the machine (*hopper*) of electrostatic precipitator coller Pabrik Tuban IV. Based on data obtained after the pre-survey and work accident report, the purpose of this study was to identify hazards on welding activities in confined space using checklist instrument so the management can control the hazards with appropriate programs.

METHODS

This research was a qualitative research with the observational data collection. The data was collected with systematic recording by making observations to find interactions in the actual situation and there was no treatment on the objects. The hazard identification for welding activities in confined space used descriptive method which describes a situation objectively and it was presented in the form of a narrative observation and assessment. Observations were made at the rapping bar electrostatic precipitator cooler Tuban IV, PT Semen Indonesia Tuban. The observations were carried out at April 20th-27th 2019. Since the observations took place in a certain time period, it used cross sectional method.

Informant of the research were welders in the rapping bar section and safetyman PT X Tuban in non-routine maintenance activities of electrostatic precipitator cooler Tuban IV PT Semen Indonesia Tuban. This study used a purposive sampling method with the principle of appropriateness and adequacy to obtain two welders and a safetyman as an informant.

Primary data collection techniques based on interviews and observation of welding activities was checklist sheets that have been adapted to welding SOP in confined space. The checklist instrument contained a description of general information about confined space, the structure of buildings, the work environment, the welding equipment used, and the characteristics of welders. Secondary data was collected in the form of company profiles, SOP for welding activities in confined spaces, daily safety report and other data that support the research. The result of the interviews and observations were then presented in the form of hazard identification tables of confined space and welding activities. Data analysis was presented in the form of narratives about the causes and consequences of accident and occupational

diseases that can be used as conclusions and suggestions for appropriate control.

This study passed the ethical test from the Faculty of Dentistry Universitas Airlangga with a certificate number 142/HRECC.FODM/IV/2019.

RESULT

Description of Welding Activities in Confined Space

Non-routine maintenance of machine by PT X Tuban carries out with a contract system of project electrostatic precipitator cooler repair for 8 days. There are several engine components that must be replaced and repaired which involve welding activities in the process of connecting iron and plates. PT X Tuban's workers on project contracts consists of 16 casual daily laborers. The workers are divided into three groups including the top box, rapping bar and hopper section. Each section consisted of 2 welder who already have a welder certification. These parts were connected to each other in a multi-room inside the electrostatic precipitator cooler. Based on the hazards of welding in the confined space, each part has the same risk. However, when it is viewed from the configuration of the building, the rapping bar section has the highest potential hazards because it is located at a height, directly connect to the moving machinery, and among the welding activities at the top box and hopper.

Welding activities is one of the techniques of joining two or more metals by heating until the part of metal is melted and fused in a cold state. The activities related to the welding process are cutting plate/ iron, grinding, and tearing with slag hammer (Wiryosumarto and Okumura, 2010). PT X Tuban using SMAW (Shield Metal Arc welding) techniques that use electric current to form a current arc and use webbed electrodes. Welding equipment which commonly used in the SMAW process are a traformator, welding cable, slag hammer, electrode arc clamp, and electrode arc. Electrostatic precipitator cooler is a dust collector tool (ash collection) from the combustion of coal and cement that uses an electric field to separate ash from air. The electrostatic precipitator cooler is completely shut down after getting a repair work permit.

PT X Tuban management system in the project has a good communication flow because it is supported by a clear organizational structure. The principle of occupational safety and health applied by PT X Tuban is to identify and mange risks before work is carried out, periodically evaluate the level of workers compliance in accordance with applicable regulations, applying 5S in the workplace, provide understanding and direction regarding safety and hazards in the workplace, conducting supervision, and increasing the worker's concern for occupational safety and health.

Result of Hazard Identification on Welding Activities in Confined Space

Hazard identification instruments are adapted from five main categories of Ishikawa analytical techniques which is machinery, materials, environment, methods, and human resources. The categories are adjusted to the SOP so that it becomes a description of general information about confined space, the structure of the buildings, work environment, work done in confined space (material and method), and worker characteristics (unsafe behavior).

Identification is done to look for potential hazards, the possibility of workplace accidents, as well as occupational diseases that will occur. Hazards of the welding activities in confined space are divided into eight types namely physical hazards, electrical hazards, chemical hazards, falling hazards, biological hazards, mechanical hazards, atmospheric hazards, and ergonomic hazards.

Table 1. Hazard Identification result Based on *Checklist Sheets*

Category	Types of Hazards	Potential Hazard
General Information and Configuration Structure of Confined Space Building		
Stationary confined space	Mechanical	Hit the machine iron/ plate when working
Confined space totally closed	Atmospheric	Engulfment with toxic and carcinogenic gases, lack of oxygen
The entrance dimensions is < 610 mm	Ergonomic	Work posture
	Falling	Fall from height and slippery floor surface
Entrance partially vertical then horizontal	Falling	Fall from height and slippery floor surface
Limited interior air volume	Atmospheric	Engulfment with toxic and carcinogenic gases, lack of oxygen
Hard to move around	Mechanical	Hit the machine iron/ plate when working
Perforated floor surface	Falling	Perforated and slippery floor surface
Inadequate light	Physical	Inadequate light/ visibility
Presence of toxic agents, asphyxiation substance	Chemical	Inhalation of toxic substances, carcinogenic, asphyxiation of cement dust and coal
Presence of flammable products	Chemical	The existence of explosive/ burning material
Presence of corrosive, irritants, and carcinogenic substance	Chemical	Inhalation of toxic substances, carcinogenic, asphyxiation of cement dust and coal
Presence of sediments, residues, etc.	Chemical	The existence of explosive/ burning materials
Equipment must be secured is moving machine	Mechanical	Hit the machine iron/ plate when working
Equipment must be secured is moving machine electrical	Electrical	Electrical flow from machine that have not been totally extinguished
Presence free-flowing materials is cement dust and coal	Chemical	The existence of explosive/ burning material and Inhalation of toxic substances, carcinogenic, asphyxiation cement dust and coal
Work Environment		
Technically difficult to access	Falling	Fall from height, Perforated and slippery floor

(e.g. at height, on unstable ground)		surface
Exposed to other workers	Chemical	The existence of explosive/ burning material and Inhalation of toxic substances, carcinogenic, asphyxiation of fume
	Mechanical	Falling object, Hit the machine iron/ plate when working, hit by the hammer, exposed to remaining electrodes
	Physical	Exposed to sparks, welding light, radiation, noise, high pressure tubes and hoses
	Electrical	Electrical flow from flaky hoses, welding protectors are broken, excessive current sources of electrical power
Presence of moving machine	Mechanical	Inadequate light/ visibility
Inadequate light	Physical	
	Falling	Fall from height, Perforated and slippery floor surface, Falling object
Welding (hot work) have an impact on confined space	Chemical	The existence of explosive/ burning material and Inhalation of toxic substances, carcinogenic, asphyxiation of fume
	Mechanical	Hit the machine iron/ plate when working, hammer slag hit, Falling object, exposed to remaining plate
	Physical	Exposed to sparks, welding light, radiation, noise, high pressure tubes and hoses
	Electrical	Electrical flow from flaky hoses,
Category	**Types of Hazards**	**Potential Hazard**
	Electrical	welding protectors are broken, excessive current sources of electrical power
Adjacent to hazardous materials	Chemical	The existence of explosive/ burning material
Changeable condition of air flow	Chemical	The existence of explosive/ burning material and Inhalation of toxic substances, carcinogenic, asphyxiation
Welding Activities in Confined Space		
Entrance to the working space partially vertical then horizontal	Falling	Fall from height, Perforated and slippery floor surface
High-pressure cleaning	Atmospheric	Engulfment with toxic and carcinogenic gases, lack of oxygen

	Physical	High pressure tubes and hoses
Hot work (welding)	Physical	Exposed to sparks, welding light, radiation, noise, high pressure tubes and hoses
	Chemical	The existence of explosive/ burning material and Inhalation of toxic substances, carcinogenic, asphyxiation of fume
	Electrical	Electrical flow from flaky hoses, welding protectors are broken, excessive current sources of electrical power
Working at height	Falling	Fall from height, Perforated and slippery floor surface
Use specific tool (welding equipment)	Mechanical	Hit the machine iron/ plate when working, hammer slag hit, Falling object, exposed to remaining plate
	Physical	Exposed to sparks, welding light, radiation, noise, high pressure tubes and hoses
	Electrical	Electrical flow from flaky hoses, welding protectors are broken, excessive current sources of electrical power
Setting up temporary lighting	Physical	Inadequate light/ visibility, radiation
Use a generator (traformator)	Electrical	Electrical flow from flaky hoses, welding protectors are broken, excessive current sources of electrical power
Use of chemicals (electrode arc, *oxy-asitelyn gases*)	Chemical	The existence of explosive/ burning material and Inhalation of toxic substances, carcinogenic, asphyxiation of fume
Category	**Types of Hazards**	**Potential Hazard**
Release of particles, dust, etc.	Chemical	Inhalation of toxic substances, carcinogenic, asphyxiation of cement dust and coal
Work under load, load at height, etc.	Ergonomic	Physical exertion and work posture
Handling of heavy object	Ergonomic	Physical exertion and work posture
Discretion of using PPE	Ergonomic	Physical exertion and work posture

The identification of hazards on welding activities in confined space were using checklist sheet which consist of seven types of hazards, namely mechanical hazards, atmospheric hazards, ergonomic hazards, falling hazards, physical hazards, chemical hazards, and electrical hazards. Each answer of the checklist describes the potential hazards that may exist in confined space and welding activities.

The Most dominant potential hazards on welding activities in confined space were physical hazards and chemical hazards. There are 6 potential physical hazards such

as inadequate light, sparks, visible light, noise, high pressure tubes and hoses. Meanwhile, the potential chemical hazards are identified such as inhalation of toxic substance, carcinogenic, asphyxiation, explosive/ flammable materials, and oxidizing agents.

The types of hazards that got least attention from the companies and workers were ergonomic hazards. There are 5 potential ergonomic hazards which are work posture, awkward position of entering the room, repetitive movements, physical exertion, and lack of using PPE. In addition, psychology of the workers while working is also included in ergonomic hazards.

Types of hazards associated with welding equipment are mechanical hazards, falling hazards, and physical hazards. There are 5 potential mechanical hazards such as hit the iron/ plate when working, falling object, hit the slag hammer, and exposed to sharp plates/ remains electrodes. Falling hazards have 5 potential hazards include falling at height, slippery floor surfaces, perforated floor surfaces, and falling object. Meanwhile, electrical have 4 potential hazards namely electrical flow from electrostatic precipitator machine, electrical flow from cables, protective welding wear, and excessive sources of electrical current power.

Potential atmospheric hazards consist of 4 hazards including engulfment of toxic gases, carcinogenic substances, oxidizing gases, and oxygen deprivation. Atmospheric hazard is a type of hazards that only exists in confined spaces.

The potential hazards identified in the structural configuration of the building without any welding activities are 7 types of hazards with 15 potential hazards. In a work environment where there is welding work in a confined space there are 5 types of hazards with 21 potential hazards. Welding activities and other work in confined space also the characteristics of workers have 7 types of hazards with 27 potential hazards. The results of hazards identification are presented in Table 1.

DISCUSSION

Hazard identification is one of the stages in occupational safety and health risk management based on ISO 31000. In the planning stage the company identifies hazards to recognize potential hazards in the work environment and establishes its characteristics so that they can be used as the development and implementation of safe operating procedures (Ramli, 2013). Identification of potential hazards related to general information on confined space, configuration structure of building, limited work environment, welding activities include equipment, materials, procedures, worker attitudes, etc.

Hazard Potential Analysis of General Information on Confined Space and Building Configuration Structures

The results of the identification of potential hazards in confined space based on building configuration structures without any work are categorized according to the types of hazards that can cause work accident or occupational diseases. Each potential hazard was further being analyzed in the aspects of the sources, risk, consequences, and attitudes of workers in order to recognize the hazards and exercise appropriate controls.

Potential mechanical hazards which occur in confined space is workers at risk of being hit by iron/ plates and pinched plates due to limited space and the presence of moving machinery. It may cause bruising and tearing to workers body. The mechanical hazards are in accordance with research of (Wulandari, 2017) in welding activities at PT Dumas Tanjung Perak

Shipyard which stated that the hazards of hit work materials can cause bruising to workers including moderate hazards that need to be considered by workers.

Atmospheric hazards consist of engulfment of poisonous gas/ toxic gas and lack of oxygen caused by confined space totally closed and the limited volume of the air. Lack of oxygen in confined space can occur if the oxygen concentration in the air is below 19.5% or exceeds 23.5%, workers may experience difficulty breathing or oxygen poisoning (Pengawasan, Keselamatan and Kerja, 2006). Workers are at risk of decreased concentration until they lose consciousness with symptoms of headache/ dizziness and heat stress.

Ergonomic hazards occur when entering the confined space in an awkward position. Since the door size is less than 610 mm, workers have to bend and squat. Squatting can cause occlusion or blockage of blood flow due to pressure on the knee and can cause leg muscle tension (Soedirman and Prawirakusumah, 2014). The risk of sprained and falling when entering confined spaces can cause injury to fractures. One of the unsafe behaviors of workers is to enter confined space by carrying work equipment made a highest risk of dislocation joints and falling.

Falling hazards occur because of the door's location is 100 cm higher than the surface of the floor and perforated floor surface has the risk of falling from height, tripping on a plate, and slipping. If workers don not wear PPE such as safety shoes and improper footrests, it can cause them to bruises, and fracture bones when slipping or falling. This is accordance with research conducted by Bakhtiar in 2013 which found that workers often fall due to descending vertical stairs, handrails are not tight and slippery, the shoes slip when stepping on (Bakhtiar, 2013).

Physical hazards in confined space that have the greatest risk are inadequate natural lighting. The natural lighting that comes in only slightly through the entrance. The presence of dust in the workspace reduces the intensity of natural lighting in confined space. Limited lighting of work floors and around of work space makes the worker's excessive focus so workers feel tired eyes to headaches. Research at PT PERTAMINA Persero in the overhauling the tank found that the lighting around the work area of the confined space was lacking or non-existent. So, it cause workers collision by plates (Ambarani and Tualeka, 2017).

Chemical hazards inhalation of toxic substances, exposed to carcinogenic materials, exposed to the dominant asphyxiation material in confined space such as cement dust and coal. Coal dust is a flammable material when it is in a high enough concentration and exposed to heat. Chemical substance entered the worker's body at high concentration, long-term exposure, and unsafe worker's behavior can cause respiration irritation (pneumoconiosis). Workers wearing masks that do not adequately protect them from dusting of cement dust and coal, so the danger of chemical substance entering the body is even greater. Research conducted by Dhi'fansyah in 2016 at PT Semen Indonesia the risk of accumulation of dust inhaled by workers is not immediately felt but in the long-term condition can cause several diseases such as lung cancer, tuberculosis, and asthma (Dhi'fansyah, 2017).

Electrical hazards in the electrostatic precipitator cooler are the main engine must be extinguished completely because this machine has a main power of electrical. The risk of being stung by electrical hazards can result burns to death. The company (PT Semen Indonesia Tuban) has implemented the LOTO system to prevent the engine

from being started without supervision. Based on Saputra's research in 2015 at PT PetroChemical Gresik the LOTO program on work machines was implemented to control energy, use lockout devices to lock the machine when repairs, use tag outs as a lockout complement, ensure LOTO was carried out thoroughly in accordance with standards, carry out documentation, implementing occupational safety and health policies in the presence of LOTO procedures, and effective training (Saputra, 2019).

Analysis of Potential Hazards in the Work Environment in Confined Space with Work Contained Within

The work environment in a confined space that has welding activities inside has potential hazards that need to be considered by workers and companies. The falling hazards is caused by work at height, access to narrow stairs, slippery and perforated floor surfaces, limited room lighting, risk of slippery, tripping of plates/ falling object, and falling at height. Uncontrolled hazards can result in workers experiencing torn wounds, fractures, bruises, until death. Research conducted by Wiranto at PT Indonesia Power stated that falling from height more than 2 meters is a high risk hazards and the greatest potential hazards because it can cause fractures to death (Winiarto and Mariawati, 2013).

Other work in confined spaces includes welding and oxy-cutting which has an impact on the environment, including chemical hazards due to explosive/ flammable materials, oxidizing agents such as oxygen gas, asphyxiation agent and carcinogenic materials such as electrode welding fumes and oxy-cutting fumes. The presence of hot work in confined space can trigger explosions of fires due to heat and reactions with flammable liquids, gases, vapors or dust that have concentrations exceeding 10% of BRDM (Pengawasan, Keselamatan and Kerja, 2006). Measurement and examination of dust or gas levels in confined space has not been carried out. The most dangerous aspect of welding activities is welding fume because it contains a complex mixture of metal oxides, silicates, fluorides, and chromium (Popov, 2017). Welding electrode fumes and oxy-cutting fumes inhaled by welder can cause metal fume fever, in the long run accumulation of the fumes containing beryllium, cadmium oxide, chromium, fluoride, iron oxide, manganese, CO_2 gases, etc. can effect on body cell that trigger the growth of cancer cells and Parkinson's syndrome. CO_2 gases in excess of 700 ppm NAV can cause increased respiratory rate, fatigue, drowsiness, headaches, seizures, dyspnea, sweating, and anesthetic effects. Desy Riesa's studied results at PT PAL Indonesia Persero stated that there were 3 workers who experienced pulmonary function disorders with the category of mild obstruction and restrictions caused by exposure to welding fumes (Desy and Sulistyorini, 2008). If the fumes enter the worker's eyes can cause pain such as sparks.

Asphyxiation materials such as cement dust and coal inhaled by workers who are working in confined space can cause shortness of breath to irritation of the respiratory tract (pneumokoniosis). As a study conducted by Desy at PT PAL Indonesia that there is a worker who has pulmonary function disorders due to dust levels at the work site of 10.9 mg/m^3 (Desy and Sulistyorini, 2008).

Mechanical hazards in welding and oxy-cutting are pieces of plate can fall and affect the body parts of workers, the danger of being squeezed plate to be connected, hit by slag hammer, exposed to pieces of sharp plate/ remains electrode. Mechanical hazards can consequence in bruising, tearing, and fractures. Research conducted

by Thursina at PT Bangun Sarana Baja Gresik, there were 2 workers who had an occupational accident and suffered a fracture due to the iron cutting process (Thursina, 2018).

Physical hazards in confined space are limited work floor lighting and work space. Physical hazards increase due to welding activities including welding/ torch sparks, welding/ torch light, noise, high pressure tubes and hoses. Welding sparks have an average temperature of 1200^0C to 1600^0C so that that if exposed to flammable materials can cause a flame (Sukaini, 2013). Artificial lighting for welding is not allowed to be too bright because it can irritate the eye. Based on (Wiryosumarto and Okumura, 2010) lighting voltage for welding activities maximum 12 Volt. Excessive lighting from lamps and the presence of welding light/ torch can result in tired eyes, welding eyes, and irritation. This is supported by research (Ambarani and Tualeka, 2017) that exposure to welding light and sparks can cause welders to experience eye irritation so that welders feel pain in the eyes after exposure to welding light, besides sparks causing burns.

Noise on welding and oxy-cutting activities has the potential to interfere with communication between welders and other workers. This is supported by research (Dhi'fansyah, 2017) that noise such as hammer banging, welding process, and grinding in cement companies can cause hearing loss. High pressure tubes and hoses come from oxygen cylinders and must be provided with safety in the form of valves and tubes tied so as not to fall easily when used. Tubes that leak and come into contact with heat/ fire can cause explosion and flame (Rinjanto, 2011).

Electrical hazards are derived from the flow of flaky welding electrical wires, large flow of excessive traformator, wear welding arc insulators. Welding cables that are chipped due to frequent trampling by welders. This is supported research by (Bakhtiar, 2013) at PT Dok and Shipping Surabaya that the cable insulator is peeled off causing workers to be stung by electrical.

The welding traformator is set at a starting electrical voltage of 120 to 220 volts adjusted to the electrode used, after that the electrical arc setting with a voltage of less than 45 volts. In addition, welders need to regularly replace electrodes not less than 6 cm so that the arc welding insulator does not wear out easily (Wiryosumarto and Okumura, 2010). If it is not according to welding procedures, workers are at risk of being stung by electrical and fire which can cause burns to death.

Analysis of Potential Hazards on Welding Activities in Confined Spaces

Identification of potential hazards in equipment, materials used, and specifications of welding activities in confined space have been partially identified in the question of the work environment in confined spaces, namely chemical, mechanical, physical, and electrical hazards.

Another physical hazards on welding activities carried out in electrostatic precipitator machines are the process of dust removal and the remaining welding material that adheres to the plate using high pressure gas from the blower. The gas pressure on the blower is well regulated and there is no leakage in the hose. Workers need to pay attention to the position of the hose so as not to get caught, bent, or twisted because it can made explosion due to gas pressing on the blocked point.

Falling hazards because the welding location is at a height, the access condition from the entrance has a perforated floor surface, slippery floor surface, and scattered equipment. The welding activity in the rapping bar scafolding has been installed so

that the welders can safely welding the underside of the machine. Equipment in the work area such as welding cables and other welding equipment in the entrance can risk of slipping and falling, and further cause bruising, tearing, and death. Research conducted by Bakhtiar at PT Dok and Shipping Surabaya stated that the danger of materials scattered in the work area allows accident (Bakhtiar, 2013).

Atmospheric hazards include the presence of asphyxiation gases, toxic and carcinogenic dust. Welders in confined space risk being exposed to dust and welding residue while cleaning the room. Dust entering the respiratory lines of welders can increase the risk of breathing problems in workers. Workers who work with exposure of dust above NAV have a 14 times greater risk of experiencing pulmonary physiology (Triatmo, Adi and D., 2006).

Ergonomic hazards of welding include awkward positions, repetitive movements, and excessive reach/ physical exertion. This potential ergonomic danger creates discomfort for workers to use PPE, especially work helmet. Ergonomic hazards of welding in confined space cause complaints MSDs to workers. Cumulative trauma disorder in the form of injuries to nerves, muscles, tendons, ligaments, bones and joints in the upper body, lower body, and spine that includes the back and neck are the risk of ergonomic hazardz. Carpal tunnel syndrome in the form of pain, numbness, and tingling caused by repetitive movements and vibrations in work equipment (Soedirman and Prawirakusumah, 2014). Ergonomic hazards affect the psychological condition of workers, namely fatigue.

CONCLUSION

The conclusion of this research is the dominant potential hazard come from physical hazards consisting of inadequate light, welding sparks, optical radiation, noise, high pressure gas and hoses. Some hazards inflict accidents and illness due to work on welding in confined space of the cement production company are welding sparks, fume, oxygen and asitelyn gases, as well as toxic and carcinogenic substance such as cement and coal dust. Thus, some hazards that have been identified on welding activities in confined space of the cement company need to be controlled to prevent and reduce the number of accidents and occupational diseases.

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