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SPRAY PAINT ACTIVITY RELATED WITH VOLATILE ORGANIC COMPOUNDS (VOCS) : A LITERATURE REVIEW

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SPRAY PAINT ACTIVITY RELATED WITH VOLATILE ORGANIC COMPOUNDS (VOCs); A LITERATURE REVIEW

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Abstract

Currently, industrial workers are exposed to contaminants and affect on occupational health at workplace. Spray painting activity is related with inhalation of volatile Organic Compounds (VOCs) exposure. This paper highlight issues from the review of every angle of painting activities and the relationship to VOCs. Painting activity can be divided into three (3) elements. This includes the effect of painting activity, assessments and managing. Furthermore, worker exposure, effect and control of VOCs and a need of ventilation system will be discussed. The spray-painting activity is significantly related to VOCs exposure and will lead to occupational health diseases and sufficient ventilation systems should be applied.

Keywords:—Volatile Organic Compounds, Occupational Safety and Health, Spray Paint Activity, Ventilation, Green Technology.

1. INTRODUCTION

Industrial ventilation is a system of controlling airborne toxic chemicals or flammable vapors by exhausting contaminated air away from the work area and replacing it with clean air. It is one of the alternatives to control employee exposure to air contaminants in the workplace. On the other hands, the employers ensure workers' safety, health and welfare by protecting workers from exposing themselves to any risk of accident.

The objective of a Local Exhaust Ventilation (LEV) system is to remove the contaminant as it is generated at a source. Controlling the air in which they are contained controls gases and vapors. Special procedures are required to control large particles that are generated at the source. These particles are controlled for reducing exposure to workers related with health purposes.

In United Kingdom, there is an issue in Occupational Safety and Health (OSH), whereby occupational asthma materializes due to exposure to isocyanate. Workers working as a vehicle paint sprayers in motor vehicle repair (MVR), body shops and in the commercial vehicle and trailer manufacturing industry the most affected. The risk is over 80 times greater than the industrial average [1].

This paper will investigate painting activities and the Volatile Organic Compounds (VOCs) and their relations due to health impact to the workers.

Three main aspects of LEV is highlighted as follows:

A. Interpretation of LEV

Controlling the air in which they are contained controls gases and vapors. The initial opening through which contaminated air enters a local exhaust system is called the hood. The term hood is used generically for any opening, whether it is specifically designed or consists of

simply the open end of a round or rectangular duct system. Hoods are specifically designed and located to meet the requirements of the operation and the contaminant being generated.

After the contaminated air has entered the hood, it flows through a duct system that directs the flow of contaminated air and prevents mixing of this air with the workshop atmosphere. Branches may exist within the duct to join separate local systems into one single exhaust system. The third component of a local exhaust system is a method for cleaning the air. It is often necessary to remove the contaminant from the air before exhausting the air into the atmosphere to prevent hazardous materials from entering the breathing zone of individuals in the community surrounding [2].



Figure 1: Illustration Local Exhaust Ventilation [2]

B. Importance of LEV

Change to clean air to the workers who are exposed to contaminants such as air borne toxic chemicals or flammable vapor can control the exposure by controlling the ventilation. Hazard control method is to eliminate the toxic contaminant is the best solution. Commonly used in the industrial ventilation to remove contaminant from workplace where exposed [3].

A qualified ventilation engineer or firms specializing in this field should handle the design and troubleshooting of industrial ventilation systems. A Guideline

Spray paint activity workers are affected while working in the Rhode Island automotive refinishing industry sector and found that nearly one-half of the spray painters double as body repair technicians thereby increasing their potential exposure to workplace contaminants. Endander et al [5] conduct a survey of pollution prevention, environmental control, and occupational health and safety practices found that nearly all of the shops reported that they use spray-painting booths, only 38 % own booths of the more effective down-draft design. Finally they suggest better methods of risk communication; a professional licensing requirement, that solvent exposures are reduced with Spray Painters in Automotive Body which Repair Workshop. Workplace assessment and airborne sampling component of the study done by Winder & Turner [7]. The methods are, interviewed 50 apprentices and 14 experienced spray painter at breathing-zone samples. They found that solvent exposure was highest when spraying acrylic paint in the open workshop and lowest when spraying two pack paint in a spray booth. Thus, risk control such as providing Personal Protective Equipment and Material Safety Data Sheet not available at workplace.

Meanwhile other studies in Australia conducted found that solvent exposures are reduced with Spray Painters in Automotive Body which Repair Workshop. Workplace assessment and airborne sampling component of the study done by Winder & Turner [7]. The methods are, interviewed 50 apprentices and 14 experienced spray painter at breathing-zone samples. They found that solvent exposure was highest when spraying acrylic paint in the open workshop and lowest when spraying two pack paint in a spray booth. Thus, risk control such as providing Personal Protective Equipment and Material Safety Data Sheet not available at workplace. Other chemical emission from spray both is benzene. Health effects exposed are drowsiness, dizziness, and unconsciousness. Liu, et al., [8] conducted a review online and manual searching, as well as expert discussions aimed at providing insight into factors affecting benzene exposure levels in paint/coatings industries from 1956 to 2005 and found mean benzene exposure was significantly lower for paint manufacturing than paint spraying. No significant difference was found among paint types and benzene exposure for paint application. Benzene exposure was significantly higher in workplaces judged to have poor ventilation. No significant differences were found in benzene exposure as a function of industry type and recent benzene exposure measurements suggested. Exposures to latest concentrations are proposed to measure and compare with previous study.

B. Assessment of painting activity

While exposure to the hazards, precaution should be considered in order to protecting continuous exposure to the worker. A box model, for example contaminant concentrations is based on the mass rate of change of compounds used during the industrial process and the results of the dilution of air was occurring due to a high channeling of air was in the painting area. It refers to basic ventilation rate in the painting area. It refers to basic equation in mass balance to develop the model such as below:

$$C_{eq} = \frac{G}{Q} \quad (1)$$

recommended by American Conference of Governmental Industrial Hygienists (ACGIH) provided information in a guideline can be influenced by other factors in an industrial environment (material handling techniques, cross-drafts and replacement air, work practices and housekeeping) [2].

C. Requirement of LEV compliances

Compliance to the regulation is an approach to reduce and maintain the exposure level of employees to chemicals hazard to health. The requirements are to the lowest practicable level or below permissible exposure limits.

Engineering Control Equipment (Regulations 2) means any equipment, which is used to control exposure of employees to chemicals hazard to health, includes local exhaust ventilation equipment, water spray or any other airborne chemical removal and containment equipment. The equipment shall be maintained and operated at all times while any machinery or plant is in operation, and for such time. (Regulation 17)[1].

Design, construction and commissioning of local exhaust ventilation equipment. Regulation 18: any local exhaust ventilation equipment installed shall be designed according to an approved standard by a registered professional engineer and constructed according to the design specifications; and tested by a registered professional engineer after construction and installation to demonstrate that the equipment meets the design specifications [4].

This subsection requires the designers (engineers) to ensure that a plant for use at work is designed and constructed to be safe and without risk to safety and health. Hence, properly used means that the designer must have been given instructions, employers as well as employees must follow the instructions. The designers are required to carry out testing and examination of the plan and running test before the employees use it. As designers have a duty to carry out the necessary research to discover and eliminate or minimize any risk to safety or health that there design or plant might cause. [5]

II. INDUSTRIAL PAINTING ACTIVITY

Spray painting activities are commonly used either in automation or manually. Currently it becomes an issue to the workers involved in these activities. Most of industry involved in car manufacturing and repair activities. Although painting is also used in other activities such as wood based, metals and others. This activity will affect the workers exposed on long term.

A. Effect of painting activity

Workers mostly involved in spray paint will be exposed to inhaling the chemical in term of mist. Studies show that workers who involved in this activity and exposed to chemical directly which affect occupational health. Lately, until 2010 study related with spray paint and effect to health,

$$C_{eq} = \frac{G_1}{Q} \quad (2)$$

Where:
 C_{eq} = Concentration of gas or vapor in ppm.
 G = Rate of generation.
 Q = Effective Volumetric flow rate.

Mass balance box model can be useful for estimating emissions scattered. Flynn et. al. [10] presents a mathematical model to predict a breathing zone concentrations of airborne contaminants generated during compressed air spray painting in cross-flow-ventilated booths in his study and the result indicates that a dimensionless breathing zone concentration is a nonlinear function of the ratio of momentum flux of air from the spray gun to the momentum flux of air passing through the projected area of the workers body. In his recommendation, further research into the overspray generation mechanism is needed as well, particularly information on the spatial distribution of droplet sizes and velocities. Therefore, a study to assessment in spray paint activity can carry out from many angles and the focus is to reduce any hazardous chemicals from the chemical will affect workers' health.

C. Managing painting activity

Benzene emission from spray paint activity is difficult to remove from a site 100 %. A study by Jafari et. al. [11] in Iran, was conducted, investigation on successful design and implementation of several exhaust ventilation systems in a paint-manufacturing factory. Using references based on ACCIH, ASHRAE, USEPA and USNIFPA to design and analyzing using OSHA method 12. The results are reducing of benzene, toluene and xylene and also difficult to remove 100 % benzene. Jafari suggested designing over by 20 %.

The method to control emission is especially to reduce VOCs while detected. Pollutant concentration of emission high and Darvin, Proffitt, & Jackie, [12] used a method multiple sampling systems to investigate dispel safety concerns regarding the use of recirculation. The results show that pollutant concentration within each booth not significantly increased, the cost be reduced, and reductions of exhaust flow rates of up to 90 %. The author recommended that to summarize the regulatory and safety design issues of recirculation spray booths.

III. VOLATILE ORGANIC COMPOUNDS [VOCs]

Spray paint activity emissions VOCs. This part will discuss from literature related with exposure to the VOCs, the effect of exposed and part of study on control and using Computerized Fluid Dynamics (CFD). Even though, there are a lot of study in VOCs emissions, effects, and

purposed to control the workers, there are no recent studies related to this in current country.

Three main characteristics of VOCs are reviewed as follow:

A. VOCs Exposure

Sources of contaminants are emission from the process from many sources. The investigation found that workers are to high volatile exposure. Workers from constructions industry especially interior workers and office workers are exposed to very high VOCs concentration in their work environment by Chan et. al. [13]. On the other hand, the study proposed to install ventilation system to reduce the concentration of the contaminants.

Exposed to contaminants in constructions not only harmful to interior workers but also to others. The methods of painting activity also related with this exposure. Investigate the relationship between air concentrations of VOCs during bridge painting and potential influencing factors, by Qian et. al. [14] including paint application methods (spraying, rolling, and brushing), paints coating type (primer, intermediate, and finish coatings), and meteorological conditions (temperature, humidity, and wind speed) through multivariate regression models. As a result Qian concluded that regression models then could be used to predict solvent exposure during bridge painting.

Commonly issues of exposed to VOCs are related with health effect to building. Chemical involved are chemicals include hexane, benzene, toluene, ethylbenzene, m,p-xylene, o-xylene, styrene, tetrachloroethylene (PCE), trichloroethylene (TCE), 1,2-dichloropropane (DCP), chloroform, and limonene. Ongyandee et. al. [15] investigated of volatile organic compounds in office buildings in Bangkok, Thailand conducted to quantifying levels and source strengths and determining indoor/outdoor relationships. And the results indicated that many air-conditioned office buildings in Bangkok have very low ventilation rates, which could be due to energy conservation measures enacted in Thailand over the past two decades. In reducing the exposure and considered successfully implemented measures for source control was a legislative ban on smoking in all public buildings.

To characterize general worker practices with respect to the use of aerosol solvent product. To quantify exposures to hexane, acetone, and toluene during typical vehicle repair tasks Worker Exposure to Volatile Organic Compounds in the Vehicle Repair Industry study by Wilson et. al. [16]. There is a characteristic pattern of aerosol solvent use that is largely independent of the task type, shop, or individual. As a consequence, there is a correlation between the task-based solvent emission rate (g/min) and the breathing zone VOC exposure concentration (mg/m^3) ($R^2 = 0.45$). Further evaluation of exposures to VOCs is needed in this industry along with information on effective alternatives to aerosol solvent products.

concentration of toluene depends on the specified exit velocities and the position of the exit and recommended good exhaust efficiency of contaminant materials could be acquired.

Using filters can control exposure to workers. Filter media play important roles in early prevention. Sridharwan et. al., [22] used Activated Carbon Filter (ACF) to investigate potential environment and energy benefits as air cleaning in Heating Ventilation Air Conditioner (HVAC) and ACF not perform well which removal 25-30 % with heated for formaldehyde and concluded not necessarily include a heating phase on every cycle for optimal usage of ACF.

Meanwhile study on activated carbon fiber materials by Navari et. al. [23] to evaluating their performances in terms of VOC adsorption capacity, and looking at the influence of specific area, number of layers, and gas type, velocity and concentration on this parameter. The results shows as 40 %, confirming carbon fiber materials are suitable for VOC removal applications. Navari also recommended based from lab analysis is a suitable replacement for powdered activated carbon because their adsorption capacity is high, even with volatile gases.

IV. CONCLUSIONS
Design a LEV is refer to American Conference Governmental Industrial Hygienist (ACGIH). [1] Meantwhile to comply with local requirement need to comply with Regulation [5] and Occupational Safety and Health Act 1994 [5]. Designer and manufacturer of Local Exhaust Ventilation are responsible to any safety and health affect to the workers as prescribe in the legislations.

Most hazardous activity is painting where workers are exposed to various contaminants. Workers are highly affected with exposures during this activity. A few writer [6][18] and [28], agree that inhalation of Volatile Organic Compounds will lead to breathing effect to the workers, dizziness, diarrhea, etc as mention by Liu [8] in his study. For Example dizziness, dizziness etc as mention by Liu [8] in his study. For assessing the exposure for painting activity, Taylor [9] and Flynn [10] come out with mathematical model in Computerized Fluid Dynamic for their suggestions.

Workers in interior construction and office are highly exposed to VOCs studied by Chun [13]. Qian, [14] investigate to predict and produce a model the level of solvent exposed during painting activity such as spraying, rolling and brushing and analytical using NIOSH method. On characteristics pattern of solvent, Wilson came out a correlation between task-based solvent emissions rate and the breathing zone VOC exposure concentration.

Normally chemical exposed affected to occupational health, study by Chuck [17] showed that, the symptom of Sick Building Syndromes as a indicator. Meanwhile, on asthmatics issues Beach explain in a study, while workers are exposed and inhale the VOCs. Sources of emissions of VOCs are from some laminated flooring office. To control exposed to VOCs are to install good

B. Effect on VOC exposure

Workers are exposed to chemical can cause harm to them. The available evidence indicates that VOCs can cause adverse health effects to the building occupants and may contribute to symptoms of Sick Building Syndrome investigated by Chuck & Crump, [17]. The results are Polymeric materials important sources of VOC emissions in buildings and secondary products from the reactions of some monomers, solvents or plasticizers and some are the plasticizers used in the production of the material. Therefore Chuck recommended development of voluntary labeling schemes, databases of material emissions and strengthens the demand for low VOC emitting products.

The effects on asthmatics of exposure to a conventional water-based and a volatile organic compound-free paint study by Beach et. al. [18] compared the effects of using a traditional water-based paint and VOC-free paint on respiratory symptoms, sputometry, and airway responsiveness to methacholine among a group of asthmatic subjects in a double blind. Respiratory symptoms, lung function, and air-way responsiveness were measured. A significant in reported "wheezing" and "breathlessness" was detected during use of conventional paint. In contrast, lung function measurements showed a small but significant increase during the use of both paints.

There was no significant change in airway responsiveness after use of either paint. Not reflected in measurements of lung function or airway responsiveness. Some exposure required to analyses the effect of VOCs. Analyses the effect of elevated temperatures on the emission of formaldehyde and VOCs from laminate flooring investigated by Wiglusz et al. [19]. As a result, at 23 and 29°C the measurements did not show any emissions of formaldehyde and very low emissions of VOCs. The author, Wiglusz claims that some laminate flooring may affect the chemical contamination of indoor air with the use of floor heating.

Others region such as tropical country possible shown different findings. Analyses the findings of VOCs levels found in two tropical offices by Zuraini et. al. [20]. They found majority of the VOCs rose in concentrations after the ventilation system has shut down with exceptions for benzene, benzaldehyde and tridecanoic acid that are attributable to outdoor and occupant related activities and ventilation systems and recommended utilizing the ventilation-resolved mass balanced model method to evaluate contributions of sources (from area specific emission rate) from outdoors, building materials, occupants, their activities and ventilation systems have yielded relatively good and accurate results.

C. Control of VOC

Others chemical hazards to health were also considered in a few studies. Kim et. al. [21] investigated ventilation characteristics of toluene have been analyzed in a room of a small-scale process with various exit location and with different suction velocities at exit and found that the

- [3] Washington State Dept. of Labor and Industries Industrial Ventilation System and Good Filters to Absorb Navarri [23], study on the performances of activated carbon filter to absorb the VOCs.
- Finally, they suggest better methods of risk communication, a professional licensing requirement by Enabler [4]. Thus, risk control such as providing Personal Protective Equipment and Material Safety Data Sheet not available at workplace, explain expressed by Winder [7]. Even though, control the hazards are taken in consideration but prevention and monitoring are required to protect workers from suffers by Prosek [28]. In reducing the exposure and consider successfully are implemented measures for source control was a legislative ban on smoking in all public buildings by Onsayadee [15]. Therefore Chuck [17], recommended development of voluntary labeling schemes, databases of material emissions and strengthens the demand for low VOC emitting products. Chun [13] and Kim [21] recommended good exhaust efficiency of contaminant materials could be acquired.
- Exposures to latest concentration are proposed to measure and compare with previous study said Liu [8]. Therefore, a study to assessment in spray paint activity can be carried out from many angles and the focus is to reduce any hazardous chemical from the chemical will affect workers health. Flynn [10] and Jafari [11] suggested designing over by 20 %, Darvin [12] recommended that to summarize the regulatory and safety design issues of reconditioning spray booths. To minimize contaminant exposed to workers, proper design of spray paint system, operation include the local exhaust ventilation and cost consideration should took in place before execute the project by Ogonowski [27]. As a result Qian [4] concluded that regression models then could be used to predict solvent exposure during bridge painting. Navarri [23] also recommended based from lab analysis a suitable replacement for powdered activated carbon because their adsorption capacity is high, even with volatile gases. Kassomenos [24] and Flynn [25] also recommended CFD model are very useful tools for evaluation and analysis of existing ventilation equipment. Further issue highlighted by Leung [26] is health risk where worker exposed high voc when carried out cleaning process.
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