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Baseline Inspection and Measurement of Local Exhaust Ventilation (LEV) Systems at Spray Booth in Manufacturing Plant

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Abstract

Examination and testing of local exhaust ventilation systems (LEV) that was conducted could help the management to create base or annual performance measurement in industry operations.The LEV will also be verified compliance with original design data, in order to determine adequate of transport velocities are being maintained. The examination also to determine if additional exhaust hoods can be added to the existing systems and compliance with Occupational Safety and Health (OSH) regulations.This Examination is to obtain the necessary data such as airflow static pressure, speed and total pressure at appropriate points LEV system. The method used is to inspect, analyze and evaluate the performance of local exhaust ventilation systems and related components, evaluate and recommend necessary measures for the restoration or repair of the damage.LEV also need to carry out inspection and tested by a registered professional engineer after construction and installation to demonstrate that the equipment meets the design specifications.Methodology for measurement and testing were based on American Conference of Governmental Industrial Hygienist (ACGIH). Selections of testing points for fume hood and canopy hood with individual suction fan, face velocities were measured and where applicable and accessible, duct transport velocities and static pressure measurements were carried out. Results from measurement data obtained is 65 fpm face velocity and flow rate 6500 fpm is lower than the value proposed by the ACGIH and show spray booth is not able to bring out the contaminants out of the workplace. The LEV systems has been examined and tested; both spray booth number1 and number 2 was below the ACGIH Standard while measurement and inspections conducted and not comply with local legislation to protect workers safety and health.

Keywords: ACGIH, Local Exhaust Ventilation (LEV), Spray Booth, Occupational Safety and Health (OSH),

1. Introduction

Control over contaminant exposure by workers is an issue that should be addressed during the employer. The effectiveness of the control device for separating preparation of workers to contaminants already in place in many parts of the work needs serious attention by employers.The method used is the measurement and testing of the system provided.The testing was carried out in order to comply with the Occupational Safety & Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulation 2000. Others are to document the conditions and performance of the LEV for future assessment and record keeping and the important are compliance with the Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000.[1]

United Kingdom Health and Safety Executive reported more workers exposed to painting activity. Issues in Occupational Health related with Occupational Asthma due exposed to isocyanate while working in workshop and the risk is 80 times greater than normal industrial worker as average.[2] Impact and exposed to spray-painting activity is harmful and will affect to workers health especially industrial workers. Spray-painting activity is significantly related to VOCs exposure and become an Occupational Disease.[3]

Enander*et. al.*(1998) in the Rhode Island automotive refinishing industry found that nearly one-half of the shops employ three or fewer people in spraying activity. Many cases, they observed spray painters double as body repair technician and this situation will increasing their potential exposure to workplace contaminants. They[4]conduct a survey of pollution prevention, environmental control, and occupational health and safety practices found that nearly all of the shops used spray painting booths and only 38% own booths have effective downdraft design. Suggested by author for better methods of risk communication and professional licensing requirement to improve on safety and health.

Workplace assessment and airborne sampling component study in Australia conducted any found solvents are related with spray painters in automotive body repair workshop done by Winder & Turner. The methods are interviewed to 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 spray two-pack paint in a spray booth. Others findings are Personnel Protective Equipment and Material safety Data Sheet not available at workplace.[5]

Wilson *et. al.* (2007) in their study to characterize general worker practices with respect to use of aerosol solvent product and to quantify exposure to hexane, acetone and toluene during typical vehicle repair task where the greatest exposures occur in the first 1 to 2 minutes following initiation of spraying.[6]On the other hand, most risk situation during the spray painting activity is initial starting.

The purpose of the inspection is to get the variable calculation of static pressure, velocity pressure and total pressure for LEV systems. In addition to inspecting, testing and evaluating the performance would explain the ability of LEV systems. If there is damage and improvement, all of which must be approved and tested by a registered professional engineer.The objectives of this paper to inspection air flow data such as static pressure, velocity pressure and total pressure at the appropriate points of the LEV system, inspect, test and assess the performance of LEV system and its associated components, evaluate and recommend where necessary, remedial or improvement measures of malfunction areas of the LEV that require rectifications/improvement and to check if the LEV system has been tested by a registered professional engineer after construction and installation to demonstrate that the equipment meets with the design's specification. The test and evaluations were conducted at spray booth number 1 and spray booth number 2 respectively in this company as a future reference in order to compare the performance of overall data related with LEV Systems.

2. Methods

Equipment's are used in this study such as Thermal, Tachometer, Vane anemometer and measuring tape is used to measure the length and distance. To cover-up the holes on the duct, Adhesive Tape are used. Pitot tube is used for pressure measurements. Clamp Meter to measure current and voltage. Manometer is used for airflow measurements. Selection of testing points for fume hood and canopy hood with individual suction fan, face velocities were measured and where applicable and accessible, duct transport velocities and static pressure measurements.

The testing of LEV system was carried out in accordance with the methodology in the handbook of the American Conference of Governmental Industrial Hygienists (ACGIH)[7]. LEV system is comprised of several components such as the hood, duct, air cleaner, motor & fan and stack. Method of measurement refers to ACGIH. The choice of location measurement using the recommended equipment is in component to get the data in determining the efficiency of LEV system.

In testing procedure, a sketch of the LEV and its associated components was drawn indicating the shape and position of the hood and location of fan/motor and air cleaner.Visual inspection for suitability of hoods, connections between hoods and ducts, obstruction of hoods, position of hoods and workers breathing zones, denting, corrosions, damages to hoods, fans and air cleaners and conditions of work areas.Smoke tube tests carried out at hoods, to determine the dispersion of contaminants, effectiveness, capture distance and cross drafts on hood performance.

Conducting smoke tube tracer tests are to evaluate dispersion of contaminants by blowing the smoke at the source of the contaminants and observing the dispersion. Smoke tube will help to identify the point where the initial velocity of contaminants away from the hood is dissipated, determine the effect of cross drafts on hood performance, and finally to locate and study turbulence around openings, spillage and leakage at the hood

Duct velocity pressure measurements were taken at suitable points along the duct to determine the transport velocity, volumetric flow rate in the duct. Small holes of 3/8 inches diameter are drilled at traverses across the diameter of duct at right angle to each other. Whenever possible, the traverses are made at distance of 7.5 diameters or more downstream from any major air disturbance such as an elbow, hood, branch entry etc. If measurements are made closer to disturbances, the results will be considered subject to some doubts and re-checked at a second location. If agreement within 10% of the two traverses is obtained, reasonable accuracy can be assumed and the average of the two readings is used. A third location is selected only if the variation exceeds 10% and the two airflows in the best agreement is averaged and used as the result. Velocity pressure was measured at various points over a number of equal areas in the cross section of the duct. The average velocity measured was used to determine the transport velocity at the point of the duct.

Duct static pressure measurements points were similar to that of the velocity pressure measurements. The measurement could be used to measure performance and to diagnose any malfunction. The locations of measurements chosen were at entries of branch into main duct, on each side of air cleaners, on each side of fan and at several points along ducts. The actual points chosen for measurements were indicated as in the relevant appendices.Inlet and outlet static pressure of the air cleaners were determined by using Pitot tube and anemometer.The fan rpm and the static/velocity pressure were measured before and after the fan by using Tachometer, Pitot tube and Anemometer.

3. Case Study Description

The testing of Local Exhaust Ventilation was conducted at Motor Manufacturing Company located at Shah Alam, Selangor, Malaysia. This testing and examination of the LEV systems was performed first time in 2012 and set as a baseline data. The test and evaluations were conducted at spray booth number 1 and spray booth number 2 as shown in Figure 1 and Figure 2.

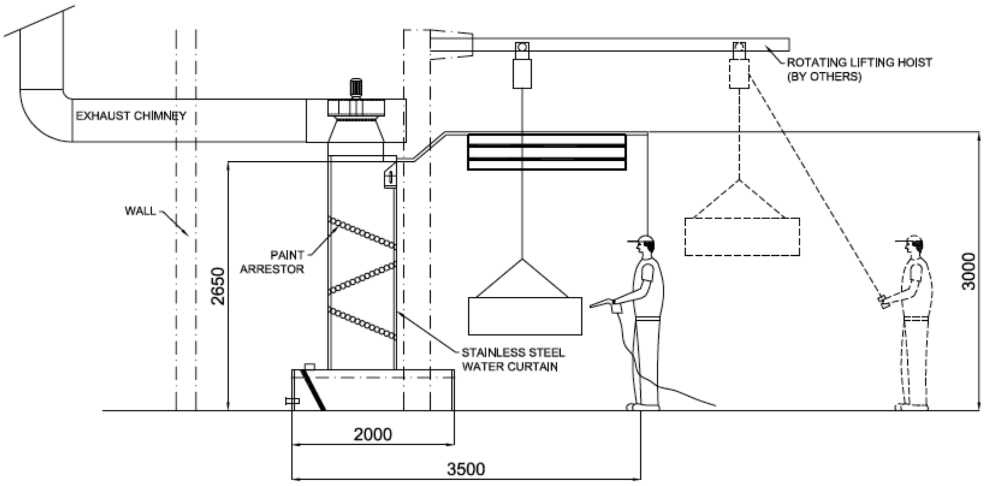

Figure 1: Sectional View of Spray Booth (measurement in mm)

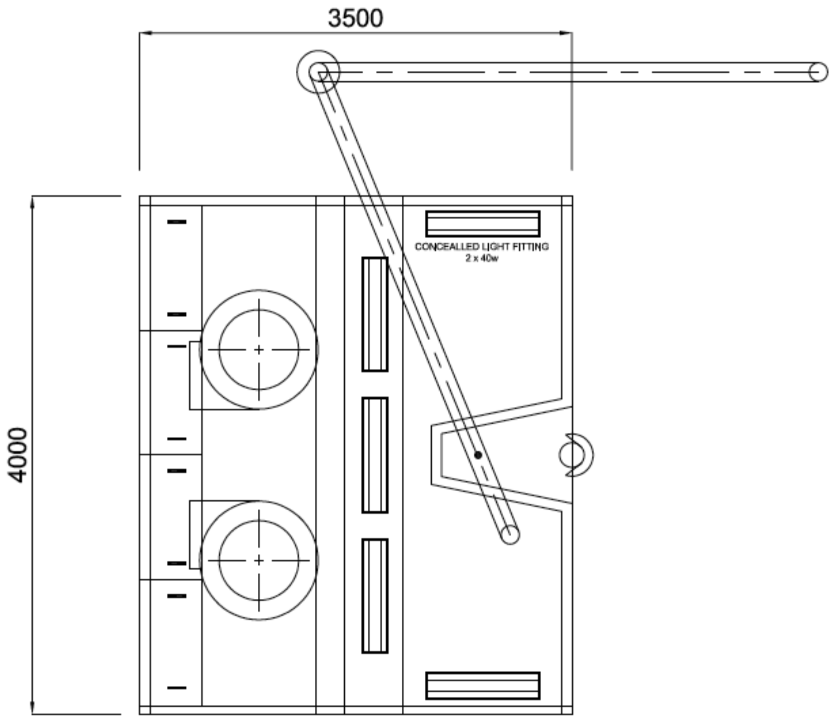

Figure 2: Plan View of Spray Booth

The testing and data measurement was undertaken together with qualified an Industrial Hygiene Technician registered with Department of Occupational Safety and Health (DOSH). All the data taken represent the operational condition of the facility and represent the normal routine daily operation. Figure 3 shows the measurement are taken and Figure 4 shows the activity at the spray booth.

Figure 3: Measurement is taken at the spray booth.

Figure 4: Activity at the spray booth.

4. RESULTS AND DISCUSSION

All testing and measurement was conducted at spray booth number 1 and spray booth number 2 respectively. The results of measured transport velocities and face velocities are compared with the recommended values stipulated by ACGIH [7]

In normal calculation, the Total Pressure (TP) is the sum of Static Pressure (SP) and Velocity Pressure (VP).

$$TP = SP + VP$$

In actual condition, TP is equivalent to the sum of SP plus lossesand VP. This is due to static pressure losses.

$$TP = [SP + Loses] + VP$$

Both spray booth are inspected and measure the face velocity and flow rate. Results of measurement are comparing to recommended value by American

Governmental of Industrial Hygienists. Result of inspections were carried out are in table 1.

Table 1: Data measurement on Spray Booth Number 1 and 2 Opening

Testing Area	Face Velocity V_{face} (fpm)		Opening			Face Flow Rate, Q_{face} (cfm)	
	Rec. value	Tested	Type	Face size (in)	Face area (ft^2)	Rec. value	Tested
Spray Booth 1	100 - 200	75	Open	113 x 104	81.6	8161 - 16320	7500
Spray Booth 2	100 - 200	65	Open	153 x 118	125.4	12540 - 25080	6500

Note:$Q_{face} = V_{face} x\ A_{face}$,A_{face} = Face area, L=Length, H=Height

Data measured for both spray booths for face velocity are below recommended value by ACGIH for open type i.e. 75 fpm and 65 respectively where the recommended value is between 100 to 200 fpm. While for face flow rate calculate based on individual face are show that Spray Booth number 2 flow rate is halve compare to minimum recommended value is 12540 cfm. Tested flow rate value for spray booth number 1 slight lower than minimum recommended value is 8161 cfm.Results and measurement data obtained is 65 fpm face velocity and flow rate 6500 fpm face is lower than the value proposed by the ACGIH and show spray booth is not able to bring out the contaminants out of the workplace.

Transverse velocity measured is to identify the performance of ducting for both booths. Result of transverse velocity measured show in table 2.

Table 2: Transverse Velocity

Booth	Duct size (in)	Duct area (ft2)	V_P (in wg)	Velocity (fpm)	Flow rate (cfm)	Result
1	24 x 24	4.0	0.155	1575	6302	Pass
2	32 x 32	7.1	0.012	439	3115	Failed

Results above are measured after the fan to see the velocity in a ducting and performance check on Spray Booth System. Transverse Velocity for spray booth number 2 failed due to the below than standard recommended in ACGIH for Vapour/gas/smoke is between 1000 – 2000 fpm. While spray booth number 1 in between the range and comply with the standard.

Table 3: Static Pressure, Velocity Pressure and Total Pressure

Booth	Duct size (in)	Static pressure SP (in wg)	Velocity pressure VP (in wg)	Total pressure TP (in wg)
1	24 x 24	1.764	0.155	1.919
2	32 x 32	0.098	0.012	0.11

Table 3 show the result measured and calculation for both spray booth system for Static pressure, velocity pressure and total pressure. Booth number 2 shows all value are low compare to booth number 1.

Others measurements were carry out to obtain data on the fan static pressure, velocity pressure and flow rate. Unfortunately the only outlet point can assess and no measurement was taken at the inlet point (before) due to difficulty of assess the area. Result shows in table 4.

Table 4: Data measurement on point area (before and after fan)

Booth	Point	Static Pressure (S_p) ("wg)	Velocity Pressure (V_p) ("wg)	Flow rate (cfm)
Number 1	Inlet	NA	NA	NA
	Outlet	1.764	0.155	6302
Number 2	Inlet	NA	NA	NA
	Outlet	0.098	0.012	3115

As a result no baseline data was produced from measurement and calculation such as for speed (rpm), Fan Static Pressure (in-wg), Fan Total Pressure (in-wg), Break Horse Power (BHP) and Flow rate (Q). No comparison data can make in future measurement.

Baseline Value, as main objective in measurement at spray booth are not available due to no data available from measuring to calculate Fan Static Pressure (FSP), Fan Total Pressure (FTP) and Brake Horse Power (BHP). As a result table 5 shows the baseline for 2012.

Table 5: 2012 Baseline Values

Description	Speed (rpm)	FSP (in-wg)	FTP (in-wg)	BHP (hp)	Flow rate Q (cfm)
Baseline (2012)	NA	NA	NA	NA	NA

5. Conclusion And Recommendation

Both spray booths are conducted LEV's baseline monitoring in the plant with the full cooperation from the management and staffs. By carrying out the LEV's baseline monitoring, the company has not complied with DOSH's USECHH 2000 Regulations. From the airflow measurements, visual assessment and other tests conducted the overall performance of the spray booths were found to be satisfactory. Improvements need to be done at the spray booths to ensure the transport velocities comply with the standard.

Not available data for both inlet fans for data measurement due to difficulty of assessing fan area as shown in table 4. On the other hand, total system of spray booth at the industry measured are not comply with USECHH Regulation 17, the LEV system are not maintain and Regulation 18, tested for LEV not apply after construction to meet specifications. [1]

Overexposure to airborne chemicals can cause serious or fatal respiratory diseases. So, the most important functions of LEV system is to capture, remove, treat the contaminated air before exhausting out only clean air to atmosphere. Normally, the machine operators have little control over the LEV's performance that was already in place. Increasing the effectiveness of the system required recalculation of the way the system. The operators requireusing a safe and standards operating procedures (SOP) to ensure the efficiency use of the systems at all times. Management should control any chemical hazardous at work place through hierarchy of control in Regulation 15, USECHH. [1]

To ensure the effectiveness and efficiency of the LEV system, it is necessary to make sure that the LEV systems are properly designed. In addition, regular preventive maintenance and visual inspection are equally important to ensure that the LEV systems are always functioning according to the design specifications. However the machine operators are still advised to wear the suitable personal protective equipment such as respirators, safety shoes and hand gloves when they are advised to do so by the safety officers while at work as in Regulation 18 USECHH. [1]

Housekeeping is also important in the workplace. Any chemical spillage should be immediately clear and clean. Close all the unused chemical containers and machine doors to prevent the built-up of airborne contaminants in the ambient air. Every LEV systems that were installed in the plant shall maintain regularly and operated at all times while the machinery or plant is in operation. Finally although the burnt of responsibility over the accuracy of the fairness of the report lies on the hygiene technician's shoulder but, through close cooperation and understanding from all the parties concerned, the ultimate main aim of protecting the workers' health will be achieved. Occupational Safety and Health Act 1994 on required employer responsibility to ensure workers safety, health and welfare.[8]

Improvements of the system for spray booths are required due to incompliance of ACGIH standard and USECHH Regulation 2000. In addition suggestion by Hasan NH*et. al.* to add on computational fluid dynamic (CFD) before fabricate the LEV system to check the performance of system.[9] Furthermore the author [10]suggested prediction of the hazard before fabricate and installation.

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