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Evaluation of Local Exhaust Ventilation (LEV_S) Efficiency to Emissions Control in some Industries: A Case Study in the Alborz Industrial City in Iran

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Abstract:

Background: Healthy workplaces are created in the shadow of improved work environment quality. Local Exhaust Ventilation (LEVS) has a prominent place as a method of emission control from the source.

Objectives: This study aims to evaluate the efficiency of (LEVs) in a number of industries in Alborz Industrial City.

Methods: This descriptive and cross-sectional study was carried out on LEVs in a number of industries from Alborz Industrial City in winter 2015. Qualitative and quantitative evaluations were performed according to ACGIH standard methods.

Results: (LEVs) were evaluated in 23 companies, but 12 of them did not have measurable quantitative and qualitative characteristics. In other companies, design and implementation of (LEVs) have been conducted regardless of the emission sources characteristics and (LEVs) design principles. Physical defects and leakages in the studied systems were obvious, and the amount of leakage, considering life and system pressure, was about 20%. In terms of energy consumption, there was no match between the actual needs of the systems and electric powers. Comparing the number of airborne particles in the production halls with the factory yard showed not only inefficiency of (LEVs), but also direct discharge of polluted air into the environment.

Conclusions: LEVs surveyed were not in good condition. Improving the quality of (LEVs) requires serious rethinking in university education, reforming of laws (especially hard and hazardous jobs law), and improving the interaction of organizations involved in the field of occupational health, environment, and safety and creating a legal mechanism to enforce employers to recruit specialists in the field of design and implementation of (LEVs).

Keywords: Local Exhaust Ventilation System (LEVs), Hood, Work place improvement, air Quality

1. Background

A healthy workforce has a key role in the creation and retention of wealth and prosperity in society. The key role of healthy people in sustainable development shows the importance of Occupational Hygiene services in determining a country's global ranking. Everyone attends work half of their walking hours and would be exposed to a variety of hazardous factors; the neglect of these factors can cause incidents and occupational diseases that will impose heavy costs on the health system (1-4). Occurrence of more than 14724 workplace accidents and more than 90,000 deaths from occupational diseases in 2015, and 55 % cause of death with silicosis in silica grinding small Industry in the study reported by (Mohebi et al,2015) shows the importance of air quality in the workplaces(5, 6).

Healthy work environments are created as a result of the workplace improvement programs. Local Exhaust Ventilation System (LEVs) as a method of control at the source has a prominent place in the hierarchy of air pollution control methods (7-9). Despite the undeniable importance of (LEVs), inefficient ventilation systems implemented by nonprofessionals have no benefit but creating new costs and hazards such as noise and pollution discharge to environment (10-12). According to a report by Health and Safety Executive (HSE), it is estimated that only a quarter of the industries in England had LEVs, and 40% of them were checked because of government pressure (5, 13-15). Given the importance of LEVs as a key element in the workplace environment programs, in this research, we studied LEVs performance in a number of industries in Alborz industrial city, IRAN.

2. Methods

This descriptive and cross- sectional study executed in the winter of 2015.A total of 23 companies in the groups of automobile parts manufacturing (6 companies), plating (3companies), ceramic tile (4 companies), silica grinding and preparation of raw materials for the glass industry (2 companies), electronic boards (2 companies) production of plastic parts (3 companies), plot and the film, medicine bandages, and soap production were participated in this study. The evaluation of LEVs carried out after becoming familiar with production lines and workers.

LEVs were assessed qualitatively by means of checking different factors such as shape, defects, modifications, type and location of ventilation hoods and relation to the emission source, fan type, power and location. Quantitative assessments of face velocity and environmental wind speed were made using smoke tube, hot wire anemometer (KIMO VT-100). Duct velocity measurement were carried out using Pitot tube (KIMO 12974) and digital differential pressure gauge (Air Flow-APM 50K (8, 15, 16). All measurements were performed according to the verified ACGIH methods.

The effect of LEVs on air quality was examined by measuring numbers of 2.5 and 0.3 µm particles matter (PM) in the area of production halls and factory yard using calibrated laser counters (CW-HPC200). In order to achieve reliable results, three measurements were taken at each station for 20 sec.

3. Results

Ventilation systems of 12 companies out of 23, were poorly designed, therefore quantitative measurement of different factors were not feasible. The average results in the remaining industries are summarized in Table 1.

Table 1. Investigated (LEVS) quantitative parameters

Industry	Face/Slot Velocity (fpm)	Duct Velocity (fpm)	note
Plating	843±317	2100±875	18 slot hoods
Parts manufacturing	1159±287	4500±367	16 slot hoods
Ceramic	160±43	2400± 556	>100 hoods

In the plating industries, slotted hoods were used to provide a steady suction on the surface of the tubs. LEVS were implemented based on proper design criteria, however due to lack of proper maintenance and upgrading, minimum slot velocity of 80% of the studied industries were as low as 400 fpm. Only 20% of the cases had a minimum slot velocity of 1000 fpm. In one case, the ventilation system and positioning the hoods was installed 30 years ago with a designed slot velocity was 1300fpm. Because of changes in the dimensions of the plating baths during theyears, capture velocity at distances of 3 and 5 cm from the slot was 220 and 430 fpm, respectively. In other cases, systems were broken with serious corrosion.

The design of ventilation systems in the ceramic tiles industries was carried out based on a combination of plenum and tapered systems. Design, implementation and installation of LEVs and production line in two companies were executed at the same time. In one case, however, implementation of the ventilation system was done after several years based on the proposed plan. In all cases, flexible ducts leading to emission sources had no hood and were released near the sources of emissions. Airflow in the terminal ducts and in the source were 800 ± 300 fpm, 70 ± 30 fpm, respectively and often couldn't be measured. In enclosing hoods, minimum face velocity in most cases was 160fpm that complied with the 100-150 fpm ACGIH criteria. Duct velocity was about 2400±556 fpm. Of note, powdered materials deposited in ducts resulted in a more than 30% clogging of the duct cross-section.

The plot and the film and medical bandage production industries had the solvent recovery system. Because density of solvent vapor is greater than air, in order to control the exposure to organic solvents emission form baths, the slots with face velocity of 4000fpm and airflow of 50cfm were placed at the lowest point on the floor, but those couldn't control the baths located at a distance of 2 feet from the slots.

Out of six automobile parts manufacturing companies that were studied in this research, only two had proper slotted hood with good capture velocity for welding fumes control, and in other cases, different shapes ducts and axial and centrifugal fan were used to transfer pollution from one sector to the others. In silica grinding and preparation of raw materials for the glass industry, axial flow fans installed on the wall were used to discharge polluted air to the environment. In the production of plastic parts (placed in the group of hot industries), canopy hoods with axial fans and disproportionate dimensions in comparison with the size of the source had been used. The existence of competence air currents in the environment, the installation of the hood at high height, the small size of the hood and face velocity of less than 50fpm were resulted in escaping of pollutant from the hood.

In galvanized sheet production industry, ammonium chloride, tin and lead melted baths were used, but due to the mismatch of the bath dimensions with the hoods, fumes could be escaped. In this study, just one tile industry had the LEVs design plan and maintenance program, and in other industries, only lubrication and belt replacement for fans were performed. Damage in ducts, hoods, and improper connections in ducts, fans, existence of external parts and clogged ducts in all studied ventilation systems were observed. After resolving the mentioned problems, airflow increased up to 20% in some industries and 50-70 % in ceramic tile industries. In terms of energy consumption, there were obvious differences between ventilation system designs. For example, a system with 30 branches and an air cleaner device with 270 bags, used 50KW electric power, but smaller systems used up to130KW electric power.

Number of particulate matter (PM) in the workplace air and companies yards with the (PM) in Qazvin city ambient air shows the efficiency of LEVS and air cleaning systems are summarized in Table 2.

Table2. Comparing the number of 0.3, 2.5 µm (PM/L $_{air}$) in indoor and outdoor of industries

Particle count Industries		0.3µm/L air $_{in}$	2.5µm/Lair $_{in}$	0.3µm/Lair $_{out}$	2.5µm/Lair $_{out}$
Tiles Ceramic		130135±12002	35633±4206	103209	6762
plating		347802±30870	2450±1200	35460	966
Soap powder		195874±11120	2530±401	80136	399
ABS part from powder		385092±73544	15680±4897	11928	454
ABS part from granule		243849±30931	1250±252	10376	520
Part manufacturing	Welding station	328041±110494	2280±433	27300	504
	breathing zone of welders	510762±60784	1929±458	27300	504
	Aluminum welding	117096±1533	2583±798	27300	504
	Aluminum milling	54537±2504	1561±259	27300	504
galvanized sheet	pipe Welding	349461±89540	4851±890	25487	105
	Molten pool(ground floor)	175350±23562	1890±478	25487	105
	Molten pool(1th floor)	315399±45780	1953±310	25487	105
	Molten pool(sec floor)	337618±56230	7818±524	25487	105
Machining		22380+8851	4371+2600	45738	714
Qazvin ambient air		17346	168		

4. Discussion

In ceramic tiles and electroplating industries, LEVs were designed by professional designer, because of the impact of dust on products quality and the risk of gas explosion, respectively. In other industries, amateur and experimental duct makers were designed and installed LEVs without considering design criteria and emission sources characteristics. Therefore, in more than 70% of studied industries, axial flow fans attached to duct or installed in the hood was used as a LEVs. In mineral and silica industries, working in dusty and polluted environments was assumed as a part of the work. Due to this approach, the risk of lung disease among workers increases, and after diagnosing early signs and symptoms of disease in the occupational medical examinations, labor contract is canceled (6).

Bahrami et al believe that low efficiency of LEVs is because of the design by non-expert and amateur manufacturers, improper design and maintenance, imperfect repair, and changes in the system.

Jamshidi et al with the assessment of particles mass around these systems highlighted the low efficiency of LEVs (17). Only in the ceramic tiles, plating and parts manufacturing industries, quantitative assessment was done. Although average face velocity in enclosing hoods was 160 ± 43fpm and transport velocity in the main ducts was 2400 ± 556 fpm in the ceramic tiles industries, however, because of disregarding the location of hoods in relation to the emission sources, tear ducts, and leakage in the main ducts and such things, surface contamination and workers' inhalation exposures were increased. Studies revealed that 69% increase in static pressure and 2.2 times increase in fans horse power is needed for compensating 30% leakage, therefore, fixing leaks in LEVs is important (8, 13). A huge mismatch between required fan power and energy consumption is because of the Quality uncertainty of the fans and components of the ventilation system and employers' high expectations of the LEVs.

Nazarian reported that in Anzali Steel processing factory, a fan with airflow of 42000cfm was used in order to control emissions caused by a 10 tons furnace; and in a steel complex in Esfarayen, 2 fans with 1600 kw power and with airflow 450000 cfm were used to control emissions caused by a 50 tons furnace, whereas only one-third of fan capacities were used (18). Considering the VS-105 and even 10% ACGIH uncertainly coefficient, 2750 cfm air flow per ton of steel will be required, which means 27500 cfm and 125000 cfm airflow for emissions control caused by 10 and 50 tons furnace are needed (8). Therefore, 34 kW power is needed instead of 1600KW, which means proper design of LEVs could lead to serious energy saving and prevention of environmental consequences (16).

In terms of the air cleaning system, except for the ceramic tiles industries, other industries suffered from the lack of the filtration or they had to use various forms of primitive filtration systems that resulted in pollution released to the environment [Table2]. Ceramic tiles industries have a large natural ventilation capacity because of multiple large heating sources. It should be noted that natural ventilation will increase if temperature gradient between indoor and outdoor environment increase. In this study, at the temperature gradient of 29 °C, the air velocity at the door surface with a 10 m^2 was 1300fpm, and the natural ventilation reached to 142000cfm. There was the same condition in a distance of 30 meters from door that airflow was 130fpm.

Reentry of air to Production halls resulted in re-suspending of settled dust on floors and surfaces to air leading to a poorer workplace air quality (19). This may result in an increased levels of pollution in the plant area and even the nearby streets. For this reason, that average particle count in the environment of ceramic tiles industries was significantly higher than other industries (pv≤0.05). The use of axial fans only increased average environmental noise 9±3db_A without measurable positive affect on the work place air quality. The result of particle count in production halls in comparison to the area of factory or even in Qazvin city with a 95% confidence interval showed that studied LEVs were unaffected in terms of controlling workers' respiratory diseases and pollution control before discharging into the environment. Discharging polluted air into the environment caused not only returning pollution to production hall, but also leading to air pollution of the nearby areas. In this study, the numbers of 0.3μm particles in production halls were 10 times higher than the environment and 2 times higher than Qazvin city. These results reveal the importance of using air cleaning systems.

4.1. Conclusion

Undoubtedly, the air quality in the working environment and the effect of that on workforce health, the environment, society and industry competitiveness and innovation capacity is an important subject that requires serious rethinking in university education, the reformation of laws and improving the interaction of organizations involved in the field of occupational health, environment, labor and social welfare (20, 21). By enforcing safety regulations and regular inspection, industries should keep accountable for their contribution to the air pollution in order to safeguard the environment and their workers' health and safety. In this regard, design and implementation of LEVs by professionals and obtaining technical efficiency certification at the time of starting and determined intervals are necessary.

Despite the fact that regulatory bodies and other authorities are trying to improve health and safety of workplaces, however, because of living conditions and job security, many of workers in these industries prefer early retirement. It is unfortunate, but true, that some of them even try to demolish control systems and resisting to reforming measures. It seems revising of the work safety regulations as well as early retirement criteria in these hazardous jobs are necessary. For this purpose creating an independent regulatory body is needed.

As noted above, spending money on improving the workplaces environment is a wise investment. Many studies in this field clearly confirm the high return of investment in this area (22, 23).

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