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분사연마작업에서 발생되는 호흡성 및 총 에어로졸에 대한 개인시료포집방법간의 비교연구

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A Study of Comparison of Methods for Personal Sampling of Inhalable and Total Abrasive Blasting Aerosol

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에어로졸의 흡입은 작업환경으로 인한 높은 사망률의 여러 가지 요인중 대표적인 것의 하나이다. 에어로졸이 호흡기내에 침착하여 건강상의 문제점을 일으키는 경우 지금까지 전통적으로 사용되어 오던 방법은 소위 총 에어로졸 측정법 이었다. 미국에서 1970년대부터 이 총 에어로졸을 측정하기 위하여 주로 사용한 것은 37㎜ 여과지가 장착된 포집기였다. 그러나 이에 대한 비판, 즉 호흡성 에어로졸을 적절히 측정하지 못하고 있다는 비판이 일어나 소위 호흡성 에어로졸을 측정하기 위한 장치가 개발되기에 이르렀다. 이 호흡성 에어로졸을 측정할 수 있는 장치중 하나가 TSI Respicon®이다. 본 연구는 전통적인 37mm 여과지가 장착된 포집기와 TSI Respicon®를 동시에 사용하여 선박의 녹제거 작업시 발생하는 에어로졸 량을 각각 측정하여 그 차이를 검토하였다. 호흡위치에서 15분간 측정을 통해 29건을 비교한 결과 15건에서 종래의 37mm 여과지가 장착된 포집기의 값이 TSI Respicon®의 값보다 높게 나타났다. 그러나 origin regression model, Wilcoxon Signed Rank Test 등을 통한 통계적 분석에서는 유의한 차이를 발견할 수 없었고 따라서 호흡성 에어로졸의 측정에 있어서 종래의 37mm 여과지가 장착된 포집기 사용이 불가하다는 최근의 경향은 재고되어야 하겠다.

주제어 : 호흡성 에어로졸, 총분사연마 에어로졸, TSI Respicon® 포집기.

Ⅰ. INTRODUCTION

The major route of exposure to chemical agents in the workplace is via inhalation. Inhalation of occupational aerosols remains a large source of mortality in the occupational environment. During the 29-year period from 1968 to 1996, NIOSH has documented a total of 113,519 workplace related pneumoconiosis deaths among United States residents of age 15 and over (NIOSH, 1999). NIOSH statistics estimate number of occupational aerosol diseases of the lungs reported by employers to reach 3500 in 1996, an all time high since reporting began in 1973(NIOSH, 1999).

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Exposure to occupational aerosols is estimated by the physical sampling of air in a workers breathing zone. The traditional approach to evaluate worker exposure to aerosols that pose a health risk when particulate matter is deposited anywhere in the pulmonary system is commonly referred to as total aerosol sampling. In the United States, the common method for collecting total aerosol is through the use of a 37mm, closed faced sampling cassette. Since the late 1970s total aerosol sampling has been scrutinized because of its decreased collection efficiency when used with aerosols having relatively large particle sizes (approximately 45 ㎛ or greater)(MARK & Vincent, 1986; Kenny et al,1997). This finding has resulted in a collaboration among the international industrial hygiene community to develop a harmonized set of criterion that relate true aerosol inhalability as a function of particle size(ISO, 1995). An outcome of the collaboration is the institution of an aerosol size fraction termed the inhalable fraction which is expressed as a sampling convention which samplers for this fraction must emulate. The TSI Respicon® sampler shown in Figure 1 is a sampling device marketed as having the ability to collect an aerosols inhalable fraction.

The development of a new inhalable fraction has caused the American Conference of Governmental Industrial Hygienists (ACGIH) to establish inhalable threshold limit values (TLVs) for a few select aerosols. It is the intent of the ACGIH to replace all total aerosol TLVs with inhalable TLVs where appropriate (ACGIH, 1999). Thus, the ACGIH has requested that side-by-side sampling studies be performed using the 37-mm total aerosol sampler and newer inhalable fraction sampling devices to justify this TLV replacement (ACGIH, 1999). This research performs such a study by comparing side-by-side personal breathing zone samples collected during abrasive blasting operations using the 37mm cassette total aerosol sampler and the TSI Respicon® inhalable aerosol sampler.

Figure 1. TSI Respicon® sampler

Figure 2. Location of each sampling device

Ⅱ. METHODS AND MATERIALS

1. Sampling Protocol of Acquired Aerosol Data

Comparison of sampler performance was evaluated by occupational sampling of abrasive blasting. Aerosol sampling consisted of side-by-side collection of total aerosol (using a 37-mm, closed faced cassette) and inhalable aerosol (using a TSI Respicon® sampler) from the breathing zone of an abrasive blaster during 15-minute sample runs.

Figure 2 shows the location of each aerosol collection device. One aerosol sampling run resulted in one set of paired data: A mass concentration result from the total aerosol sampler and a mass concentration result from the TSI Respicon® sampler. A total of 29 aerosol runs were performed yielding 29 sets of paired data.

All aerosol mass was collected on a Zeflon pre-weighed, matched weight mixed cellulose ester membrane filter (0.8㎛ pore size). For both sampling devices, negative pressure to collect a sample was provided by SKC Aircheck High Flow sampling pumps. Flowrates for the total and inhalable samplers were 2.0 and 3.11 liters per minute, respectively. After each sampling run, new sampling media was placed in the breathing zone of the abrasive blaster. In an effort to reduce sampling bias the location of each collection device was switched after the performance of each sampling run. Gravimetric analysis was used to quantify collected total and inhalabel aerosol mass.

2. Data Analysis

A through-the-origin linear regression analysis was used to determine the relationship between the two measures of exposure so that total aerosol results from the 37-mm cassette sampler could be converted to equivalent TSI Respicon® sampler results for inhalable aerosol. This analysis was performed by plotting paired TWA mass concentration values against each other and determining the slope of the resulting regression line. This type of regression allows for the relationship ER = S(E37), where ER is the TSI Respicon® sampler exposure, E37

the 37-mm sampler exposure, and S is the slope of the regression line. This statistical method has been applied in a previously published side-by-side sampling study investigating the differences between the collection of total and inhalable aerosol fractions(Spear et al, 1997).

Furthermore Wilcoxon Signed Rank Test was done to investigate the signifcance of difference of two concentrations between Respicon and Total Aerosol.

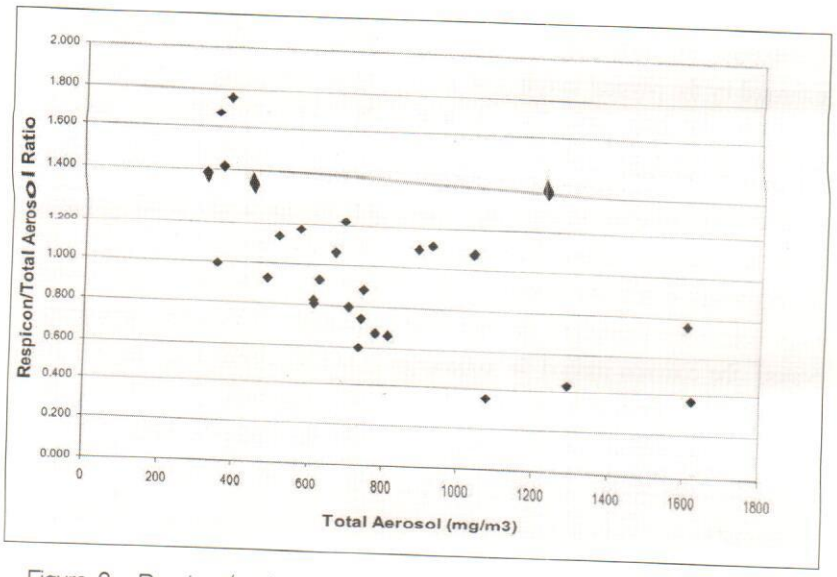

Figure 3. Respicon/total aerosol ratios based on total aerosol concentration

III. RESULTS

Table 1 shows a comparison of the 15-minute TWA exposure concentration results for the 29 paired samples. Figure 3 graphically displays E Respicon®/Etotal ratios as a function of Etotal. The exposure rations ranged .920 to 1.76 when total aerosol concentrations were greater than 500mg/㎥. Figure 4 shows results of regression analysis and the resulting 0.984 conversion factor to be applied to the total aerosol sampling device.

According to Wilcoxon Signed Ranks Test, there was no significant difference of two concentrations between Respicon® and Total Aerosol.

Table 1. Comparison of exposure concentrations for total and inhalable a aerosol

Sample Run	Total(㎎/㎥)*	Respicon(㎎/㎥)*	ERespicon®/ Etotal ratio
1	447	611	1.37
2	355	593	1.67
3	886	964	1.01
4	807	534	.662
5	923	1,042	1.11
6	687	842	1.22
7	368	522	1.42
8	325	451	1.39
9	623	574	.921
10	351	348	.992
11	1,076	370	.344
12	665	707	1.06
13	1,290	556	.431
14	610	490	.804
15	568	667	1.17
16	384	676	1.76
17	512	578	1.13
18	742	653	.880
19	483	444	.920
20	1,603	1,219	.760
21	1,619	592	.365
22	1,035	1,120	1.09
23	1,033	1,109	1.07
24	1,226	1,726	1.41
25	704	558	.793
26	608	499	.821
27	732	439	.600
28	735	544	.739
29	774	520	.671

* 15 minute TWA

IV. CONCLUSIONS

Although previous research has shown that the 37㎜ total aerosol sampler can underestimate an aerosols true inhalable fraction, the abrasive blasting exposure results acquired from this study suggest a different outcome. Fifteen of the 29 E Respicon®/ Etotal ratios where greater than 1.00 indicating a nearly equal distribution of overestimation vs. underestimation when comparing the total aerosol sampler to the inhalable aerosol sampler. Further, a conversion factor of 0.984 applied to the 37mm total aerosol sampler suggests an approximate 1:1 relationship between sampling devices. It is recognized that the variability among sampling results and the

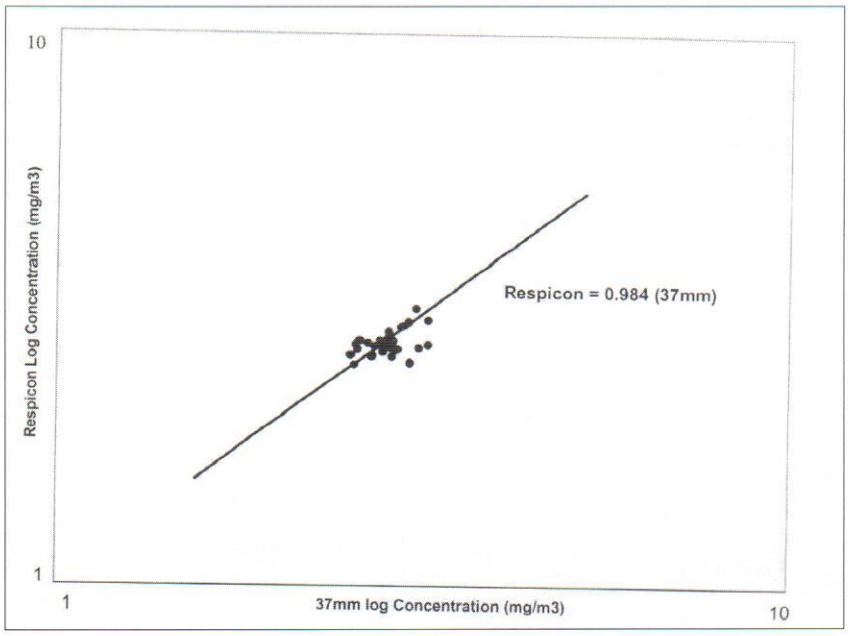

Figure 4. Regression analysis

small sample size of 29 does not allow for conclusive recommendations regarding the sampling method that accurately measures the inhalable fraction of an abrasive blasting aerosol. Thus, given the high exposure concentrations obtained in this study and the resulting health implications to workers performing abrasive blasting, more research in this area is necessary.

REFERENCES

National Institute for Occupational Saqfety and Health(NIOSH). Work Related Lung Disease Surveillance Report 1999. NIOSH, US Department of Health and Human Services, Centers for Disease Control and Prevention, Division of Respiratory Disease Studies, DHHS #2000-15, 1999

Mark D, Vincent JH. A New Personal Sampler for Airborne Total Dust in Workplaces. Ann Occup Hyg 1986; 30(1): 89-102

Kenny LC, Aitken R, Chalmers C, et al. A Collaborative European Study of Personal Inhalable Aerosol Sampler Performance. Ann Occup Hyg 1997; 41(2): 135-153

ISO International Organization for Standardization(ISO) 7708 Air Quality Particle Size Fraction Definitions for Health-Related Sampling. ISO, Geneva 1995

American Conference of Governmental Industrial Hygienists (ACGIH). 2000 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. ACGIH, 1999. Cincinnati, OH

Spear TM, Werner MA, Bootland J, Harbour A, Murray EP, et al . Comparison of Methods for Personal Sampling of Inhalable and Total Lead and Cadmium-Containing-Aerosols in a Primary Lead Smelter. Am Ind Hyg Ass J. 1997; 58:893-899