USE OF DOWNDRAFT BOOTH DESIGN IN REMOVING TOXIC DUSTS FROM PROTECTIVE CLOTHING

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ABSTRACT

Recently promulgated OSHA lead and arsenic standards require the removal of dust from protective clothing before workers enter lunch and change areas if the particular workers are exposed to concentrations of these contaminants above prescribed levels. The arsenic standard requires the use of vacuuming to do the cleaning, a process which is cumbersome, time-consuming, and not always effective. A prototype downdraft booth was developed and tested at a large copper smelter to determine whether it would be a feasible alternative for vacuuming of arsenic dusts. The booth utilized downdraft ventilation to collect dust particles dislodged from clothing by a series of air nozzles. Respiratory protection was needed during the process, which took about a minute. The effectiveness of this method was demonstrated by evaluation of airborne and settled arsenic levels in the lunchroom; the vacuuming method was evaluated in similar fashion. The results showed very small differences in contamination of the lunchroom between the two methods. The downdraft booth had the advantages of being a faster method, was more acceptable to workers, and visually did a better job.

INTRODUCTION

Both of the recently promulgated OSHA lead and arsenic standards require employees to remove dust from their protective work clothing before entering the lunchroom/changehouse areas. Although the aim of these respective provisions is to reduce levels of contamination in such facilities, the specific requirements are different. The arsenic standard requires that protective clothing be cleaned when airborne exposures exceed 0.100 mg/m^3. (The eight-hour permissible exposure limit for arsenic is 0.010 mg/m^3). Vacuuming is the only method that can be used in removing such dust. The lead standard, on the other hand, requires that all employees exposed above the permissible exposure limit of 0.050 mg/m^3 clean protective clothing before entering lunchroom and hygiene facilities. Removal of dust can be accomplished by either vacuuming, a downdraft booth, or "other cleaning method". When a situation is encountered where employees are exposed to both arsenic and lead, vacuuming, the method dictated by the arsenic standard must be chosen as the method of surface dust removal.

One such situation was encountered at a large copper smelter located in the Pacific Northwest. Before the arsenic standard, it was already recognized that arsenic and lead dusts could be a source of contamination in the lunchroom. The common practice for many years was to remove dust from protective clothing with an air hose before leaving the work area. Respirators were always worn when performing this task. With the advent of the arsenic standard, it was resolved that vacuuming would have to be substituted for this practice. However, it was soon realized that there were some aspects of vacuuming that made it less than desirable. Undesirable aspects of vacuum cleaning include:

1. Vacuuming tends to be cumbersome and time-consuming. Employees were found to take up to five minutes to do an adequate job.

2. Some types of smelter dusts tend to be "sticky", and are especially hard to remove with a vacuum when clothes are damp from perspiration or rain.

3. It is difficult for an employee to vacuum his back adequately by himself, making it almost essential that two employees to the job.

4. Vacuuming does not receive much employee acceptance in the plant, the major complaints are that it takes too long, and that much of the visible dust would not come off the clothes.

An alternative to this method would be to use a downdraft booth, as mentioned in the lead standard, with compressed air nozzles for cleaning clothes. However, to be in compliance with the arsenic standard, it would be necessary to obtain a variance from the vacuuming requirements. It was decid d that to accomplish this goal, it would be important to design, construct, and evaluate such a booth for its efficiency in cleaning protective clothing as compared to the vacuuming m thod.

DOWNDRAFT BOOTH DESIGN

One such booth has been built outside the lead and arsenic work areas of the Cottrell Department at the copper smelter, adjacent to a lunchroom/changehouse facility. This department's function is to collect dust by electrostatic precipitation before process gases are exhausted to the main stack. Arsenic content in the dusts handled here may run as high as 50%.

The prototype booth was constructed of plywood, 2.24m (8 ft) high by 1.52m (5 ft) square (Figure 1). Air is drawn through the booth at approximately 0.94m^3/sec (2,000 cfm) by a fan located outside the structure. This results in an average air velocity of 1.02m/sec (200 fpm) through the booth. Air enters the booth through openings in the ceiling. After passing a steel grating raised 15 cm (6 in.) from the floor, air is exhausted from the booth through openings located opposite each other at the bottom of the enclosure. Exhausted air is fed into a duct leading to the plant's main stack, located about 9 m (30 ft) away. This takes advantage of the natural draft already present in the stack and eliminates the need for an

Figure 1. Outside view of downdraft booth. Air is exhausted from the booth through the lower protrusions on either side of the enclosure.

individual dust collector next to the booth. Although booth intake air is untempered, it is not felt to cause a significant draft on workers, because of the relatively mild climate of the area.

In conjunction with the downdraft system are eighteen air nozzles (Figures 2 and 3) arranged on the wall opposite the door of the booth. The nozzles are located at different levels and at 45 degree angles to the worker's body. Average air velocity through each of the air nozzles is about 51m/sec (10,000 fpm). A regulator in the air line ahead of the nozzles ensures that the pressure does not exceed 2.1 Kg/cm^2 (30 psi).

USE OF THE DOWNDRAFT BOOTH

After the prototype downdraft booth was constructed, a specific procedure was adopted for use of the booth. Upon leaving the work area, the employee determined to have an airborne arsenic exposure above 0.100 mg/m^3, or a lead exposure above the permissible exposure limit of 0.050 mg/m^3 is instructed to use the booth before entering the lunchroom/changehouse facility. Before using the booth, the worker must check to make sure he has

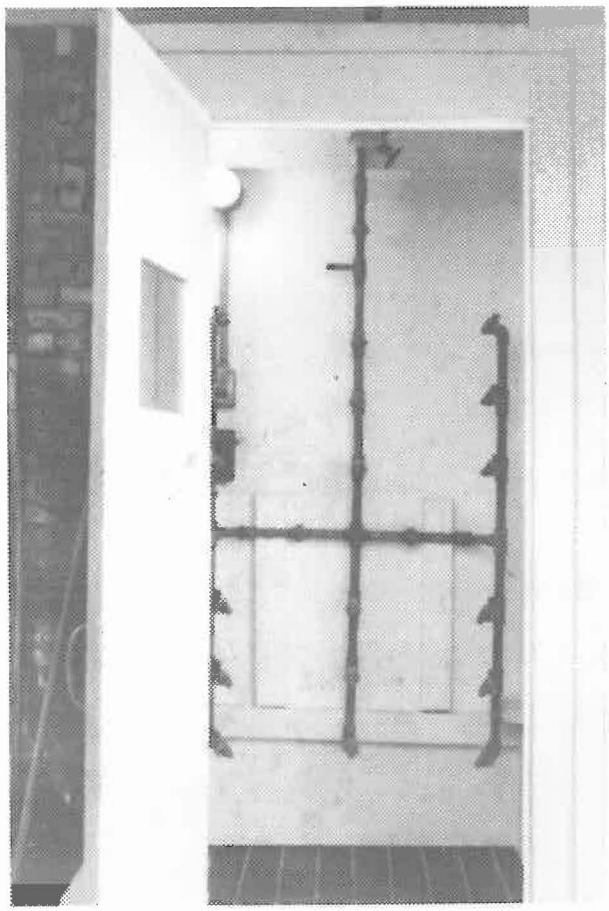

Figure 2. Inside view of downdraft booth. Banks of compressed air nozzles can be seen, with steel grating at floor level.

on all the required personal protective equipment, including respiratory protection. Protective equipment includes all that is worn in the work area: coveralls, shoes, gloves, hat, and appropriate respirator. Some of the employees use powered air-purifying respirators, which can pose a special problem when using compressed air in the downdraft booth. Since the filter/blower assembly unit is carried on the waist, the somewhat delicate high-efficiency filters are vulnerable to rupture by any compressed air directed at the unit. Therefore, a plastic guard was designed by the maintenance department to slip over the unit while the employee is in the booth cleaning his clothes. This guard protects all exposed openings of the filters from the direct impact of compressed air, but still allows air to be drawn through the filters and into the facepiece.

After properly adjusting the respirator to ensure a good face-to-facepiece seal, dust on the shoes is loosened by a foot brush located over a grating adjacent to the booth. After entering the booth, the downdraft fan pulling air through the grating at the bottom of the booth is first turned on, followed by the compressed air nozzles. Clothes are cleaned by moving body

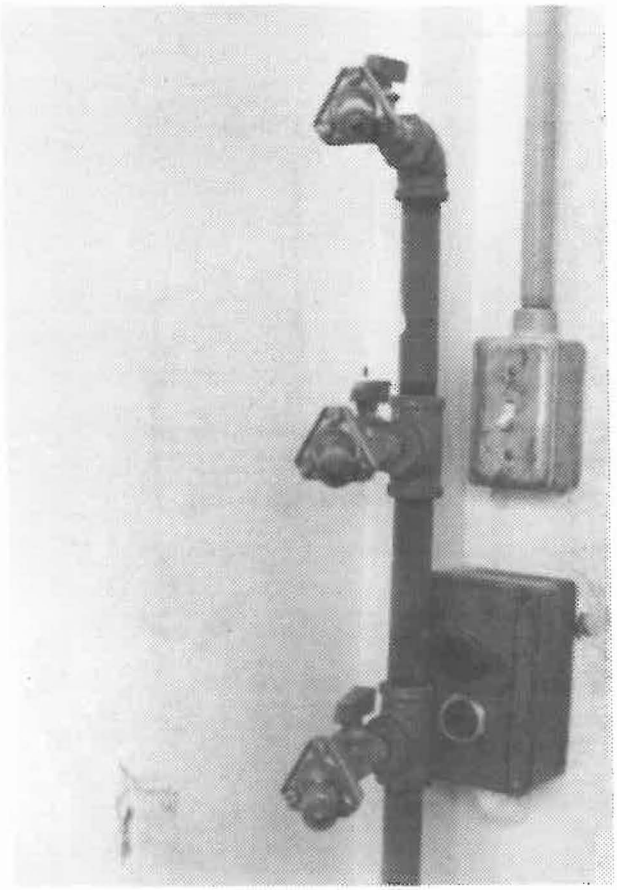

Figure 3. Close-up of air nozzles. Switch for light and on/off buttons for downdraft fan also can be seen.

and clothing past the bank of nozzles in vertical and horizontal motions. After clothing and shoes are cleaned, which usually takes no more than a minute, the nozzles are turned off. Before leaving the booth, the employee turns off the downdraft fan.

EVALUATION

Because the OSHA arsenic standard limits the cleaning of work clothing to vacuuming only, it was necessary to determine if the downdraft method is as effective as the method prescribed by this standard. Arsenic contamination in the lunchroom was selected as the criterion for effectiveness, since one of the main objectives of cleaning work clothes by either method is to reduce arsenic levels in this area. The lunchroom used for sampling in this test is pressurized by filtered air. Airborne and settled arsenic levels were monitored for two weeks on day shift while employees used the downdraft booth, and for two weeks while employees vacuumed their clothes.

Vacuuming was conducted in the open, and averaged about 4-5 minutes per employee. Cleaning clothes with the downdraft booth averaged about one minute per employee. During the test period, eight of the fourteen employees using the lunchroom cleaned their clothes before entry, based on their measured airborne arsenic exposure.

For each of the two week periods, full shift air samples were collected on a daily basis at three locations in the lunchroom. Short term air samples were obtained during the lunch period. On several occasions, breathing zone samples were collected from an average of three individuals per sample, while employees either vacuumed or blew their clothes off in the downdraft booth. Wipe samples were collected for four lunch counter locations in the lunchroom for each of the two week periods, before and after the lunch period.

All airborne samples were collected with MSA Model G portable pumps and closed-face millipore filter casettes (0.8μ pore size). Settled arsenic samples were obtained in the form of wipe samples. Each wipe sample was collected on a four-inch Whatman 41 filter, moistened with distilled, deionized water. All samples were analyzed by a colorimetric method, based on the reaction of arsine with a pyridine solution of silver diethyldithiocarbamate, producing an intense red color.

RESULTS

Results of airborne arsenic sampling conducted in the lunchroom during periods of vacuuming and downdraft booth use indicate very small differences in contamination levels when using either of the two methods (Table 1). A t-test shows the differences between all sets of data not to be significant.

Table 2 shows that breathing zone air samples collected while employees used the booth were higher than during vacuuming. This, however, could be expected, since in dislodging dust with compressed air, some of it is liable to drift into the breathing zone before it can be swept out of the booth. It is interesting to note that airborne arsenic breathing zone levels were above the eight-hour permissible exposure limit of 0.010 mg/m^3 when the prescribed method of vacuuming was used.

Table 3 summarizes the results of the wipe samples. The means given in the table are the differences in the samples taken after the lunch period minus the samples taken before lunch. Although increases in lunch counter contamination were noted in most cases after employees had finished lunch, these samples are not viewed as being too valuable, since results were, for the most part, erratic. It is felt that the qualitative nature of this test and the uneven distribution of arsenic contamination on the counters limited its effectiveness. In spite of these problems, a t-test again shows that no difference could be found between those collected during vacuuming and those collected during downdraft booth use.

Table 1. Average airborne arsenic levels in Cottrell lunchroom.

Full shift sampling	Vacuuming n	Vacuuming Mean, mg/m^3	Downdraft booth n	Downdraft booth Mean, mg/m^3	Difference	t	Probability
Location 1	10	0.0063	8	0.0168*	-0.0105	0.665	0.56
Location 2	9	0.0091	8	0.0056	+0.0035	1.40	0.19
Location 3	10	0.0098	8	0.0075	+0.0023	1.02	0.34
Short term sampling-lunch period							
Location 4	9	0.0129	8	0.0141	-0.0012	1.84	0.09

*This mean is reduced to 0.009 mg/m^3 when the one value of 0.071 mg/m^3 is not used in the calculations.

Table 2. Breathing zone arsenic levels while cleaning protective clothing.

Vacuuming n	Vacuuming Mean, mg/m^3	Downdraft booth n	Downdraft booth Mean, mg/m^3	Difference	t	Probability
5	0.102	7	4.36	-4.258	2.20	0.05

Table 3. Wipe samples analyzed for arsenic.

Location	Vacuuming n	Vacuuming Mean, µg*	Downdraft booth n	Downdraft booth Mean, µg*	Difference	t	Probability
Northwest section of counter (after-before)	9	12.81	8	18.33	-5.52	0.24	0.42
Southwest section of counter (after-before)	9	14.12	8	-37.4	51.52	1.36	0.11
Northeast section of counter (after-before)	9	25.56	8	3.3	23.26	1.13	0.15
Southeast section of counter (after-before)	9	11.46	8	5.18	6.28	1.20	0.13

*Mean of the differences in arsenic samples taken after lunch minus samples taken before lunch.

SUMMARY

The data presented above demonstrate that the downdraft booth can be as effective as vacuuming in accomplishing the goal of reducing arsenic contamination in the lunchroom/changehouse area. It takes less time than vacuuming, and also has the advantage of greater employee acceptance and better removal of visual dust that adheres to the clothing.

QUESTIONS, ANSWERS AND COMMENTARY

Comment (L. Bullock, Globe Union):

I think you failed to mention that the part of the lead standard you are dealing with in regard to employee vacuuming of clothes has been stayed as of right now.

Answer (K. Gerecke, OSHA):

It was stayed initially for a month, but it hasn't been stayed since then, so it's in effect.

Comment (L. Bullock):

You are more or less presuming that dirt on clothes affects airborne lead readings. You could also assume that dirt on clothes could also affect dirt on hands, and thus ingestion of lead which may or may not be shown by wipe and air samples.

Question (J. Dionne, Gould Inc., Metals Div.):

What was the average residence time the individual stayed in the booth and how many people can go through the booth at the same time?

Answer (C. Dungey):

It was about one minute. Only one person can fit in the booth at a time. If there are, for example, eight people that need to use the booth before lunchtime, it will only take about ten minutes to get everyone through. Often they don't all come at one time. If the number is larger than this multiple booths may be required, just as multiple vacuuming stations would be required.

Question (J. Dionne):

Or perhaps a longer booth?

Answer (C. Dungey):

A longer booth used simultaneously by a number of employees is a possibility.

NIOSH

Proceedings of the Symposium on Occupational Health Hazard Control Technology in the Foundry and Secondary Non-Ferrous Smelting Industries

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

PROCEEDINGS OF THE SYMPOSIUM ON OCCUPATIONAL HEALTH HAZARD CONTROL TECHNOLOGY IN THE FOUNDRY AND SECONDARY NON-FERROUS SMELTING INDUSTRIES

December 10-12, 1979
Chicago, Illinois

Rexnord Inc.
Environmental Research Center
Milwaukee, Wisconsin 53214

Symposium Coordinators:
Robert C. Scholz
La Donna Leazer

Contract No. 210-79-0048

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
4676 Columbia Parkway
Cincinnati, Ohio 45226

August 1981

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DHHS (NIOSH) Publication No. 81-114