Applied Occupational and Environmental Hygiene

ISSN: 1047-322X (Print) 1521-0898 (Online) Journal homepage: http://www.tandfonline.com/loi/uaoh20

Case Studies

R. E. Korczynski

To cite this article: R. E. Korczynski (1996) Case Studies, Applied Occupational and Environmental Hygiene, 11:1, 5-8, DOI: 10.1080/1047322X.1996.10389114

To link to this article: https://doi.org/10.1080/1047322X.1996.10389114

Published online: 25 Feb 2011.

Case Studies

Effectiveness of Downdraft Ventilation in Morgues

Dawn Tharr, Column Editor

Reported by R.E. Korczynski

Introduction

The Workplace Safety and Health Branch conducted a case study to assess the effectiveness of a downdraft ventilation table recently installed in the morgues at the St. Boniface General Hospital, Winnipeg, Manitoba, Canada. This study was in response to concerns raised in the health-care and funeral industries regarding the appropriateness of this ventilation system in hospital morgues and embalming rooms. Most morgues and embalming rooms employ the conventional dilution ventilation system. The recent change in the allowable airborne formaldehyde concentration [American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value-ceiling (TLV-C) to 0.3 ppm adopted 1992][1] and concern over exposure to bloodborne pathogens in autopsy and embalming procedures[2,3] have prompted a search for an effective alternate means of capturing contaminants at the source.

A previous 3-year study in the funeral industry in Manitoba[4] prompted questions from the funeral directors regarding effective ventilation controls in embalming rooms. Specifically, is the downdraft table effective in controlling personal exposures to airborne formaldehyde to levels below the current ACGIH TLV-C standard of 0.3 ppm, and if so, at what flow rate? The cost of these tables is another consideration in this industry.

Background

Formalin, widely used in embalming solutions, has been predominant in this trade since the turn of the century.[5] The long-term implications of formaldehyde use, particularly its link to human cancer, are as yet unresolved. Possible carcinogenic effects of formaldehyde in occupational environments have been cited by the National Institute for Occupational Safety and Health (NIOSH), the International Agency for Research on Cancer, and the Occupational Safety and Health Administration.[6] Effects of exposure to airborne formaldehyde include irritation of the eyes, nose, and throat; chest tightness; headaches; and fatigue.[4]

Most embalming rooms and hospital morgues in Manitoba employ conventional dilution ventilation systems with wall or ceiling exhaust fans (air flow rates of 75 to 100 ft^3/min.[4] These fans are often poorly located, relative to the embalming table, to provide for efficient movement of contaminants out of the room. The result is costly energy loss and reduced contaminant control effectiveness.[4] Airborne formaldehyde exposures among embalmers in 83 percent of the embalming rooms were found to exceed the ACGIH TLV-C of 0.3 ppm.[4] Variability was attributed to existing ventilation in the embalming room and individual work practices.

Local exhaust ventilation is one of the primary techniques used in controlling workplace exposures to airborne contaminants.[7,8] Employing this principle, modifications to existing embalming tables have been developed and tested.[9] Local exhaust ventilation was found to control the mean personal formaldehyde concentrations during the embalming procedures to less than 0.73 ppm.[9]

In other studies in the funeral industry, personal formaldehyde exposures were also found to be in excess of the current ACGIH standard. At a college of mortuary science, personal exposures ranged from 0.31 to 8.72 ppm (21 ppm peak).[10] Monitoring at seven funeral homes in the West Virginia area found time-weighted average personal formaldehyde exposures ranging from 0.1 to 0.4 ppm and from 0.5 to 1.2 ppm during the embalming of intact and autopsied bodies, respectively.[11] A study of Toronto embalmers found that ambient formaldehyde concentrations were 0.36 ± 0.19 ppm.[12] Airborne formaldehyde exposures in Pennsylvania mortuaries ranged from 0.03 to 3.15 ppm.[13] In the Detroit area, exposures in embalming rooms ranged from 0.09 to 5.26 ppm.[14]

Methods

Downdraft Table Specifications

The model DEM autopsy table, manufactured by The Jewett Refrigerator Co., Inc. (Buffalo, New York), is divided into two main areas: the pedestal base and the drainboard (Figure 1). The table's basic features include an electric vertical height adjustment (81 to 97 cm), a 180° table rotation, and perimeter spray tubes for quick flushing. The table drainboard consists of three perforated movable panels. The table was modified to have an 800 ft^3/min exhaust flow rate. The outside diameter of the air exhaust vent line is 15.2 cm. The central table exhaust is covered with a 25-cm^2 removable perforated strainer to capture any debris that may fall off the drainboard (Figure 2).

The table exhausted 40 to 50 percent of the room air supply. The remainder was exhausted through a slot exhaust located at the head of the work bench which extended along one wall and grills located at the perimeter of the ceiling.

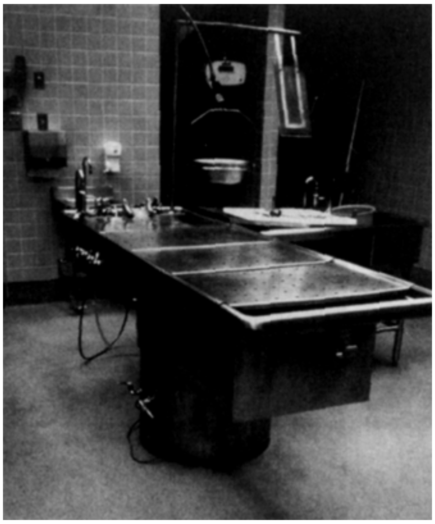

FIGURE 1. Downdraft ventilation table showing the pedestal base and drainboard consisting of three movable perforated panels.

Fresh air was supplied through three vents, each contributing 525 ft^3/min (total = 1575 ft^3/min). The positioning of the vents simulates a laminar flow over the table, analogous to a push-pull system.

The morgue was under slightly negative pressure, with an air exchange rate of approximately 20/h.

Analytical Testing

A theoretical air flow analysis and a normal work condition were monitored to assess the effectiveness of the downdraft table. In the theoretical test, the tracer gas, sulfur hexafluoride (12% SF_6:88% N_2), was used to determine the effectiveness of gas removal from the worker's breathing zone. For this test there was no body on the table. Under normal working conditions, an embalming of an autopsied body was monitored to assess personal exposures to airborne formaldehyde.

Theoretical Analysis

Sulfur hexafluoride was selected as the most suitable tracer gas.[15] The MIRAN IB portable ambient air infrared analyzer was used (minimum detectable concentration 10 ppb). The gas was introduced via a line from the cylinder through a fritted glass bubbler distributing the gas in a spherical manner.

The gas was released at secondary points above the table, but monitoring was conducted only at the worker's breathing zone (80 cm above the tabletop and 6 cm from the worker's nose). At each of the secondary points, the gas was continuously introduced for 3 minutes at a flow rate of 80 L/min (total = 240 L). Gas concentrations were recorded as 5-second averaging.

The first secondary release point was immediately above the perforated drainboard (10 cm from the tabletop). Two successive locations were 30 cm (body height) and 80 cm (breathing zone of the worker) above the tabletop (Figure 3).

Before releasing gas at each secondary point, the ambient concentration was allowed to decay to a nondetectable level. Velocity readings were taken at each of the three release points using the TA 3000 air flow instrument.

Normal Working Conditions

Airborne formaldehyde monitoring to assess the personal exposures of the embalmers was conducted during the embalming of an autopsied body. The actual air flow rate would be impeded by the presence of a body. Embalming procedures are discussed in Polson and Marshall.[5] The solution injected was a 20 percent formalin solution. The duration of this test was 70 minutes.

Personal exposures were determined by pinning two sets of impingers onto the outer garments of the two embalmers. In addition, four area samples were taken. One area sample was situated adjacent to the embalming machine which contained the formalin embalming solution. This location was chosen since, in practice, this unit is left uncovered to avoid creating an internal vacuum which would impede flow during injection. The other three samples were located in close proximity to the downdraft table.

Samples were analyzed using NIOSH Method 3500 (lower detection level 0.1 ppm). All samples were analyzed at the Environmental Sciences Centre, an American Industrial Hygiene Association board-certified laboratory, 745 Logan Avenue, Winnipeg, Manitoba.

FIGURE 2. Downdraft ventilation table showing the movable perforated drainboard panels and central exhaust with a 10-inch movable perforated strainer.

Results and Discussion

In the theoretical air flow analysis, no tracer gas was detected in the worker's breathing zone (80 cm) when sulfur hexafluoride was released immediately above (10 cm) the tabletop (Figure 3). The downward velocity recorded at this level was 1000 ft/min. Also, no gas was detected in the worker's breathing zone when sulfur hexafluoride was released at the table body height (30 cm) (Figure 3). The downward velocity recorded at this level was 725 ft/min.

Sulfur hexafluoride was, however, detected in the worker's breathing zone when released at the level of the worker's nose (80 cm) (Figure 3). At this height, the gas concentration averaged 277 ppm [arithmetic mean (AM), standard deviation (SD) ± 169, peak 880]. The downward velocity recorded at this level was 60 to 90 ft/min. As expected, these data confirm that the table exhaust has a reduced capacity as the point of generation increases from the table surface.

Under normal working conditions, the presence of a body on the table will impede the flow rate. Although the drainboard is perforated, the size of the body would be a contributing factor.[16] In the test conducted under actual working conditions, the body embalmed covered approximately 70 percent of the drainboard.

Both the personal exposures and ambient formaldehyde concentrations in the morgue were within the current ACGIH standard. The overall exposure of the two embalmers compared well with their movements to different locations during the embalming procedure and air flow patterns around the table.

One embalmer had an average personal exposure of 0.15 ppm (AM, N = 2, SD ± 0.003). The other embalmer had a personal exposure of 0.16 ppm (AM, N = 2, SD ± 0.01).

Ambient formaldehyde concentration for the area sample located by the uncovered embalming machine was 0.15 ppm.

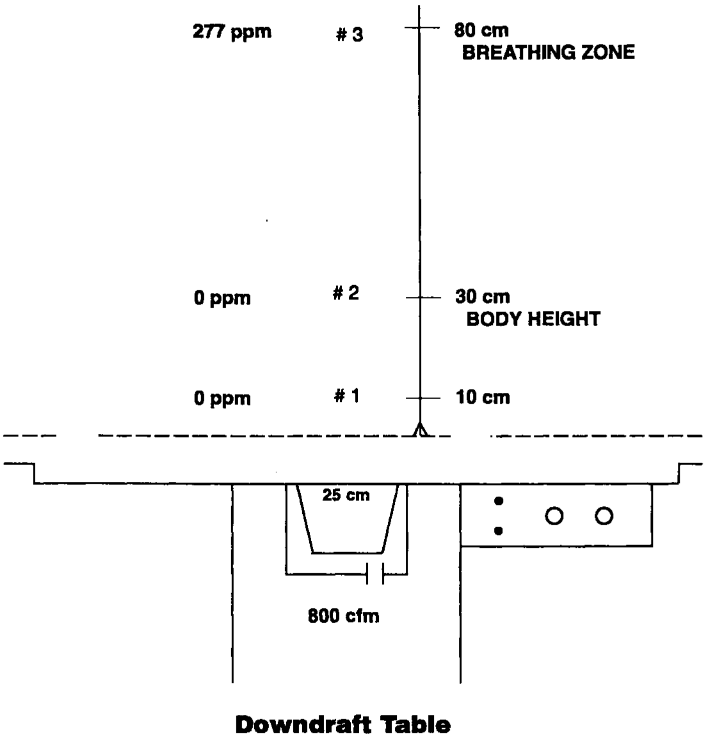

FIGURE 3. Sulfur hexafluoride concentrations (ppm) recorded at the worker's breathing zone when released at points 1 (10 cm), 2 (30 cm), and 3 (80 cm) above the drainboard.

The other three area samples were all below the detection limit of 0.1 ppm.

Conclusions

Independent variables that can influence a worker's personal exposure are diffusion and mixing rates, supply and exhaust rates, free convection around the workers, and the rate of generation of the contaminants.[7,16,17] Future research should focus on their individual and combined effects.

Engineering controls recommended to achieve effective exhaust capability of the downdraft table for use in hospital morgues and embalming rooms include:

1. Increasing the capacity of the downdraft table from the manufacturer's specifications of 280 ft^3/min (Carmen S. Muniz, Jewett International Corporation, personal communication) to 800 ft^3/min. This can be achieved by boosting the fan size. A damper on the fan is recommended to reduce the noise output.
2. Adequate maintenance of the table ex-

haust to ensure that the system is operating at its 800 ft^3/min capacity and removing any debris that accumulates on the strainer impeding air flow.
3. Placement of the supply air vents directly above the table to augment the performance capabilities of the downdraft system.
4. An air make-up unit to replace air exhausted from the table, ceiling grills, and any stationary bench slot.
5. Balancing the air handling system to maintain a slight negative pressure in the morgue with respect to adjacent rooms.
6. Keeping the cover on the embalming machine and opening a small vent into the unit to allow for replacement air as the embalming fluid is pumped out.

When these criteria were implemented, the downdraft table appeared to be effective in reducing a worker's personal exposure to airborne formaldehyde in a morgue to below the current ACGIH TLV-C of 0.3 ppm.

Acknowledgments
Special thanks to Dennis Marcoux, Claude Lavack, and JoAnne Morin, Desjardins Funeral Chapel, Winnipeg, for conducting the embalming. Thanks also to Dr. R. Stark, Brian Russell, Mike Lysyk, Horst Kaiser, and Doug Hahn, St. Boniface General Hospital, Winnipeg, for allowing the embalming to be conducted in the hospital. Ivan Sabesky, Workplace Safety and Health Branch, is gratefully acknowledged for his assistance in the field and discussion of this work, and Jim Prokopowich, Environmental Sciences Centre, Winnipeg, for preparation of field equipment. The following Workplace Safety and Health Branch staff are acknowledged for their assistance: Peter Griffin, Jim Duthie, Mark Blackburn, and Jean VanWalleghem. This material was presented at the annual American Industrial Hygiene Conference and Exposition, Anaheim, California, May 27, 1994.

References
1. American Conference of Governmental Industrial Hygienists: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices: 1992–1993. ACGIH, Cincinnati, OH (1992).
2. Henry, K.; Dexter, D.: Recovery of HIV at Autopsy. N. Engl. J. Med. 321(26): 1833–1834 (1989).
3. Bankowski, M.J.; Landay, A.L.; Staes, B.; et al.: Postmorteum Recovery of Human Immunodeficiency Virus Type I from Plasma and Mononuclear Cells. Implications for Occupational Exposure. Arch. Pathol. Lab. Med. 116:1124–1127 (1992).
4. Korczynski, R.E.: Formaldehyde Exposure in the Funeral Industry. Appl. Occup. Environ. Hyg. 9(8):575–579 (1994).
5. Polson, C.J.; Marshall, T.K.: The Disposal of the Dead, 3rd ed. The English Universities Press Ltd., London (1975).
6. Blair, A.; Saracci, R.; Stewart, P.A.; et al.: Epidemiologic Evidence on the Relationship Between Formaldehyde Exposure and Cancer. Scand. J. Work Environ. Health 16:381–393 (1990).
7. Sandberg, M.: Ventilation Efficiency as a Guide to Design. ASHRAE Trans. 89(2B):455–479 (1983).
8. Ellenbecker, M.J.; Gempel, R.F.; Burgess, W.A.: Capture Efficiency of Local Exhaust Ventilation Systems. Am. Ind. Hyg. Assoc. J. 44(10):752–755 (1983).
9. Gressel, M.G.; Hughes, R.T.: Effective Local Exhaust Ventilation for Controlling Formaldehyde Exposures During Embalming. Appl. Occup. Environ. Hyg. 7(12):840–845 (1992).
10. Stewart, P.A.; Herrick, R.F.; Feigley, C.E.; et al.: Study Design for Assessing Exposures of Embalmers for a Case-Control Study. Part I. Monitoring Results. Appl. Occup. Environ. Hyg. 7(8):532–540 (1992).
11. Williams, T.M.; Levine, R.J.; Blunden, P.B.: Exposure of Embalmers to Formaldehyde and Other Chemicals. Am. Ind. Hyg. Assoc. J. 45(3):172–176 (1984).
12. Holness, D.L.; Nethercott, J.R.: Health Status of Funeral Service Workers Exposed to Formaldehyde. Arch. Environ. Health 44(4):222–228 (1989).
13. Moore, L.L.; Ogrodnik, E.C.: Occupational Exposure to Formaldehyde in Mortuaries. J. Environ. Health 49(1): 32–35 (1986).
14. Kerfoot, E.J.; Mooney, T.F.: Formaldehyde and Paraformaldehyde Study in Funeral Homes. Am. Ind. Hyg. Assoc. J. 36:533–537 (1975).
15. Hampl, V.: Evaluation of Industrial Local Exhaust Hood Efficiency by a Tracer Gas Technique. Am. Ind. Hyg. Assoc. J. 45(7):485–490 (1984).
16. Homma, H.; Yakiyama, M.: Examination of Free Convection Around Occupant's Body Caused by its Metabolic Heat. ASHRAE Trans. 94(1):104–124 (1988).
17. Klm, I.G.; Homma, H.: Distribution and Ventilation Efficiency of CO_2 Produced by Occupants in Upward and Downward Ventilated Rooms. ASHRAE Tech. Data Bull. 8(2):93–101 (1992).

EDITORIAL NOTE: Dr. Korczynski is with the Occupational Hygiene Unit, Workplace Safety and Health Branch of the Manitoba Labour Department. She can be contacted at 200-401 York Avenue, Winnipeg, Manitoba, Canada R3C OP8; telephone: 204-945-3614; fax: 204-945-4556.