IN-DEPTH SURVEY REPORT

CHARACTERIZATION OF METALWORKING MISTS DURING THE EVALUATION OF A COMMERCIAL AIR CLEANER

at

Sauer Sundstrand Company
LaSalle, Illinois

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Public Health Service
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National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
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PLANT SURVEYED	Sauer Sundstrand Company Airport Road LaSalle, Illinois 61301
SIC CODE	3561
SURVEY DATES	March 4–5, 1997
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ABSTRACT

On March 4-5, 1997, researchers from the National Institute for Occupational Safety and Health (NIOSH) visited the Sauer Sundstrand transmission plant in LaSalle, Illinois This visit was conducted because the Engineering Control Technology Branch (ECTB) is considering projects involving the implementation of control measures to limit occupational exposure to metalworking fluids Four personal breathing zone samples collected and analyzed for total particulate revealed concentrations which ranged from 0 21 to 0 28 milligrams of particulate per cubic meter (mg/m^3) of sampled air

Exposure mapping with Respirable Aerosol Monitors (RAMs) indicated that exposures are relatively higher near the back of the transfer lines Video exposure monitoring conducted at transfer line 2901 indicated that a nearby flume and the operation of the transfer line were the source of the monitored employee's exposure, rather than any job or task performed by that employee Video exposure monitoring performed at Makino Machining Center 4853 revealed that the monitored employee's exposure was caused by mist leaking from the nonventilated machining centers The use of compressed air to remove chips and fluid from finished castings and standing in front of the enclosure to remove parts from the machining center increased the employee's exposure

Because very few of the machines at this plant use ventilation to control mist, the mist appears to be uniformly dispersed throughout the plant Therefore, addressing a few sources of mist generation will probably not reduce exposures at this plant To control metalworking fluid exposures at this plant would require the installation of air cleaners on all machining centers and reduction of mist generated at the transfer lines by enclosing them Because of the configuration of the transfer lines, enclosing them may be prohibitively expensive

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is located in the Centers for Disease Control and Prevention (CDC), under the Department of Health and Human Services (DHHS) (formerly the Department of Health, Education, and Welfare). NIOSH was established in 1970 by the Occupational Safety and Health Act, at the same time that the Occupational Safety and Health Administration (OSHA) was established in the Department of Labor (DOL). The OSHAct legislation mandated NIOSH to conduct research and education programs separate from the standard and enforcement functions conducted by OSHA. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards.

The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering (DPSE) has been given the lead within NIOSH to study and develop engineering controls and assess their impact on reducing occupational illness. Since 1976, ECTB has conducted a large number of studies to evaluate engineering control technology based upon industry, process, or control technique. The objective of each of these studies has been to evaluate and document control techniques and to determine the effectiveness of the control techniques in reducing potential health hazards in an industry or for a specific process.

At the time of this visit, NIOSH was in the process of developing a recommended exposure limit for metalworking fluids. This recommended exposure limit may involve a time-weighted average of 0.5 mg/m^3. This exposure limit is likely to be much lower than the existing limits which are enforced by OSHA. This visit was conducted because ECTB is considering projects involving the implementation of control measures for occupational exposure to metalworking fluids. The purpose of such a project would be to evaluate the feasibility of controlling metalworking fluid mist exposures to concentrations which are below 0.5 mg/m^3. In addition, this visit was conducted to gain background information about the sources of metalworking fluid mist exposure.

HEALTH EFFECTS OF AIR CONTAMINANTS AND ENVIRONMENTAL CRITERIA

There are many health effects associated with metalworking fluid exposures including dermatitis,[1] respiratory disease,[2] and asthma.[3] Cross-shift decrements in lung function are reported for inhalable aerosol exposures larger than 0.2 mg/m^3. Microbial contamination and endotoxins (debris from dead microbes) may also be responsible for adverse pulmonary health effects.[2] Some ongoing research has suggested that lifetime exposures to specific types of metalworking fluids (straight, soluble, and synthetic) are associated with several digestive cancers.[4] For these reasons, it is prudent to control exposures to metalworking fluids.

The primary sources of environmental evaluation criteria in the United States that can be used for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs), (2) the American

Conference of Governmental Industrial Hygienists's (ACGIH) Threshold Limit Values (TLVs), and (3) the U S Department of Labor (OSHA) Permissible Exposure Limits (PELs) The OSHA PELs are required to consider the feasibility of controlling exposures in various industries where the agents are used, the NIOSH RELs, by contrast, are based primarily on concerns relating to the prevention of occupational disease [5,6] ACGIH Threshold Limit Values (TLVs) refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects ACGIH states that the TLVs are guidelines [7] The ACGIH is a private, professional society It should be noted that industry is legally required to meet only those levels specified by OSHA PELs Exposure limits for substances listed on the material safety data sheets are summarized in Table 1 and the limits listed in Table 1 are all as time-weighted average (TWA) exposures A TWA exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday Some substances have recommended short-term exposure limits (STEL) or ceiling values that are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures

Table 1. Exposure Limits for Air Contaminants.

SUBSTANCE	OSHA PEL (mg/m^3)	ACGIH TLV (mg/m^3)
Oil Mist	5	5
Triethanolamine		5
Particulates Not Elsewhere Regulated	15	10

PLANT DESCRIPTION

Sauer Sundstrand Company, in LaSalle, Illinois, was 32 years old at the time of the survey In this location, there are approximately 200 employees in the production area. Transmissions are produced for off-the-road vehicles such as lawn mowers and agricultural equipment The iron and steel castings which are brought in the plant are preshaped for transmissions Additional metalworking is performed on the piece including milling, drilling, tapping, and grinding These operations are performed at automated machining centers, transfer lines, and machining cells which involve less automation

At the machining centers, the worker feeds the part in the machine The machine is controlled by a computer After a number of operations are performed on the part, the worker removes the part from the machine, and uses compressed air to blow the metalworking fluid and metal shavings off of the part These machines are very enclosed, which protects workers from the machine spray Generally, each machine had its own fluid reservoir and fluid-cleaning equipment

At the transfer lines, the worker feeds parts onto a conveyor line The conveyor moves parts to a number of stations At each station, a machining operation is performed while coolant is flooded over the part The workstation is situated such that the worker can see all of the machining operations, which are arranged on a straight line The coolant drains into an open flume which drains into equipment which cleans the fluid In these flumes, the flow toward the fluid treatment unit is augmented by coolant jets After the last machining station, the part stops at a "washing station " At this station, coolant is flooded over the part This operation seemed to generate visible mist emissions and, in some instances, this operation was located close to other workstations

This plant has some machining cells Machining cells have all the machine tools needed to carry out a number of operations At these machining cells, the worker manually fed parts into the machines These operations did not involve computer control and the operations appeared to be much less automated than the other operations

MEASUREMENT PROCEDURES

One purpose of this visit was to obtain some insight into mist generation at less automated machining operations Aerosol photometers were used to study how the mist concentration varied throughout the plant At two machining operations, the effect of specific tasks upon exposure were studied by recording exposure measurements from an aerosol photometer and concurrently recording the workers activities with a video camera This procedure is termed "Video Exposure Monitoring " In addition, total particulate concentrations were measured on four workers The details of these measurements are described below

CONCENTRATION MAPPING

In this plant, support columns are identified by letters and numbers These support columns are arranged in a square grid with a distance of approximately 50 feet between each column One of three Real-time Aerosol Monitors (RAM) (MIE Inc , Bedford, Massachusetts), RAM-1, was used to record the RAM reading near each column A team of four investigators (Heitbrink, Echt, Olenec, and Zack) recorded a RAM reading near each column These RAMs were zeroed and spanned according to the manufacturer's directions

The RAM-1 was operated on the 0-2 milligrams per cubic meter (mg/m^3) range and at a time constant of 32 seconds After standing near the beam for a period of 1-2 minutes, the RAM reading was recorded In the instrument's sensing chamber, the RAM measures the quantity of light scattered by the entire cloud The quantity of scattered light is a function of concentration and the aerosol's optical properties Thus, this instrument's response is a measure of relative concentration

VIDEO EXPOSURE MONITORING

Video exposure monitoring was used to study in greater detail how specific tasks affected the worker's exposure to air contaminants [9,8] The worker's air contaminant exposures were continuously monitored and, concurrently, the worker's activities were recorded on videotape An aerosol photometer, the Hand-held Aerosol Monitor (HAM) (PPM Inc , Knoxville, Tennessee), was used to monitor the worker's aerosol exposures This instrument was positioned on the worker's chest using a belt and harness A battery-operated pump (SKC, Eighty-Four, Pennsylvania) was used to draw air through the HAM's sensing chamber at a rate of 2 lpm In the HAM, light from a light-emitting diode is scattered by the aerosol, and forward-scattered light is detected The amount of scattered light is proportional to the analog output of the HAM However, the calibration of the HAM varies with aerosol properties such as refractive index and particle size [9] Therefore, HAM measurements are expressed as "relative exposure" or "the HAM analog output" which has units of volts The HAM 's range was set at 0-2 mg/m^3 and the time constant was set at 1 second At these settings, the analog output of 1 volt was equal to a dust concentration of 1 mg/m^3 The analog output of the HAM was recorded by a data logger (Model dl-3200, Metrosonics, Inc , Rochester, New York) also attached to the worker's belt When the data collection was completed, the data logger was downloaded to a personal computer for storage and analysis

CONCENTRATION MEASUREMENTS

The worker's exposure to total particulate (dust) was measured using NIOSH Method 0500 [10] In this method, a known volume of air is drawn through a preweighed PVC filter by a battery-operated personal sampling pump (Escort, MSA, Pittsburgh, Pennsylvania) The weight gain of the filter is then used to compute the milligrams of particulate per cubic meter of sampled air The particulate exposures of four workers were measured

RESULTS AND FINDINGS

The four particulate exposures are listed in Table 2 All of these concentrations appear to be below 0 5 mg/m^3 This indicates that the exposures are acceptable in terms of the exposure criteria listed which are described earlier in the report Because respiratory health effects are reported at exposures as low as 0 2 mg/m^3, some exposure reduction should be considered

Table 2. Total Particulate Concentrations Measured on Four Workers.

Sample Location	Mass Collected (mg)	Sample Volume (m^3)	Concentration (mg/m^3)
Surface Grinder Operator	0 11	0 53	0 21
1137 Transfer Line Operator	0 18	0 76	0 24
0119 Transfer Line Leadman	0 18	0 63	0 28
Machine Operator-Swash Plate Area	0 18	0 71	0 25

Figure 1 presents the concentrations measured with the RAM These concentrations appear to be somewhat higher near the end of the transfer lines At this location, the RAM is close to the filter/separator units used to treat the fluids and it is close to a parts-washing station on the transfer line Both operations appeared to create much mist The following table lists additional RAM readings taken at various positions on different transfer lines These readings were taken on the afternoon of March 4th

Table 3. RAM Readings Taken Around Various Transfer Lines.

Transfer Line Number or Equipment Number	Description	RAM Reading (mg/m^3)
1137	Over flume, above a flushing jet This line was not running	0 51 0 55
414	Over flume, line not running	0 25
Filter/Separator Unit 4866		0 3
2957	At wash station, which is close to operator station for line 119	1 1
2957	Above flume, flushing jets	0 15
2957	Workstation	0 14
119	Above flume, no machining	0 25
119	Next to wash station	0 22

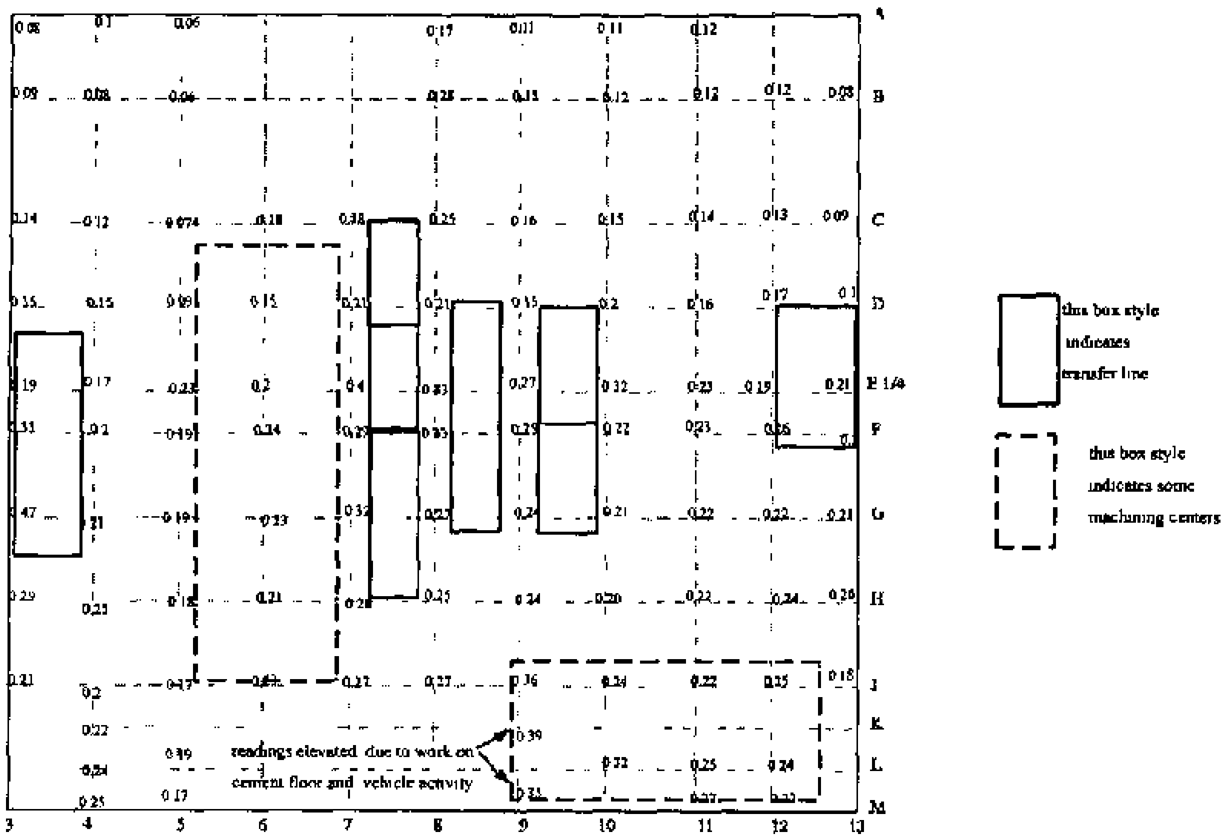

Figure 1 Concentration map Concentrations (mg/m³) were measured with RAM near various locations in the plant

Figures 2-4 present the results of the video exposure monitoring at transfer line 2901 and at a Makino machining center (Machine I D 4853) As shown in Figure 2, the operator's air contaminant exposure did not involve noticeable peak exposures This indicates that his job tasks are not causing his exposure His air contaminant exposure is probably caused by flume and the operation of the transfer line

Figure 3 presents the results of the video exposure monitoring at the Makino machining center The exposure in Figure 3 has numerous peaks and one noticeable valley The latter occurred when the worker walked away from the machining center This suggests that 50 percent of the worker's exposure is caused by mist leaking from the nonventilated machining centers Figure 4 presents a more detailed examination of some of the results presented in Figure 3 In Figure 4, compressed air blow-off and standing in front of the enclosure to remove parts from the machining center apparently increased worker exposure to metalworking fluid mist

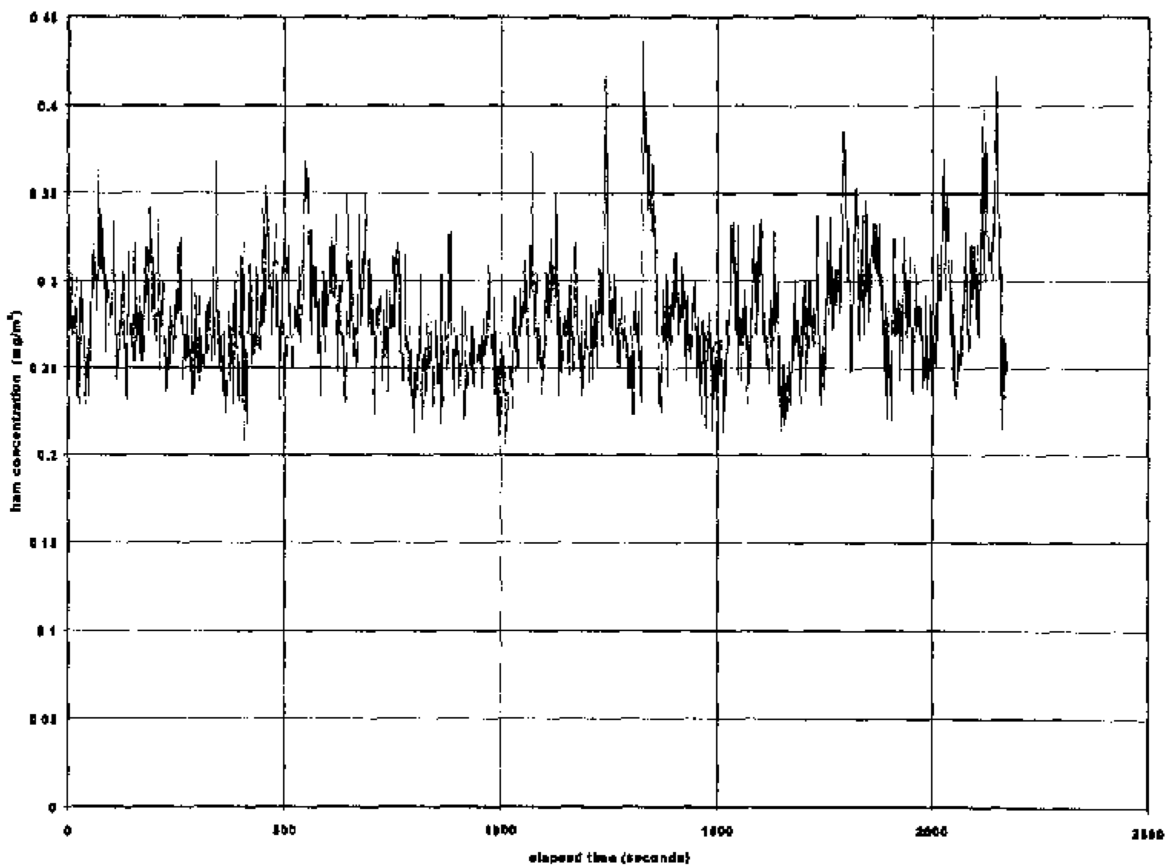

Figure 2 Worker exposure at transfer line 2901 The worker's exposure to mist appears to be unaffected by the tasks performed while standing at his workstation

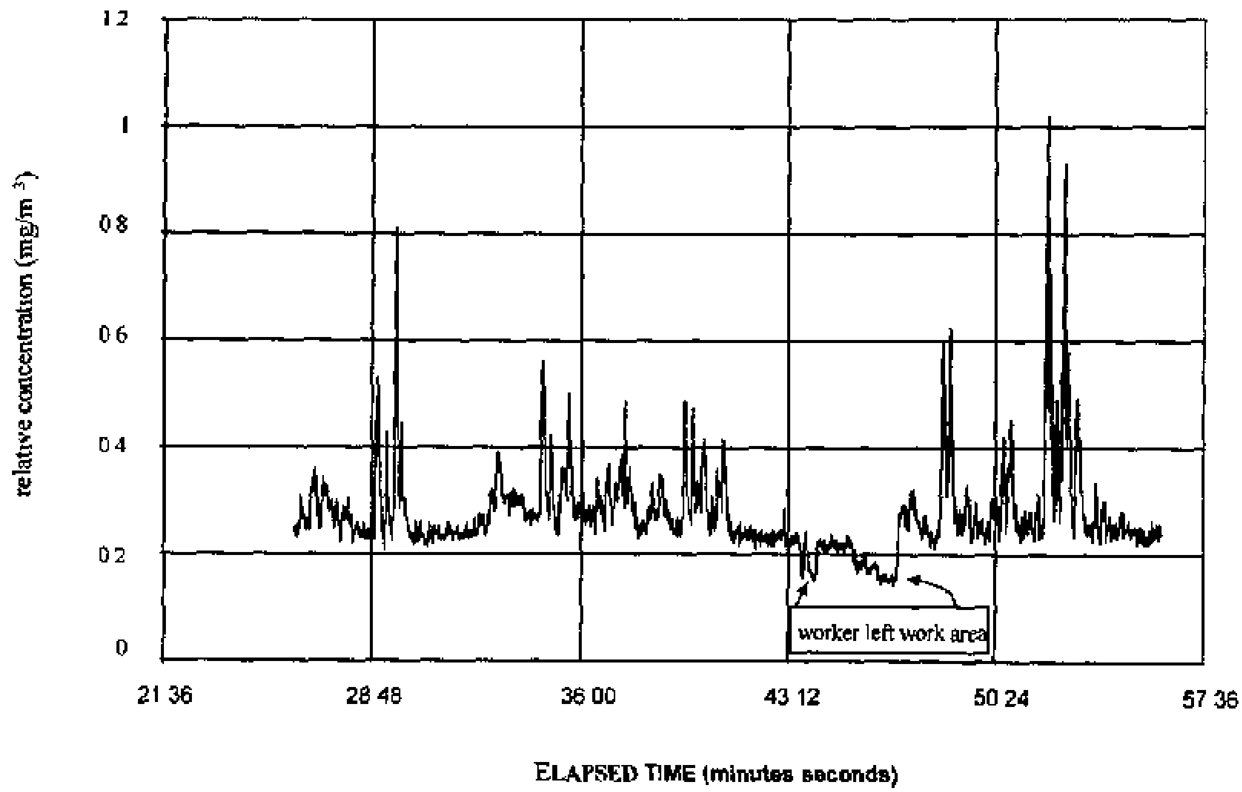

Figure 3 At Makino Machine Number 4853, the worker's exposure appears to be elevated by his presence at the workstation

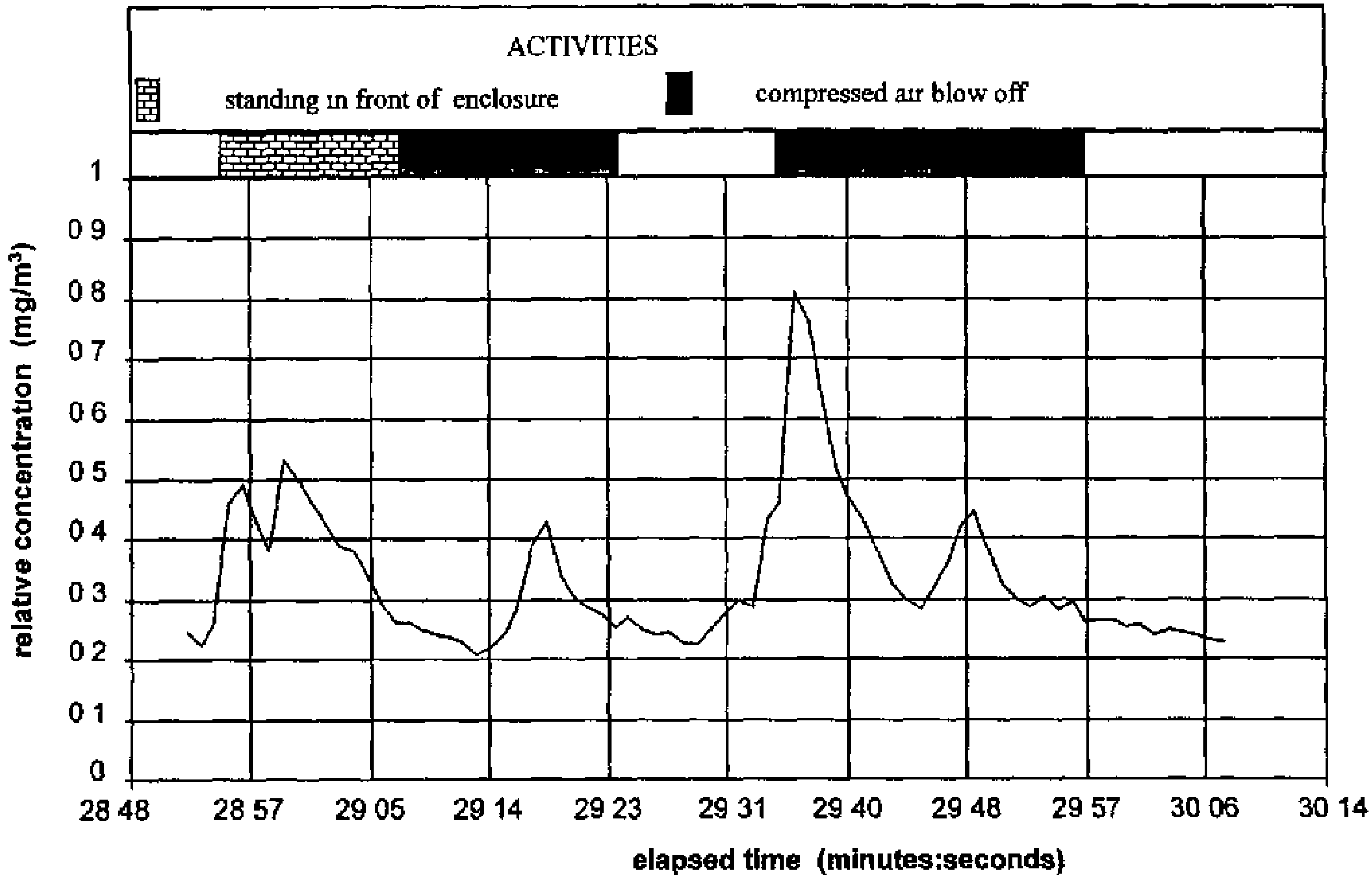

Figure 4. At the Makino Machining Center 4853, worker exposure is increased by compressed air blow-off and opening the door to the machining center This plot has finer resolution than Figure 3

DISCUSSION AND CONCLUSIONS

Very few of the metalworking machines at this plant used ventilation to control the mist generated by the machining operations As a result, mist concentrations appear to be dispersed throughout the plant and the concentrations appear to be rather uniform as shown in Figure 1 Simply addressing a few sources of mist generation probably will not reduce exposures at this plant For example, in Figure 3, about half of the exposure appears to come from the operator's machining operations The other half of the worker's exposure occurs due to this background of mist Because the transfer lines and their flumes are not enclosed, these transfer lines and flumes are probably a major source of the mist in the plant

To control metalworking fluid exposures at this plant, mist emissions from the machining centers and the transfer lines need to be controlled The mist generated at the machining centers can be controlled by using air cleaners, as was done at Sauer Sundstrand's Ames, Iowa, plant Each machining center was ventilated by an air cleaner which exhausted air from the enclosure and passed the air through a set of filters before discharging the air back into the plant At the Ames, Iowa, plant, the completely enclosed flumes and ventilated hydromation units greatly enhanced the control of metalworking fluid mists

Controlling mist generation at the transfer lines is problematical The operators' mist exposures could be reduced by using an air shower However, this does not address the mist exposures caused by the dispersal of mist from the transfer line throughout the plant To control the mist generated by the transfer line, one would probably need to completely enclose the transfer lines and ventilate each enclosure with a separate air-handling system This would result in the transfer lines being placed in a separate building within the plant Doors would be needed to access the transfer line Constructing the enclosure might require that nearby machining centers be moved At least some of this adjacent equipment is set in concrete Consequently, the costs of constructing and installing an enclosure around the transfer line may be prohibitive

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