This Health Hazard Evaluation (HHE) report and any recommendations made herein are for the specific facility evaluated and may not be universally applicable. Any recommendations made are not to be considered as final statements of NIOSH policy or of any agency or individual involved. Additional HHE reports are available at http://www.cdc.gov/niosh/hhe/reports

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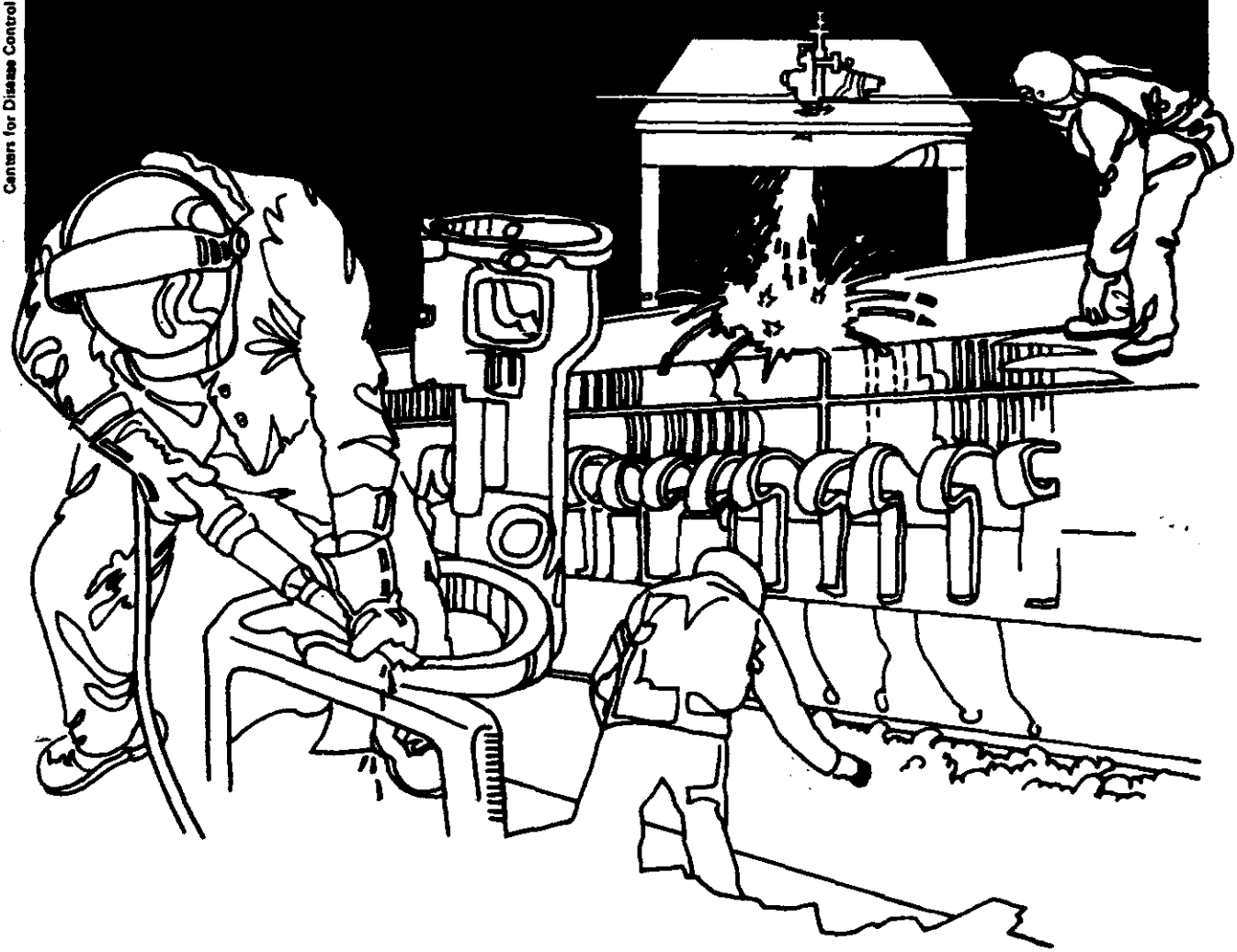

Health Hazard Evaluation Report

HETA 87-268-1900
BESTOP, INC.
LONGMONT, COLORADO

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 87-268-1900
MAY 1988
BESTOP, INC.
LONGMONT, COLORADO

NIOSH INVESTIGATOR:
Anne T. Nichting, CIH

I. SUMMARY

In May 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request from management of Bestop Inc., Longmont, Colorado to determine if there was a health hazard from exposure to a one component, urethane polyester powder coating. The powder coating is painted on automotive metal accessory parts using an electrostatic spray application method.

An industrial hygiene evaluation was conducted by a NIOSH industrial hygienist on August 5,1987 to evaluate chemical and nuisance dust exposures among Powder Spray painters. The survey included personal breathing zone (PBZ) and area air sampling for nuisance dust, caprolactam vapor, caprolactam dust, and isocyanates and collection of bulk samples for isocyanates.

The results of time-weighted average (TWA), area samples collected for nuisance dust ranged from 0.09 mg/m^3 (milligrams of substance per cubic meter of air) to 1.27 mg/m^3. The results of TWA, PBZ samples collected for nuisance dust ranged from 1.42 mg/m^3 to 12.21 mg/m^3. A PBZ sample collected from one painter (12.21 mg/m^3) was above the evaluation criteria of 10 mg/m^3. Samples collected for caprolactam dust were below the laboratory limit of detection of 0.06 milligrams per sample (0.14 mg/m^3 for the air volume sampled). Results for seven samples collected for caprolactam vapor ranged from nondetectable to less than the laboratory limit of quantitation (0.05-0.07 mg/m^3). One area sample collected near the loading dock contained 0.10 mg/m^3 caprolactam vapor. Six area samples collected for isocyanates were below the laboratory limit of detection (0.87 ug/m^3 (micrograms per cubic meter of air) for TDI and 1.2 ug/m^3 for MDI). No other isocyanate monomers were detected. Accurate face velocity measurements could not be obtained for the two paint spray booths. Ducting from roof mounted swamp coolers had been placed above both painters to provide cooling as the paint spray booths are in close proximity to the curing oven. Spray painters reported symptoms consistent with exposure to either high levels of nuisance dust or upper respiratory tract irritants.

A personal breathing zone sample for nuisance dust collected from a painter was above the evaluation criteria. The NIOSH investigator concluded a health hazard from exposure to nuisance dust existed during the survey. Using an air hose to remove dust from work clothes and using dry cleaning methods may have contributed to the painter's nuisance dust exposure. Airborne concentrations of caprolactam dust, caprolactam vapor, and isocyanates were all below the corresponding evaluation criteria; however, symptoms reported by exposed workers suggested exposure to high levels of nuisance dust or a upper respiratory tract irritant.

On the basis of the data obtained during this survey, the investigator concluded that there was a health hazard from exposure to nuisance dust during the survey. Recommendations to reduce employees' exposures to nuisance dust are contained in the full body of this report.

KEYWORDS: SIC 3714 (Motor Vehicle Parts and Accessories), caprolactam, blocked isocyanates, isocyanates, nuisance dust

II. INTRODUCTION

In May 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request from management of Bestop Inc., Longmont, Colorado to determine if there was a health hazard from exposure to a one component, urethane polyester powder coating. The powder coating is painted on automotive metal accessory parts (e.g., spare tire carrier arms, top hardware for jeep soft tops, miscellaneous mounting brackets, etc.) using an electrostatic spray application method.

On June 16, 1987 an opening conference was held with management and information concerning the painting process and materials used was obtained. Following this meeting, a walk through survey of the Powder Spray Department was conducted.

An industrial hygiene evaluation was conducted by a NIOSH industrial hygienist on August 5, 1987 to evaluate chemical and nuisance dust exposures among Powder Spray Department painters. The survey included personal breathing zone (PBZ) and area air sampling for nuisance dust, caprolactam dust, caprolactam vapor, and isocyanates and analysis of bulk samples for isocyanates. The four painters on the day shift were interviewed to determine if there were any health complaints related to either nuisance dust, caprolactam dust, caprolactam vapor, or isocyanate exposure. Results were discussed by telephone with a management representative on December 14, 1987.

III. BACKGROUND

Bestop, Inc. manufactures automobile bras and automotive accessories. A urethane polyester powder coating is used at Bestop, Powder Coating Department, to provide a protective coating and a textured finish for metal accessory parts (e.g., spare tire carrier arms, top hardware for jeep soft tops, miscellaneous mounting brackets, etc.).

Metal parts to be finished arrive in the Powder Spray Department and are hung on a chain conveyor. The chain conveys the metal parts through an enclosed and ventilated, five stage chemical wash and a 400 °F drying oven. The metal parts are then conveyed through two, ventilated spray booths where they are sprayed with a one component, urethane polyester powder coating. An electrostatic spray application method is used. After painting the metal parts are conveyed through a 375°-395°F curing oven. The finished metal accessories are then conveyed to an area where they are removed from the chain conveyor and packaged for shipment. The Powder Spray Department was located on the first floor of one building and comprised of one large manufacturing area and an enclosed office area.

There are two ten hour shifts with four powder spray painters on the day shift (5:00 AM to 3:30PM) and four painters on the evening shift (3:30 PM to 2:00 AM). Painters work half of the shift painting and half putting unfinished parts on the trolley wire, removing finished parts from the chain conveyor, and packaging finished parts for shipment.

Management expressed concern about employee exposure to chemical components of the powder coating in the written health hazard evaluation request and during the initial June 16, 1987 survey. A Material Safety Data Sheet (MSDS) obtained from the powder coating manufacturer listed a single hazardous ingredient (5%-25% by weight) with the balance nuisance dust. The hazardous ingredient was listed as a catalyst and a trade secret. The MSDS listed effects of overexposure to the catalyst as irritation of the eyes, nose, and throat with a TLV (Threshold Limit Value) of 1 mg/m^3 (milligrams of substance per cubic meter of air) for catalyst dust and 5 ppm (parts of vapor or gas per million parts of air by volume) for catalyst vapor. (Please refer to Section V of this report for a more detailed discussion of evaluation criteria, including TLVs.)

The NIOSH investigator obtained additional information from the manufacturer prior to the August 5, 1987 industrial hygiene survey. The urethane polyester powder coating is a one component system which contains a caprolactam blocked isocyanate. At cure temperatures caprolactam is expelled and the liberated isocyanate reacts with the polyester resin. The caprolactam which is expelled can diffuse and show up in the curing oven exhaust. Ventilation and collection of the expelled caprolactam is required. The blocked isocyanates are manufactured using an excess of caprolactam and therefore should contain no free isocyanate. At curing temperatures, any isocyanate formed reacts with the polyester resin and would be unlikely to diffuse out of film. The 1987-1988 ACGIH (American Conference of Governmental Industrial Hygienists) TLV for caprolactam is the same as the TLV given in the MSDS.

IV. EVALUATION DESIGN AND METHODS

On August 5, 1987 an industrial hygiene survey was conducted by a NIOSH industrial hygienist in the Powder Spray Department. Personal exposures and average area concentrations of nuisance dust, isocyanates, caprolactam dust, and caprolactam vapor were determined. Eight air samples (four personal breathing zone (PBZ) and four area samples) were collected for nuisance dust on preweighed, polyvinyl chloride filters and analyzed according to NIOSH Method 0500.(1) Six area samples were collected on coated glass wool and analyzed for isocyanates according to NIOSH P&CAM (Physical and Chemical Analytical Method) 326.(2) Eight air samples (three PBZ samples and five area samples) were collected for caprolactam vapor on XAD-2 sorbent tubes and analyzed by gas chromatography and flame ionization detection.(3) Eight air samples (three PBZ samples and five area samples) were collected for caprolactam dust on Zeflour filters and analyzed by gas chromatography and flame ionization detection.(3) Two bulk samples of powder coating were collected and analyzed for 2,4-Toluene Diisocyanate (2,4 TDI) and 2,6-Toluene Diisocyanate (2,6 TDI) by high performance liquid chromatography.

Dry bulb and wet bulb temperature measurements were taken through out the shift.

A hand held, battery operated thermo-anemometer was used to measure the face velocity of each paint spray booth. The spray booth opening was visually divided into eight grids of equal area and a velocity reading

taken at the center of each grid. The velocity reading values were averaged to give a single face velocity reading for each booth.

Smoke tubes were used to verify proper air flow and patterns for each paint spray booth. A complete traverse over the entire face area was performed.

The four painters on the day shift were interviewed to determine if there were any health complaints related to nuisance dust, caprolactam dust, caprolactam vapor, or isocyanate exposure.

V. EVALUATION CRITERIA

A. Environmental

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH recommended exposure limits (RELs), by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time weighted average (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 or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

	Environmental Exposure Limits 8-Hour Time Weighted Average (TWA)	
Caprolactam aerosol	1 mg/m^3	(ACGIH)1/
Caprolactam vapor	1 mg/m^3	(ACGIH)1/
Toluene diisocyanate (TDI)	0.140 mg/m^3 C	(OSHA)
	0.035 mg/m^3	(NIOSH)
	0.040 mg/m^3	(ACGIH)1/
Methylene diphenyl isocyanate (MDI)	0.200 mg/m^3 C	(OSHA)
	0.050 mg/m^3	(NIOSH)
	0.200 mg/m^3 C	(ACGIH)
Nuisance particulates	10 mg/m^3	(ACGIH)
	15 mg/m^3	(OSHA)

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mg/m^3 = milligrams of substance per cubic meter of air.
C = Ceiling value which should never be exceeded.
1/ 1987-1988 Notice of Intended Changes to the ACGIH TLVs

B. Toxicological

1. Caprolactam

Major commercial uses of caprolactam are as a chemical intermediate in the synthesis of Nylon 6 fibers and the manufacture of synthetic fibers of the polyamide type. In animal studies, caprolactam has been shown to be hypertensive and cause convulsive activity, accelerated respiration, and inflammation of lungs.(4) The response of workers exposed to caprolactam has been reported in the Soviet literature, by Hohensee in Germany, and by Ferguson and Wheeler in the United States. (5-7) Caprolactam is a severe irritant of the eyes and upper respiratory system. Exposure to caprolactam dust or mist can also result in skin irritation.(4) The 1987-1988 Notice of Intended Changes to the ACGIH TLVs recommends a TLV-TWA of 1 mg/m^3 for caprolactam present as vapor or aerosol. The recommended TLV is to prevent early signs of irritation to some workers.(8) The in vitro mutagenic effects of caprolactam has been evaluated in the Ames test, Chinese hamster ovary cell test, and chemical transformation tests on secondary hamster embryo cells. Uniformly negative test results indicated that caprolactam does not represent a genetic hazard to man.(9)

2. Isocyanates

Occupational exposure to isocyanates has well recognized adverse health effects. All isocyanates should be considered a class of compounds with reasonably uniform effects on employee health. The isocyanates are strong irritants of the eyes, mucous membrames and skin. Acutely, in high concentrations, these materials are severe irritants of the upper and lower respiratory tract. A second respiratory response of major concern is the potential development of sensitization to isocyanates in which some individuals may have severe asthma-like reactions (immediate, delayed, or both) at concentrations much lower than those producing irritation. A third type of respiratory response to isocyanates is that of acute and chronic decrease of ventilatory capacity. Chronic effects that have been reported include excess declines in the forced vital capacity (FVC), increased prevalence of bronchitis and dyspnea and possibly, hypersensitivity pneumonitis.(10-13) After a thorough review of the literature available at the time, NIOSH recommended a workplace environmental standard of 0.035 mg/m^3 for TDI and 0.050 mg/m^3 for MDI.(10) More recent findings indicate that even this low value may not protect sensitized workers.(8)

3. Nuisance Particulates

Nuisance dusts have little adverse effects on lungs and do not produce significant organic disease or toxic effects when exposures are kept under reasonable control. This is in contrast to fibrogenic dusts which, when inhaled in excessive amounts, cause scar tissue to be formed in the lungs. The nuisance dusts have also been called biologically inert dusts, but the latter term is inappropriate to the extent that there is no dust which does not evoke some cellular response in the lungs when inhaled in sufficient amount. The lung tissue reaction caused by inhalation of nuisance dusts has the following characteristics: 1) the architecture of the air sources remains intact; 2) collagen (scar tissue) is not formed to a significant extent; and 3) the tissue reaction is potentially reversible.

Excessive concentrations of dusts in the work room air may seriously reduce visibility; may cause irritation of the eyes, ears, and nasal passages; or cause injury to the skin or mucous membranes by chemical or mechanical action, or by the rigorous skin cleansing procedures necessary for their removal.(8)

VI. RESULTS

Eight full shift air samples, four personal breathing zone (PBZ) and four area, were collected on August 5, 1987 for nuisance dust. The results are provided in Table 1. The results of time weighted average (TWA), area samples collected on the roof, near the paint spray booths, and near the loading dock ranged from 0.09 mg/m^3 to 1.27 mg/m^3.

The results of full shift, nuisance dust samples collected near the breathing zone of four painters ranged from 1.42 mg/m^3 to 12.21 mg/m^3. The PBZ sample collected from Painter #1 (12.21 mg/m^3) was found to be above the evaluation criteria of 10 mg/m^3. Painter #1 was observed using dry methods to clean, i.e., a broom and dust pan to clean out the waste hopper and using compressed air to remove dust from his clothes. While cleaning out the waste hopper Painter #1 wore a disposable respirator over a full face beard. The nuisance dust exposure above the evaluation criteria may be the result of work practices, e.g., dry methods to clean and using compressed air to remove dust from work clothes. Painter #1 was provided and wore a disposable coverall over his street clothes.

Eight full shift air samples, three PBZ and five area samples, were collected for caprolactam dust. The results of these samples were below the laboratory limit of detection of 0.06 milligrams per sample (0.14 mg/m^3 for the air volume sampled).

Eight full shift air samples, three PBZ samples and five area samples, were collected for caprolactam vapor. Results for seven of the samples, four area samples and three PBZ samples, ranged from nondetectable to less than the laboratory limit of quantitation. The laboratory limit of detection for caprolactam vapor was 0.02 milligrams per sample (0.05 mg/m^3 for the air volume sampled) and the laboratory limit of quantitation was 0.03 milligrams per sample (0.07 mg/m^3 for the air volume sampled). One area sample collected near the loading dock contained 0.10 mg/m^3 caprolactam vapor.

Six full shift area samples were collected for isocyanates. Areas sampled included the paint spray booths, loading dock, and roof. The results of these samples were below the laboratory limit of detection. The laboratory limit of detection was 0.3 micrograms (ug) per sample (0.87 ug/m^3 for the air volume sampled) for TDI and 0.4 micrograms per sample (1.2 ug/m^3 for the air volume sampled) for MDI. No other isocyanate monomers were detected.

Two bulk samples of powder coating were collected and analyzed for 2,4-Toluene Diisocyanate (2,4 TDI) and 2,6-Toluene Diisocyanate (2,6 TDI) by high performance liquid chromatography with a diode array detector. The results of these analyses were below the laboratory limit of detection. The limit of detection for 2,4-TDI was 300 micrograms per gram and for 2,6-TDI 3000 micrograms per gram.

Accurate face velocity measurements could not be obtained for the two paint spray booths. Ducting from roof mounted swamp coolers had been placed above both painters to provide cooling as the paint spray booths are in close proximity to the curing oven. Air movement in excess of 1200 feet per minute was measured exhausting from the swamp cooler ducting. Visual observation of air flow movement with smoke tubes demonstrated that the ducting was interfering with movement into the paint spray booth. The air flow from the ducting created eddy currents around the painters and in their breathing zones.

Dry bulb temperatures measured at the paint spray booths ranged from a low of 90° F in the morning to greater than 100° F in the afternoon. The relative humidity at the paint spray booths ranged from a high of 34% in the morning to a low of 10% in the afternoon.

All four painters were males in their twenties and had worked as painters in the Powder Spray Department from 2 weeks to 7 months. The painters health complaints included sinus congestion, stuffy runny nose, eye irritation, skin irritation, coughing, and frequent sneezing.

VII. DISCUSSION AND CONCLUSIONS

A health hazard to nuisance dust existed during the survey. A personal breathing zone sample for nuisance dust collected from a painter was found to be above the evaluation criteria. Using an air hose to remove dust from work clothes and using dry cleaning methods may have contributed to the painter's nuisance dust exposure.

One painter with a full face beard was wearing a single use dust respirator for protection against nuisance dust. Employees with facial hair, e.g., excessive facial stubble, sideburns, and beards, will not obtain a high degree of respiratory protection when compared to employees who are clean shaven. Employees should be clean shaven to the point that there is no possible interference with the sealing surfaces of the respirator.(14)

Airborne concentrations of caprolactam dust, caprolactam vapor, and isocyanates were all below the corresponding evaluation criteria. Eye irritation, skin irritation, and respiratory system complaints should not occur at the levels found during the survey. The painters' health complaints of eye irritation, skin irritation, sinus congestion, stuffy runny nose, coughing, and frequent sneezing therefore seems to be related to nuisance dust.

Dry bulb temperatures and relative humidity measurements were at levels where extra caution for unacclimated or physically unfit workers should be employed.(15)

Accurate air flow measurements could not be obtained for the two paint spray booths due to excessive air flow from swamp coolers. Visual observations with smoke tubes demonstrated turbulent air flow existed around the painters and in their breathing zones.

VIII. RECOMMENDATIONS

1. Respirators should be used as a control measure only if engineering control methods (isolation, enclosure, and ventilation) do not control exposures below the evaluation criteria.

2. Respirators should be used during nonroutine operations (cleaning a spill, cleaning or repairing exhaust ductwork, etc.) when the potential for exposure above the evaluation criteria exists.

3. The use of respirators requires the institution of an effective respirator program. Respirators require quantitative fit testing, maintenance, cleaning, and training of employees in order to be effective.(14,16)

4. Employees with facial hair which interferes with the seal of the respirator to the face should not work in an area or at a task which requires respiratory protection.

5. The use of cooling air in such a way as to interfere with local exhaust ventilation should not be allowed.

6. Assess the level of heat stress that a painter might experience, particularly when a heat wave is likely to occur.

7. Personal protective clothing, including gloves, glasses, and coveralls, should be continued to be provided to powder spray painters due to the potential for eye and skin irritation.

8. Personal hygiene practices should be strictly adhered to by the painters due to the potential irritant effects of nuisance dust. These practices include washing one's hands and face before eating, drinking, or smoking, and showering as soon as possible after the work day.

9. Perform periodic inspections of the paint spray booth, curing oven, and chemical wash ventilation systems. Periodic inspection and checking of ventilation exhaust systems are necessary if control is to be maintained at an effective level.

10. Employees should be informed of all hazards related to isocyanate, caprolactam vapor, caprolactam aerosol, and nuisance dust exposures. Employees should be informed of appropriate precautions to use to limit exposure, including safe work practices.

11. Surveillance of workers as outlined in the NIOSH Criteria Document for isocyanates should be part of the medical program.

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XII. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. Bestop, Inc.
2. U.S. Department of Labor/OSHA - Region VIII.
3. NIOSH Regional Offices/Divisions
4. Colorado Department of Health

For the purpose of informing affected employees, a copy of this report shall be posted in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE I

TWA Concentration of Nuisance Dust

Bestop, Inc.
August 5, 1987

Sample #	Sample Type/Location	Sampling Time	TWA Concentration (mg/m^3)
1	PBZ/Painter #1	7:04AM - 2:41PM	12.21
2	Area/Booth #1	7:38AM - 2:41PM	1.27
3	PBZ/Painter #2	6:45AM - 2:57PM	2.55
4	Area/Booth #2	7:45AM - 2:47PM	0.53
5	PBZ/Painter #3	6:53AM - 2:58PM	1.42
6	PBZ/Painter #4	7:02AM - 2:58PM	7.04
7	Area/Loading Dock	7:50AM - 2:48PM	0.09
8	Area/Roof	8:16AM - 12:10PM	0.50

ACGIH Recommended TLV-TWA: 10 mg/m^3

Key:
TWA - Time weighted average (calculated for the sampling time indicated)
mg/m^3- milligrams of substance per cubic meter of air
PBZ - Personal breathing zone

The instrumental precision of weighing done at one sitting was 0.01 milligrams. Reported values were field blank corrected. The tare and gross weighing was done in duplicate.