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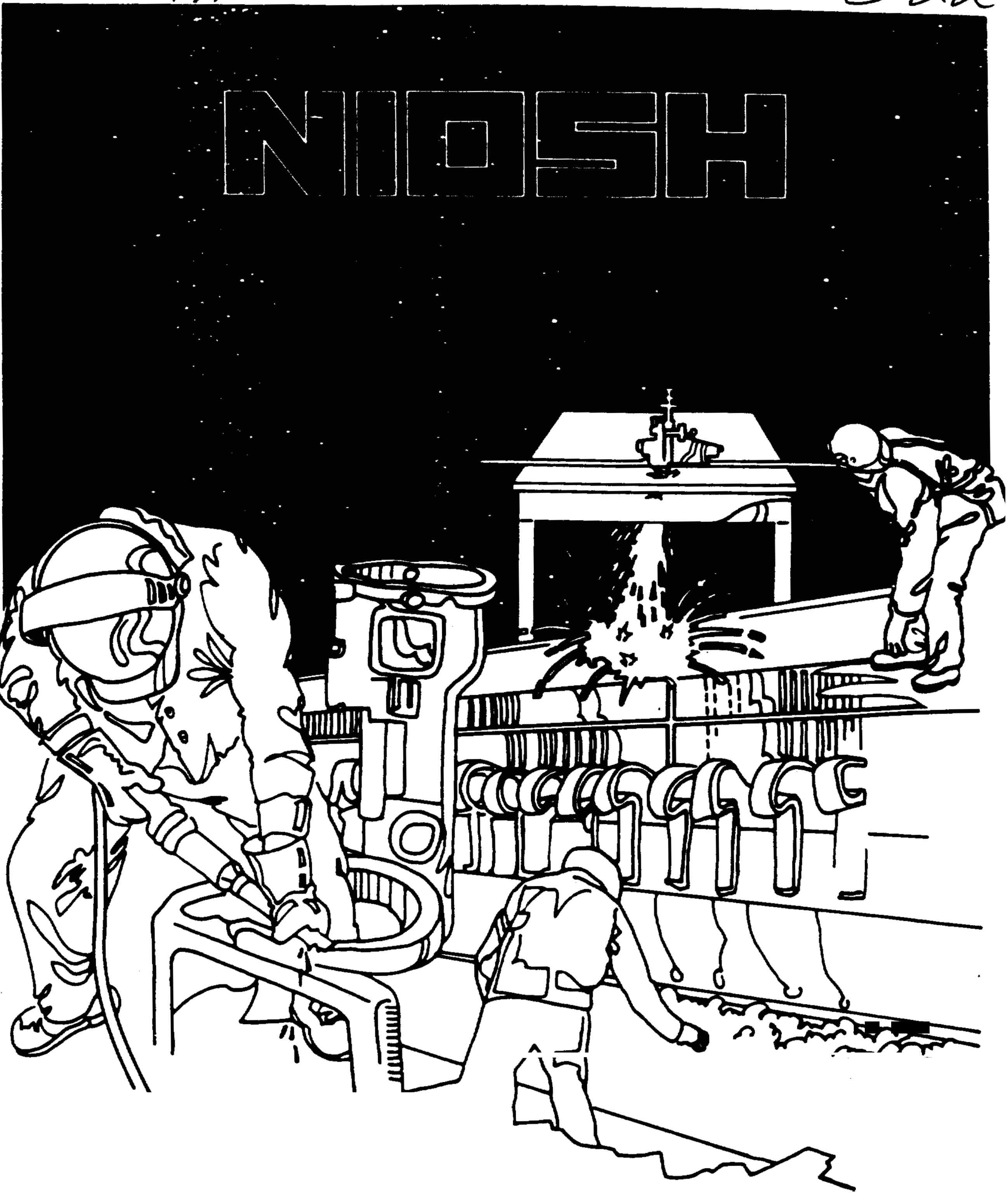

Health Hazard Evaluation Report

HETA 88-068-2077
SCHMIDT CABINET COMPANY
NEW SALISBURY, INDIANA

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.

HETA 88-068-2077
OCTOBER 1990
SCHMIDT CABINET COMPANY
NEW SALISBURY, INDIANA

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I. SUMMARY

In November 1987, NIOSH received a request from Schmidt Cabinet Company to evaluate the effectiveness of the exhaust ventilation system and evaluate exposures in the finish room of the New Salisbury, Indiana plant. An initial site-visit, which included exposure monitoring and an evaluation of the ventilation system, was conducted on August 24-25, 1988. Personal breathing zone (PBZ) and general area (GA) air samples were collected for analysis of formaldehyde, hexavalent chromium, and various hydrocarbons. The PBZ and GA air samples for hexavalent chromium (1.36 and 1.80 ug/m^3) measured exposures below the OSHA standard and ACGIH recommendations but above the RIOSH recommended exposure level of lowest feasible level. Formaldehyde concentrations from GA air samples were more than twice the OSHA, BIOSH, and ACGIH standards and recommendations. One of three PBZ exposure levels for ethylene glycol monobutyl ether (0.4 ppm) exceeded the NIOSH Recommended Exposure Limit of lowest feasible level. The airborne koncentrations of the five volatile organic compounds evaluated in this study (acetone, ethyl acetate, ethyl alcohol, methyl alcohol, and methyl isobutyl ketone) were non-detectable or less than 1% of the applicable exposure criteria. A number of ventilation related problems were identified in the Finishing area. These problems primarily involved a lack of makeup air and uncontrolled contaminant sources.

Based on the environmental results and the ventilation evaluation, the investigators concluded that a potential hazard from airborne exposure to hexavalent chromium formaldehyde and ethylene glycol monobutyl ether existed in the cabinet finish area. Several ventilation problems identified in the finish area included a lack of makeup air, ineffective use of exhaust ventilation systems, and uncontrolled contaminant sources. Recommendations to minimize and reduce exposure potential to hexavalent chromium and formaldehyde as well as recommendations aimed at improving the general ventilation and local exhaust ventilation systems of the plant are included in Section IX.

II. INTRODUCTION

The Rational Institute for Occupational Safety and Health (RIOSH) received a request from Schmidt Cabinet Co. to evaluate the effectiveness of the exhaust ventilation system in the finish room of the Rew Salisbury, Indiana plant. The request was received in November 1987. However, the company requested that the evaluation not be conducted until a new exhaust fan was installed. The fan was installed in March 1988. The company also requested that the evaluation be performed in the summer when conditions were presumably the worst. An initial site-visit including exposure monitoring and an evaluation of the ventilation system was conducted on August 24-25, 1988. Personal breathing zone (PBZ) and general area (GA) air samples were collected for analysis of formaldehyde, hexavalent chromium, and various hydrocarbons (toluene, xylene, acetone, ethyl alcohol, ethyl acetate, naphtha, methyl alcohol, methyl isobutyl ketone, and ethylene glycol monobutyl ether). This report summarizes the air monitoring results, and the evaluation results of the local exhaust ventilation system for the ten spray booths and the general exhaust ventilation system are included.

III. BACKGROUND

Schmidt Cabinet Company manufactures kitchen cabinets and bathroom vanities. The company employed 90 production workers and operated only on the day shift at time of this survey. The employees are members of the Carpenters Union. The entire plant is a one floor building occupying approximately 300,000 square feet. The original building was built in 1959. The building housing the finish area was completed in 1980 and occupies approximately 10,000 square feet. Approximately 16 production workers are employed in the Finishing area.

The company manufactures the finished cabinets from various hard woods. The process flow for the Finishing area is presented in Figure 1 while Figure 2 shows a layout of the part of the plant containing the Finishing area. The hazard evaluation request concerned only the finishing department (see Figure 2).

The constructed cabinets are finished by spraying them with a series of stains, sealers, and/or paints. Stain is usually applied with compressed air sprayers (one of the stain sprayers was airless). All of the spraying is done in ventilated booths manufactured by DeVilbiss (Toledo, Ohio). For smaller parts, such as doors, the employee would mount the part to be sprayed on a jig inside a booth, spray the part, and then remove it and stack the part on a cart outside the booth. When all of the parts are sprayed, they are moved to a central drying area (Figure 2). For larger parts, such as a cabinet body, the part is received on a cart, positioned in a booth, sprayed, and then moved to the central drying area. For some stains, the part is immediately wiped off with a shop cloth after spraying and before being moved to the drying area. After drying, the part is again sprayed with a sealer and moved back into the central drying area.

The cabinets are lightly sanded and sprayed with a coat of varnish. The spraying of all compounds is done in a spray booth by operators classified as **sprayers'*. There are two spray booths for varnishing, one equipped with an air sprayer, the other with an airless sprayer. Once varnished, the parts are pushed into a drying area near the varnish booths.

Emission Sources

The types of contaminants from the finishing process are vapors and particulates. Vapor results from the solvents used in the process. Particulates come from the atomized stains and varnishes and are the solids left by the dried stains and varnishes. Particulates can also result from sanding as well as the residues of the paints and varnishes left on surfaces.

There were several emission sources noted during the finishing process. During spraying, the stain or varnish is atomized and directed at a surface. The atomized droplets which do not impact on a surface can remain airborne and be emitted into the general room air. In addition, solvent vapor from the stains and varnishes is directly sprayed into the air or evaporates from the airborne droplets of the spray.

Contaminant emissions from compressed air spraying are greater than those from airless spraying.[1] In the former, spray is propelled at the surface by a stream of air. The air stream impacts on the surface and either flows around the surface or rebounds off the surface. Larger droplets of spray impact on the surface to be covered while smaller droplets of spray and vapor remain in the air stream. This is called overspray. Overspray can be a major source of particulate and vapor depending on how the spraying is performed; airless spray techniques tend to produce less overspray because they produce larger sized particles.

Another emission source is the evaporating solvent from the stains and varnishes as they dry. The latter is believed to be the greatest source of solvent concentrations in the general room air since parts are dried without local exhaust ventilation in the open area of the plant. Also, workers were observed cleaning stain from their hands with solvent-soaked rags. The solvent evaporating from the rags and the open container are sources of solvent vapors in the general room air. These sources, however, appear to be minor, intermittent sources.

Particulate is generated from sanding. Solids from the stains as well as wood dust can be created from sanding. The sanding dust is not vacuumed nor is there any local exhaust ventilation. However, exposure to the dust and the seriousness of the problem was not assessed during this survey because this was outside the focus of the hazard evaluation request.

Airborne particulates are also generated from cleanup of the dried stains and varnishes. These residues were found on surfaces such as booth interiors and filter surfaces. These residues can potentially cause significant, short-term, intermittent exposure depending upon how cleanup jobs are performed. One worker was observed'removing residue from a booth interior with a broom.

Hexavalent Chromium

At spray booth #1 (see Figure 2) the constructed cabinets are sprayed with a cherry stain. The cherry stains (manufactured by Guardsman Chemicals, Xnc. Grand Rapids, Michigan) are composed of methyl alcohol and chromium compounds, with the chromium content varying from 0.009% to 0.036% by weight for the light and dark cherry stains, respectively. On the day of the survey, both light and dark cherry stains were being sprayed by the operator of spray booth #1. Each cabinet is sprayed in a paint spray booth, using a regular (i.e., not airless) air sprayer. The cabinet is then moved to an open area of the finishing department by the stain spray booth and allowed to air dry.

Volatile Organic ComDounds

At spray booths #Z-8 (see Figure 2), a series of various stains (other than the cherry stains containing chromium), sealers and paints are sprayed. These chemicals are manufactured by Guardsman Chemicals, Inc., Grand Rapids, Michigan. Material Safety Data Sheets (MSDSs) are available to the employees as part of the company's hazard communication program. The MSDSs were reviewed by AIOSH. Although the compound sprayed is changed frequently throughout the day, depending on the production order, a representative composition (% by weight) of each category is presented below:

stain - ethyl alcohol (8%), ethyl acetate (8%), toluene (5%), xylene (25%), naphtha (16%), methyl alcohol (2%), methyl isobutyl ketone (5%), ethylene glycol monobutyl ether (14%), isobutyl isobutyrate (2%), isobutyl acetate (1%), and isobutyl alcohol (1%).

sealer - lactol spirits (24%), toluene (20%), xylene (5%), methyl alcohol (11%), isopropyl alcohol (11%), isobutyl alcohol (6%), isobutyl isobutyrate (4%), methyl ethyl ketone (5%), methyl acetate (2%), methyl isobutyl ketone (7%), ethyl acetate (3%), and isobutyl acetate (2%).

paint - xylene (21%), butyl acetate (2%), isobutyl alcohol (6%), toluene (9%), naphtha (7%), butyl alcohol (4%), and formaldehyde (0.26%).

Within 4 feet of spray booth #3 (see Figure 2), a table is located on which the cabinets are placed immediately after they are sprayed with stain. Approximately 4 workers classified as "stain wipers" use a rag to wipe the cabinets of excess stain. Occasionally, the rags are dipped into an open can of methanol.

Formaldehvde

At booths #9 and #10 (see Figure 2), a varnish is sprayed onto the cabinets.

The varnish (Chemveer Topcoat by Guardsman Chemicals, Inc.) is composed (% by weight) of butyl acetate (10%), naphtha (7%), xylene (9%), methyl alcohol (3%), ethyl alcohol (6%), isobutyl alcohol (16%) isobutyl isobutyrate (4%), butyl alcohol (5%), and formaldehyde (0.28%).

Ventilation Descriotion

Only the spray booths had local exhaust ventilation to control emissions from the spraying. Other than this, the plant was under general dilution ventilation.

Tubeaxial fans are located in the rear of the spray booths, either in the upper half of the back wall or in the booth ceiling next to the back wall. Exhaust air passes through furnace-type filters located about two feet in front of and parallel to the back wall. Exhaust air passes through the plant wall via a short duct, into an elbow turned downward, and then through a two-foot section of duct before being discharged.

Two of the booths (#1 and #9 in Figure 2) had exhaust fans located in the ceiling of the booth and discharged air at a right angle directly into a duct. The exhaust duct on these booths was much longer than on the other booths and ran overhead parallel to the plant floor to the outside walls. The discharge for the duct was the same elbow and duct arrangement as the other booths.

Three panel fans comprise the exhaust ventilation. EF-1 (Figure 2) was a 48" diameter Dayton fan which exhausted air from the ceiling over the drying area. Its discharge duct transverses the second floor, and air exits through a "chinese cap" vent about three feet above the roof line. EF-2 (Figure 2) was a 60" Dayton panel fan located in a side wall next to the sanding area. This fan had a damper, assumed to be backdraft type, at its outlet. The third general exhaust fan (EF-3 in Figure 2) was also a panel fan located in a side wall of the plant. Bo further information was collected on this fan because it was not operating during the time of the survey.

Makeup air was provided to the Plant by an air handler through a duct system shown in Figure 2. Reportedly, the makeup air was used only when the indoor humidity was too high. High humidity causes cloudiness in the varnish finish. When operating, the makeup air unit supplied 100% outside air. The air handling unit heated the air With a direct-fired burner--there were no cooling coils. Air from the ducts was discharged into the plant through double deflection louver diffusers.

Other makeup air flowed into the plant area from the doors shown in Figure 2 and from other areas of the plant not shown.

During winter, the air in the plant was heated by recirculating unit heaters located near the ceiling of the first floor. These heaters did not provide outside air.

Personal Protection Equipment

The company required half face respirators to be worn by all employees classified as **sprayers**.The respirator cartridges (TC-23C-737) supplied were for organic vapors and for pesticides, paints, lacquers, and enamel mists and dusts and, where deemed appropriate by the company, cartridges (TC-23C-754) were supplied for formaldehyde. During the survey it was noted that the respirators were not being properly maintained (e.g. inhalation and exhalation valves damaged or missing, improper storage and cleaning of the respirators). The *'sprayers" and "stain wipers" were supplied with nitrile gloves.

IV. MATERIALS AND METHODS

On August 25, 1988, personal breathing zone and general area air samples were collected to assess employee exposure potential to hexavalent chromium, various organic hydrocarbons, and formaldehyde.

Hexavalent Chromium

One PBZ air sample was collected from the "sprayer" for booth #1. Two GA air samples were collected at locations within the stain spraying area (see Figure 2). The air samples were collected using battery-powered pumps operating at approximately 2 liters per minute. The air samples were collected only during the time period (7:00 A.M. until 10:20 A.M.) in which stain containing chromium was being sprayed. The pumps were attached via Tygon tubing to a filter (5.0 micron PVC membrane). The filters were later analyzed by visible absorption spectrophotometry for hexavalent chromium using NIOSH method 7600.

Volatile Organic Compounds

Six PBZ air samples were collected on three employees (sprayer for booth #3, stain wiper, and sander) for selected volatile organic compounds. Four general area air samples were collected at two locations within the drying area near booths P3-8 (see Figure 2). At each location or for each employee monitored, one sample was collected for approximately four hours in the morning and another for approximately four hours in the afternoon.

The air samples were collected using battery-powered pumps operating at approximately 200 cubic centimeters of air per minute. The pumps were attached via Tygon tubing to charcoal tube collection media. The tubes were later analyzed by gas chromatography for acetone, ethyl acetate, ethyl alcohol, ethylene glycol monobutyl ether, methyl alcohol, methyl isobutyl ketone, naphtha, toluene, and xylene by NIOSH method 1500.[1]

Formaldehyde

Three 8-hour general area air samples were collected in the varnish spraying area (see Figure 2). The first sample was collected near spray booth #10 at approximately the worker's breathing zone while standing at the face of the spray booth. The second sample was collected at a distance of approximately 10 feet from the face of spray booth #10 in an area where cabinets were placed after spraying to be air dried. The third sample was collected approximately 6 feet from the face of spray booth #9 (the booth located on an exterior wall in the finishing area) where cabinets were also placed after spraying to be air dried. To collect the samples, battery-powered sampling pumps operating at approximately 0.5 liters per minute were attached via Tygon tubing to an impinger containing 20 milliliters of a 1% sodium bisulfite solution. A prefilter (1 micron PTFE membrane) preceded the impinger-pump assembly to trap large particles. The impinger solutions were later analyzed for formaldehyde concentration by visible spectroscopy according to NIOSH Method 3500.[2]

Ventilation

The instruments and their use during the ventilation survey are shown in Table 1. The Flow Hood meter along with two lengths of 10-foot tubing were used to measure the pressure differential between inside the building and outside. The tubing was extended as far as possible into the building through the east door next to the drying area and as far as possible outside of the building. The end of the tubing outside of the plant was shielded from the wind. The pressure differential was then measured with all of the doors shown in Figure 2 closed or open and with or without makeup air from the air handler (four sets of conditions). For each condition, several readings were made and averaged to get the pressure differential. When the doors were closed, the tubing was inspected to assure that it was not crimped.

Velocity readings were taken in a grid pattern at the face of the the booths. At each measurement location, the meter was allowed to stabilize before the reading was recorded. Locations of the measurements along with the actual measurement are shown in Figure 5.

The rotational speed of the fans was measured by marking or selecting a landmark on the fan shaft or a blade and taching the mark using a strobotach. Rotational speed was used to correct fan flow data received from manufacturers. This data typically gives the flow versus static pressure at various rotational speeds. To obtain the correct flow, the manufacturer's fan flow data is multiplied by a ratio of the measured rotational speed and the manufacturer's design rotational speed.

Psychrometric measurements were made at several locations throughout the finishing area and at least two locations outside both in the morning and afternoon. All of the inside measurements were averaged to get the wet and dry bulb temperatures for the day. The average wet and dry bulb temperatures along with the barometer reading taken using the Flow Hood meter were used to obtain the air density from AHCA Publication 203.3 This air density was used to correct static pressure or flow to standard conditions,

A fog machine was placed in various locations in the finishing area. A non-toxic smoke was released, and the movement of the smoke indicated the general air flow patterns.

The configurations of some of the fans did not allow for direct measurement of their air flows. Indirect measurements were possible and were used to calculate the air flow for these fans. The identical procedure was used on each fan (except EF-1), only the measurements and pressure loss factors changed.

V. EVALUATIOH CRITERIA

As a guide to the evaluation of the hazards posed by the 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 even though 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 occupationel exposures are controlled at the level set by the 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 Recommended Exposure Limits (RELs)[4], 2) the American Conference of Governmental Industrial Hygienists' (ACGIB) Threshold Limit Values (TLVs)[5], and 3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[6] OSHA amended its standards for many compounds effective March 1, 1989. Often, the AIOSH RELs and ACGIH TLVs are lower than the corresponding OSHA PELs. Both NIOSH RELs and ACGIH TLVs usually are based on more recent information than are the OSHA PELS. The OSHA PELs are required to take into account 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. 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 (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Hexavalent chromium

Chromium compounds can cause an allergic dermatitis in some workers. Acute exposure to chromium dust and mist may cause irritation of the eyes, nose, and throat. Chromium exists as chromates in one of three valence states: 2+, 3+, and 6+. Chromium compounds in the 3+ state are of a low order of toxicity. In the 6+ state, chromium compounds are irritants and corrosive. This hexavalent form may be carcinogenic or non-carcinogenic, depending on solubility. The less soluble forms have been considered carcinogenic. Workers in the chromate-producing industry have been reported to have an increased risk of lung cancer (Bidstrup and Case, 1956).[7] ACGIH has adopted an 8-hour TLV of 0.5 mg/m^3 for chromium (3t) compounds,[5] whereas the OSHA standard for chromium metal and insoluble salts is 1.0 mg/m^3.[6] NIOSH previously recommended a standard for carcinogenic chromium (6+) compounds of 0.001 mg/m^3. NIOSH also recommended a standard of 0.025 mg/m^3 for non-carcinogenic hexavalent chromium compounds, along with a 15-minute ceiling level of 0.05 mg/m^3.[4]

Sodium dichromate, a chromium VI compound, is the most soluble of all chromates. NIOSH also presented published policy which stated that only the insoluble forms of CrVI were potential human carcinogens (NIOSH 1973, IVIOSK 1975).[8,9] Since these publications however, new scientific evidence has not only demonstrated the carcinogenic activity of soluble CrVI compounds in exposed animals (Glaser et al.[10], 1986; Levy et al.,[11] 1986; Steinhoff et al.,[12] 1986), but also has shown epidemiological evidence that indicates similar carcinogenicity among workers exposed to soluble CrVI (Blair and Mason[13] 1980; Franchini et al.[14] 1983; Royle[15] 1975; Silverstein et al.,[16] 1981; Sorahan et al.,[17] 1987). Based on this evidence, NIOSH has recommended that OSHA consider all CrVI compounds as potential occupational carcinogens. In near future, NIOSH expects to more thoroughly examine the scientific data published since the CrVI Document and will determine whether a new or revised Criteria Document should be developed.

Formaldehvde

Formaldehyde gas is an irritant of the eyes and the respiratory tract; solutions cause both primary irritation and sensitization dermatitis.[18] The first signs or symptoms noticed upon exposure to formaldehyde, at concentrations ranging from 0.1 to 0.5 ppm, are burning of the eyes, tearing, and general irritation of the upper respiratory passages. Higher exposures (5 to 20 ppm) may produce coughing, tightening of the chest, a sense of pressure in the head, and palpitation (noticeable beats) of the heart. In 1976 NIOSH developed a BEL for formaldehyde of 1 ppm to prevent the irritant effects of exposures to this compound.[19] This recommendation predated animal carcinogenicity data implicating formaldehyde as an animal carcinogen and a potential occupational carcinogen. Formaldehyde has also produced positive results in mutagenicity testing, supporting the classification of this compound as a potential occupational carcinogen. IVIOSH currently considers formaldehyde a human carcinogen and recommends that occupational exposure, to formaldehyde be controlled to the lowest feasible concentration.[20,21]

On December 4, 1987, OSHA promulgated a new health standard for formaldehyde, which became effective on February 2, 1988.[22] In this revised standard, OSHA considers formaldehyde a probable human carcinogen. The PEL was reduced by two thirds, from 3 ppm to 1 ppm, as an 8-hour TWA, with an "action level" of 0.5 ppm. Exposures up to 2 ppm would be permitted for 15-minute periods, as long as the daily exposure does not exceed 1 ppm. The revised standard contains provisions for medical surveillance, recordkeeping, regulated areas, emergency procedures, control strategies, protective equipment, and hazard communication.

The ACGIH TLV for formaldehyde is 1 ppm as an 8-hour TWA and 2 ppm as a short term exposure limit. ACGIH also classifies formaldehyde as a suspected human carcinogen necessitating that exposures be kept to a minimum. ACGIH has proposed a change in the TLV for formaldehyde down to 0.3 ppm for a trial period of two years. If, after two years no evidence comes to light that questions the appropriateness of the proposed value, the value will be reconsidered for the "Adopted" TLV list.[5]

Volatile Organic ComDounds

The volatile organic compounds present in the stains, sealers, and paints are classified as aliphatic hydrocarbons, ketones, amines, esters, alcohols, aldehydes, and ethers. They function as organic solvents (i.e., used for extracting, dissolving, or suspending materials such as fats, waxes, and resins that are not soluble in water). Table 2 presents the health effects of each of the volatile organic compounds evaluated in this survey.

Studies of various groups of workers exposed to solvents (although not necessarily the specific volatile organic compounds evaluated in this study), have shown chronic changes in peripheral nerve function and neurobehavioral effects.[22] These effects include fatigue, irritability, memory impairment, sustained changes in personality or mood (emotional instability and diminished impulse control and motivation), and impaired intellectual function (decreased concentration, memory, and learning ability).

Table 3 presents the current OSHA PELs, ACGIH TLVs and NIOSH RELs for the volatile organic compounds evaluated in this study.

When two or more hazardous substances, which act upon the same organ system are present, their combined effect, rather than that of either individually, should be given primary consideration. In the absence of information to the contrary, the effect of the different hazards should be considered additive. That is, if the sum of the following fractions,

$$\frac{C_1}{E_1} + \frac{C_2}{E_2} + \frac{C_3}{E_3} = 1$$

exceeds unity, then the exposure limit of the mixture should be considered as being exceeded. C_1 indicates the observed airborne concentration, and E_1 the corresponding exposure limit. The ACGIH TLVs were used in the above calculation for the "E" values because they are the same or less than OSHA PELs.

Except for ethyl acetate, all the votatile organic compounds evaluated in this study are reported to cause adverse central nervous system health effects, therefore, this formula was used to evaluate exposure to the combination of these volatile organic compounds.

A major route of entry for organic solvents is percutaneous (through the skin) absorption. The ACGIH TLV for ethylene glycol monobutyl ether and methyl alcohol have the notation "skin" referring to the potential contribution to the overall exposure by the cutaneous route including mucous membranes and eye, either by airborne, or more particularly, by direct contact with the substances. Solvent uptake through the skin depends on 1) duration of contact, 2) skin thickness, perfusion, and degree of hydration, and 3) the presence of cuts, abrasions, or skin diseases.

VI. RESULTS

Hexavalent Chromium

The PBZ air concentration of hexavalent chromium was 1.36 ug/m^3 for the sprayer at booth #1. The general area air concentration of hexavalent chromium was 1.80 ug/m^3 at a distance of approximately 6 feet from the face of spray booth #1. At a distance of approximately 15 feet from the face of spray booth #1, the general area air concentration of hexavalent chromium was greater than the limit of detection for the method (0.56 ug/m^3) but less than the limit of quantitation (1.28 ug/m^3).

Formaldehvde

The general area air concentration of formaldehyde was 2.67 ppm at the face of spray booth #10 in an area equivalent to the operator's breathing zone. A formaldehyde concentration of 2.57 ppm was determined at an area approximately 10 feet from spray booth #10 in the drying area for the varnished cabinets. A formaldehyde concentration of 2.33 ppm was found at an area approximately 6 feet from spray booth 119 in another drying area for the varnished cabinets.

Volatile Ornanic ComDounds

Table 3 presents the personal and area air sampling results for the volatile organic compounds tested in this survey.

Ventilation

Table 4 shows the results of the exhaust flow calculations. The table values show that, for all of the conditions, the plant has a deficit air flow of at least 95,000 acfm (actual cubic feet per minute). In other words, the amount of air being pulled from the plant is over 95,000 acfm more than the makeup air being supplied. The common practice is to have a makeup air surplus of 10% so that the exhaust air systems work correctly and to prevent cold air infiltration.

VII. DISCUSSION

Hexavalent Chromium

The concentration of hexavalent chromium at the PBZ of the operator of spray booth #1 was 1.36 ug/m^3 during the three hours he was spraying a stain containing chromium. The remaining five hours of the day the operator performed a task where there was no exposure to chromium. His 8-hour TWA concentration would then be 0.50 ug/m^3. This value exceeds the AIOSH REL of the lowest feasible level. However, the operator of the spray booth wore a respirator while spraying the stain. Thus, his actual exposure to hexavalent chromium may be less than the determined value due to the protection factor of the respirator. The protection factor of a respirator depends upon the type of respirator worn, proper fit, and maintenance.

In the area where the recently sprayed cabinets were placed to dry, at distances of 6 feet and 15 feet from the face of spray booth #1, the concentrations of hexavalent chromium were 1.80 and "trace", respectively. "Trace" is defined as a value between the limit of detection and the limit of quantitation (>0.56 but <1.28 ug/m^3). Thus, if an employee spent his entire work day in this area and chromium containing stains were being sprayed at booth #1 the entire day, without respiratory protection the worker's exposure to hexavalent chromium could probably be above the RIOSH BEL.

The personal breathing zone and area air samples for hexavalent chromium were all below the OSHA standard and ACGIH recommendations.

Formaldehyde

Formaldehyde concentrations for all three area samples were more than twice the OSHA, NIOSH, and ACGIH standards and recommendations.

The formaldehyde concentration of 2.67 ppm at an area near the varnish sprayer's breathing zone would reflect formaldehyde inhalation exposure potential due *to* aerosolized varnish. Although the operator wears a respirator while spraying the varnish, this respirator protects against formaldehyde but not against the organic vapors. AIOSH recommends controlling formaldehyde exposure to the lowest feasible level through engineering controls to alleviate the need to utilize respirators. The only type of respiratory protection for formaldehyde recognized by RIOSH for carcinogens is supplied air or self-contained breathing apparatus (SCBA).

The other two area samples (2.09 and 2.33 ppm formaldehyde) were collected in the varnish drying area and would reflect volatilization of formaldehyde from the varnish as it dried on the cabinets. These are areas that employees enter for brief periods without *any* respiratory protection. The varnish spray operators, who wear respirators while spraying, are the only employees assigned to jobs requiring them to work the entire day in the varnish drying areas. Area air'sampling results represent "worse case" situations (i.e., an employee who does not wear a respirator stationed for his full shift in the area where the samples were collected).

In August 1988 Schmidt Cabinet Company conducted personal breathing zone monitoring (3M Diffusional Monitors) on several employees over a 9-hour period in the finishing department. The results were 1.10, 1.06, 1.10, 1.03, 1.10 and 0.74 ppm of formaldehyde. All but one of these values are above the OSHA PEL of 1 ppm and all values are above the OSHA action level of 0.5 ppm; these results also are above the HIOSH BEL.

Volatile Organic ComDounds

The airborne concentration of the six volatile organic compounds tested in this study (acetone, ethyl acetate, ethyl alcohol, ethylene glycol monobutyl ether, methyl alcohol, and methyl isobutyl ketone) were non-detectable or less than 1% of the stated exposure criteria.

The airborne concentrations of naphtha ranged from less than the limit of quantitation (0.2 ppm) to 7.7 ppm with a mean of 4.8 ppm. The highest value was obtained for the morning personal breathing zone sample for the stain wiper. All values were less than 10% of the stated exposure criteria.

The airborne concentrations of toluene ranged from 0.4 ppm to 1.8 ppm with a mean of 0.9 ppm. The highest value was obtained for the afternoon personal breathing zone sample for the stain wiper. All values were less than 2% of the stated exposure criteria.

The airborne concentrations of xylene ranged from 0.5 ppm to 4.4 ppm with a mean of 1.6 ppm. The highest value obtained was for the afternoon personal breathing zone sample for the stain wiper. All values were less than 5% of the stated exposure criteria.

The airborne concentrations of ethylene glycol monobutyl ether ranged from non-detectable to 0.4 ppm. The highest value obtained was for the afternoon personal breathing zone sample for the stain wiper. All values were considerably less than the OSHA PEL and the ACGIH TLV of 25 ppm. HIOSB considers ethylene glycol monobutyl ether a human carcinogen and should be controlled to the lowest feasible level.

The worse possible exposure scenario considers simultaneous exposure to the mixture of the eight contaminants that can cause central nervous system adverse health effects. Table 2 presents the mixture exposures calculated as a fraction of the TLV. If the guidance value exceeds one, the exposure would be considered potentially hazardous. The highest mixture exposure to TLV ratio was 0.13 for the stain wiper.

Ventilation

Analysis of the data in Table 4 for the effects of door position, filter condition, and makeup air was performed by comparing the change in exhaust flow for similar conditions while holding the condition to be analyzed constant. For example, to see the effect of makeup air, the exhaust flows for Conditions 1 and 2, 3 and 4, 5 and 6, and 7 and 8 were subtracted. The differences were then averaged. This same procedure was repeated for filter condition and door position. The analysis showed that the greatest effect on exhaust air was door position followed by makeup air. This further shows the starvation effect on the exhaust fans due to a lack of makeup air. If adequate makeup air were being supplied to the plant, a change in door position from open to closed would have little effect.

Makeup air, when not supplied by the air handler, is pulled into the Finishing area through the doors, from other parts of the plant and through leaks. Makeup air being pulled from other areas and through doors was shown by smoke tests. The movement of the draft air was shown to be tangential to some of the booth faces or, opposite to the normal air flow direction into some of the booth faces. This type of air motion can defeat contaminant control by pulling contaminants out of the spray booth due to a syphoning effect. Additionally, a swirling motion can be created inside the booth which can diminish hood effectiveness. Consequently, contaminants are carried from one area to another with the draft air. This contributes to contaminant concentrations detected on general area samples collected away from the booths.

An exhaust fan, EF-1, was added in the ceiling to exhaust the solvents evaporating from drying parts. This panel fan, though, was the incorrect type for the application, since it was attached to a duct system. Panel fans can only work against a limited pressure drop.

The placement of EF-1 was also only partially effective. The shortest distance between the main contaminant source and the ceiling is about ten feet for parts placed directly under the fan. Those sources located at the west side of the Finishing area are almost 100 feet away. Two feet is the greatest distance a source should be from the exhaust in an open area. The large distance between the drying parts and the exhaust fan makes them very susceptible to the effects of drafts as observed during the smoke tests. In addition, air was blown across the ceiling by the air handler. This air pulled smoke from just above the parts to the ceiling, and then blew the smoke-laden air across EF-1's opening.

While spraying some of the larger parts, some workers were observed to place the part only halfway into the booth. Then, the workers stood at the midpoint of the part's side and sprayed the part along its length, In so doing, the wotker would spray toward the back of the booth at the start, but finish by spraying in the direction opposite the booth face. The result was that the coating material was sprayed away from the control zone of the booth. Additionally, contaminants from the spray may be entrained in the air being pulled into the booth and can pass through the breathing zone of the worker as he or she works in the booth.

There are three potential paths for contaminant reentry from outside the plant. The first of these paths is through the southside door of the plant when it is open. All of the booths exhaust contaminated air through ducts pointing at the ground. Contaminated air moves along the building's south wall and is pulled into the plant as makeup air through the south door when it is open, as it commonly is when weather permits.

A second path is through the east door when it is open. Part of the building juts outward from the main building's southeast corner and, because the predominant winds are from the south/southwest, a pocket of air can be trapped just outside of the east door when the wind is right. Contaminated air from EF-2 and possibly from the booth exhausts can be caught in this pocket of air and pulled back into the plant as makeup air.

A third path for recirculating air into the plant is through the air handling unit. The exhaust duct for EF-1 is crowned with a "Chinese cap" type rain cap. This type of rain cap, besides having the disadvantage of being an energy waster, forces contaminated exhaust air toward the roof. Under certain wind conditions, a pocket of air is trapped over the roof. Contaminated air from EF-1 could be trapped in the pocket of air. The air handling unit intake is located about 20 feet laterally from the exhaust, so the unit can pull its air from within the same envelope of trapped air as that into which EF-1 exhausts.

The actual effectiveness of the booths is believed to be very good when not disturbed by drafts or improper spraying practices. Figure 3 shows the face velocity measurements made on three booths. All of the measured booths had average face velocities within the 100-150 fpm band recommended by the ACGIH Ventilation Manual. Other organizations and OSHA have similar recommended air velocities.

Analysis of the face velocity distribution measured across the booths showed that all of the measured booths had very little variation in the average velocity vertically down the booth. Horizontal variation, however, for two of the booths was much greater. These two booths coincidentally were the two with the lowest overall average face velocity. On all of the booths, average velocities tended to be lower than those found at the booth centerline. This means that if the spraying is done with the part positioned as close to the centerline of the booth as possible, there should be few problems and the height at which the spraying is performed makes little difference.

Many of the booths were found to be operating well despite poor maintenance practices. Several booths were found with cracked pulleys on the fan or motor. Besides being an unsafe situation, this seriously shortens the life of drive belts. In many instances, one of a pair of belts on each fan was found to be loose, indicating that only one belt had been changed at a time. When one belt needs changing, both belts should be changed so that both they wear equally and maintain equal contact with the pulley.

VIII. CONCLUSIONS

Based upon personal breathing zone and general area air sampling results and current .exposure guidelines, a potential health hazard existed at the time of this survey from airborne exposure to hexavalent chromium. Individuals who operate spray booth #1 may face a risk of significant exposure to hexavalent chromium if the proper personal protective equipment is not used. There is also the potential for exposure to hexavalent chromium in areas where cabinets recently sprayed with stain are placed to dry.

Based upon the general area air sampling results, and the company's personal breathing zone exposure monitoring data, there is potential for overexposure to formaldehyde for the varnish spray operators and in areas where cabinets recently sprayed with varnish are placed to dry.

Eased upon personal and general area air sampling results and current exposure guidelines, a health hazard did not exist at the time of the environmental evaluation from an occupational inhalation exposure to the volatile organic compounds tested in this survey (acetone, ethyl alcohol, methyl alcohol, methyl isobutyl ketone, naphtha, toluene, and xylene). Inhalation exposure to ethylene glycol monobutyl ether exceeded the NIOSH REL and should be substituted with a less hazardous solvent. Also, both ethylene glycol monobutyl ether and methyl alcohol can be absorbed through the skin. This route of entry was not studied in this investigation, however, the routine use of nitrile gloves by the sprayers and stain wipers should minimize exposures to these substances.

A number of ventilation related problems were identified in the Finishing area at Schmidt. Primarily, these problems involved a lack of makeup air and uncontrolled contaminant sources. Solving these problems will require additional makeup air, effective use of exhaust ventilation systems, and training of the employees. To facilitate the additional ventilation, rearrangement of two booths may be needed,

IX. RECOMMENDATIONS

1. Consideration should be given to choosing finishes that do not contain chromium and formaldehyde, or that contain a lower concentration of chromium, ethylene glycol monobutyl ether, or formaldehyde. Suppliers should be consulted on the need to reduce the concentration of these compounds in their products.

2. Engineering controls should be instituted to reduce or eliminate airborne exposures to chromium and formaldehyde. Spray nozzles and the ratio of air to spray should be adjusted to reduce overspray and aerosolization of the varnish.

3. Work practices should be reviewed, emphasizing the need for the operator to spray towards the filter bank at all times and to never allow himself to be between the spray and the filter banks (i.e., the worker should not be in line with the contaminant flowing towards the local exhaust ventilation system).

4. Air monitoring data indicate that respirators should be worn by spray operators who spray chromium or formaldehyde containing finishes. Since NIOSH considers formaldehyde and chromium compounds to be human carcinogens, the use of the most protective respirator is recommended. These include: self-contained breathing apparatus (SCBA) with a full-facepiece operated in the pressure-demand mode; or, a combination respirator which includes a type C supplied-air respirator with a full-facepiece operated in the pressure-demand mode. In addition, respirators should be worn by anyone entering the area where cabinets recently sprayed with finishes containing chromium or formaldehyde are placed to dry unless future air monitoring data indicate that their 8-hour TWA and short-term exposure to hexavalent chromium and formaldehyde are within recommended exposure evaluation criteria. Until this can be determined, access to these drying areas should be restricted. Only employees wearing a respirator should be allowed in those areas. These areas should be physically separated from the other areas with some sort of barrier.

5. The revised OSHA standard for formaldehyde contains provisions for medical surveillance, recordkeeping, regulated areas, emergency procedures, control strategies, protective equipment, and hazard communication. All aspects of this standard should be complied with.

6. A Respiratory Protection Program should be instituted and enforced. Critical components include proper storage, maintenance, and training.

7. The ventilation systems should be redesigned to bring in more makeup air to reduce draft air, to exhaust contaminants from drying parts more effectively and efficiently, and to prevent recirculation of air from outside the plant. Suggested changes to accomplish this are shown in Figure 4. The suggested changes represent one set of options. There may be other options that are just as effective, or more effective. A ventilation expert should be contacted to select and install the best option based on his assessment. In developing the changes, flow of materials in the finishing process was considered. The proposed changes include:

Booth #1 is moved to the location shown in Figure 4 to primarily create an aisle to the new locations for Booths #9 and 110. In addition, this move puts Booth 1 with the other stain booths. Booth #1's exhaust duct can be run out through the wall like the other booths along the wall.

The wiping table is placed in a booth in Figure 4 to allow for capture of the contaminants from the stains. This booth was selected because of its proximity to where the stain is applied. Booth #4 is also reoriented in Figure 4 to provide smooth material flow for the parts sprayed in Booth #3 being moved to Booth #4. This orientation also allows for maintaining the aisle in front of the other booths to permit smooth material flow to the other booths. To facilitate putting the wiping table in Booth 4, the sides of the booth must be extended at least two feet beyond the end to the table nearest the booth face.

Booths #9 and #10 were moved to the location shown in Figure 4 to locate the booths close to the modified drying area. The exhaust duct for these booths can be run up through the second floor to the roof.

For all of the booths along the outside wall, the elbows on the exhaust ducts are turned 180' to point toward the roof. Ducting is then added to the elbows to extend them to above the roof level.

The height of the exhaust stack and the type of rain protection are important to properly disperse contaminants and to avoid recirculation of the exhaust air. The height of the exhaust ducts above the roof level needs to be calculated based on information in ASHRAE's Handbook of Fundamentals.[24] Rain protection for the ducts should be a low-pressure-drop type as recommended in the ACGIH Ventilation Manual.[25] This type of rain protection is also more energy efficient than that currently used at the plant.

In Figure 4, both EF-1 and 2 have been removed. In the redesign, these general exhaust fans are replaced with more efficient general and local exhaust systems.

A plastic strip curtain is shown in Figure 4 being used to create a more efficient drying area. The area inside the curtain depends on the area Schmidt needs for its production. However, the smaller the area inside the curtain, the less ventilation air that will be needed. The location of the curtain should be as close to the spray booth as possible, but enough distance should be allowed between the booth face and the curtain for an uncongested flow of traffic.

The curtain which is suggested for use in the drying area is a plastic strip curtain similar to that commonly used for heavy traffic doorways inside plants. Manufacturers of the curtain can be found under the heading, "Curtains, Strip, Flexible for Insect and Heat Control," in the HPAC Info-dex.[26] The curtain should be suspended as close to the ceiling as possible all around its perimeter and have as small a gap as possible between the floor and the bottom edge of the curtain. The intent is to make the open area of the curtain as small as possible so an appreciable velocity is generated through any leaks in the curtain. Along with this, employees must be instructed to leave the flaps of the curtain closed to avoid pulling too much air through any one section of the curtain.

The exhaust system for the drying area should be a once-through, ducted general exhaust system inside the curtained area, as shown in Figure 4. Entrances into the exhaust system should be spaced on about ten foot centers along the entire center length of the curtained area. The entrances should be placed as close to the floor level as possible without interfering with traffic within the drying area. To get this placement, either the exhaust can be run along the floor or drops from an overhead exhaust duct can be used. A grille sized to prevent debris which could damage the exhaust fan needs to placed over the entrances to the exhaust system, These grilles should be routinely cleaned to prevent their being plugged. All exhaust ducting should be constructed of materials which can withstand abuse or should be protected.

The main exhaust duct can be run through the same holes as the current EF-1. Duct velocity should be at least 1000 fpm. Rain protection for this exhaust duct and the height of this exhaust duct above the roof level follow the same directions as those given for the booth exhaust ducts.

Makeup air needs to be supplied inside the curtain so there is a smooth, laminar flow toward the exhaust. As shown in Figure 4, makeup air is supplied inside the curtain from two ducts which run down the sides of the curtain parallel to the exhaust duct.

The makeup air needs to be supplied at a velocity of 100 fpm or less at the height of the parts being dried to prevent rebound off of the parts and disruption of the exhaust system. Furthermore, the air must be presented from the exhaust system in a fan pattern to cover the entire floor area of the drying area. Two methods can be used to get this pattern. The first is by registers with opposed blade dampers and double deflection louvres mounted in the vertical, inside face of the duct. The front louvres should be horizontal and all louvres should be able to be independently adjusted and locked into place. Air flow from each of the registers needs to be equal and can be adjusted using the opposed blade dampers, The second method to get a fan pattern is by using a perforated, radial-faced diffuser with directional blades. In locating the makeup air duct, care should be taken to not get the diffusers too close to the curtain to avoid the Coanda effect (attachment of the jet to the curtain surface). Further, diffusers should be located relative to each other so that the makeup air sweeps the entire area inside the curtain.

The source of the makeup air is suggested to be the existing air handling unit if it has adequate air flow capacity. The capacity needed is 10% less than the exhaust flow rate. With the exhaust flow greater than the makeup air, the flow of air should be into the curtained area. Moreover, the air supplied to the curtained area can be heated year-round to speed drying and cut down humidity effects without adversely affecting the employees.

Employees in the Sanding area should have a high velocity low volume (HVLV) system installed to collect dust generated from sanding. This system is the same as having a vacuum at every work station. However, a central system is much more efficient. Connections to the system can be made via drops at each work station. To make the system most effective, tools should be purchased or designed which can incorporate a sanding block and a connection to the HVLV system. The HVLV system must not be recirculating.

Makeup air for the booths and the sanding area is supplied by a new air handler and ducted system, as shown in Figure 4. Makeup air for the booths needs to be supplied in front of each booth and above and behind the employee. The air can be supplied through registers with opposed blade dampers and double deflection louvres. As before, the louvres can be used to spread the air throughout the area in front of the booth occupied by the employee and the dampers can be used to equalize the air flow at each booth. Registers need to be specified so that the velocity at the booth face is lower than the exhaust velocity at the booth face to avoid disrupting the air flow pattern into the booth.

Makeup air to the Sanding area is less critical than to other areas because of the high velocities generated by the HVLV system. Therefore, air velocities at the worker position are not-critical. Still, registers with dampers or another type of diffuser with a damper should be used to balance the air flow from the diffusers in the Sanding area.

The location of the new air handler which would supply air to the booths and Sanding area is on the ground outside the east door. In this location, there is a diminished potential of recirculation.

The air flow capacity of the new air handler needs to be 10% more than the sum of the total booth exhaust flow plus the net curtain flow plus the HVLV flow. The net curtain flow is the difference between the exhaust flow and the makeup air flow inside the curtain.

8. Workers should be trained in the proper way to use the spray booths. All parts should be sprayed so the spray is toward the filters in the booth. For small parts, this is fairly easy to follow. For larger parts, this is more difficult. Figure 5 shows the methods which can be used for spraying larger parts. As much as possible, spraying should be performed at the centerline of the booth and workers should attempt to not aim the sprayer at the side walls.

9. When spraying small parts, the parts should be kept inside the booth until a cart full is done. Then the cart of sprayed parts can be moved to the drying area for final drying.

10. Workers should to be trained in the use of control systems. Workers should be instructed in what the control does, the proper operating parameters for the control, and how to properly use the control. This training should be administered by management or a responsible, qualified employee.

11. The fans on all booths should be inspected and repaired. Loose belts and cracked sheaves should be replaced. If only one belt is loose on a fan, both belts should be replaced.

12. Use of airless sprayers at other booths should be investigated. One of the major sources of employee exposure to contaminants during spray painting is overspray. Airless spraying produces less overspray and can reduce worker exposure. If airless spraying is not feasible, then experiments should be run to find what is the lowest acceptable airline pressure. Once this pressure is found, the regulators on the airline should be locked at the pressure and only management allowed to change the pressure.

13. Workers should be discouraged from using solvents to clean their hands. Solventless cleaners should be used for this, purpose.

14. Solvent cans should have tight fitting lids. Any rags which have solvents or solvent-containing materials on them should be placed in containers that meet the local fire codes.

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XII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Schmidt Cabinet Company
2. Carpenters Union, Local 2489

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

Table 1. Instruments Used for Ventilation Survey
Schmidt Cabinet Company
New Salisbury, IN
HETA 88-268

Instrument	Model Number	Make	Use during survey
Flow Hood	CFM 86 PB	Shortridge	Used to measure: makeup air flow from ducts; pressure differential between outside and Inside plant; pressure drop across booth filters when clean and after one day's use; static pressure at outlet of EF-1; barometric pressure for air density corrections.
Hot-wire Anemometer	8500	Alnor	Used to measure face velocities on three spray booths.
Strobotach	DS 12v	Pioneer	Used to measure rotational speed of booth fans and EF-1 and 2.
Psychrometer	2573	Vista Scientific	Used to measure wet and dry bulb temperatures for air density corrections.
Fog Machine	1500	Roscoe	Used to visualize air flow patterns.
Smoke tubes	CH 25301	Draeger	Used to visualize air flow patterns.

Table 2

Health Effects of Selected Volatile Organic Carbon Compounds
Schmidt Cabinet Company
New Salisbury, Indiana

August 25, 1988
HETA 88-068

(synonym)	Health Effect
	dizziness, nausea, incoordinated movements, loss of coordinated speech, drowsiness, irritating to eyes, nose, and throat
Ethyl Acetone	weakness, drowsiness, irritating to eyes, nose, and throat
Ethyl Alcohol (ethanol)	incoordination, drowsiness, headache, irritating to eyes and upper respiratory tract
Ethylene glycol Monobutyl ether (2-butoxy-ethanol)	irritating to eyes, nose and throat
Methyl Alcohol (methanol)	headaches, weakness, drowsiness, lightheadedness, irritating to eyes
Methyl Isobutyl Ketone	weakness, headache, nausea, lightheadedness, dizziness, incoordination, vomiting, irritating to eyes, nose, and throat
Naphtha	lightheadedness, drowsiness, irritating to eyes, nose and skin
Toluene	fatigue, weakness, confusion, euphoria, central nervous system depressant
Xylene	dizziness, excitement, drowsiness, central nervous system depressant, respiratory irritation

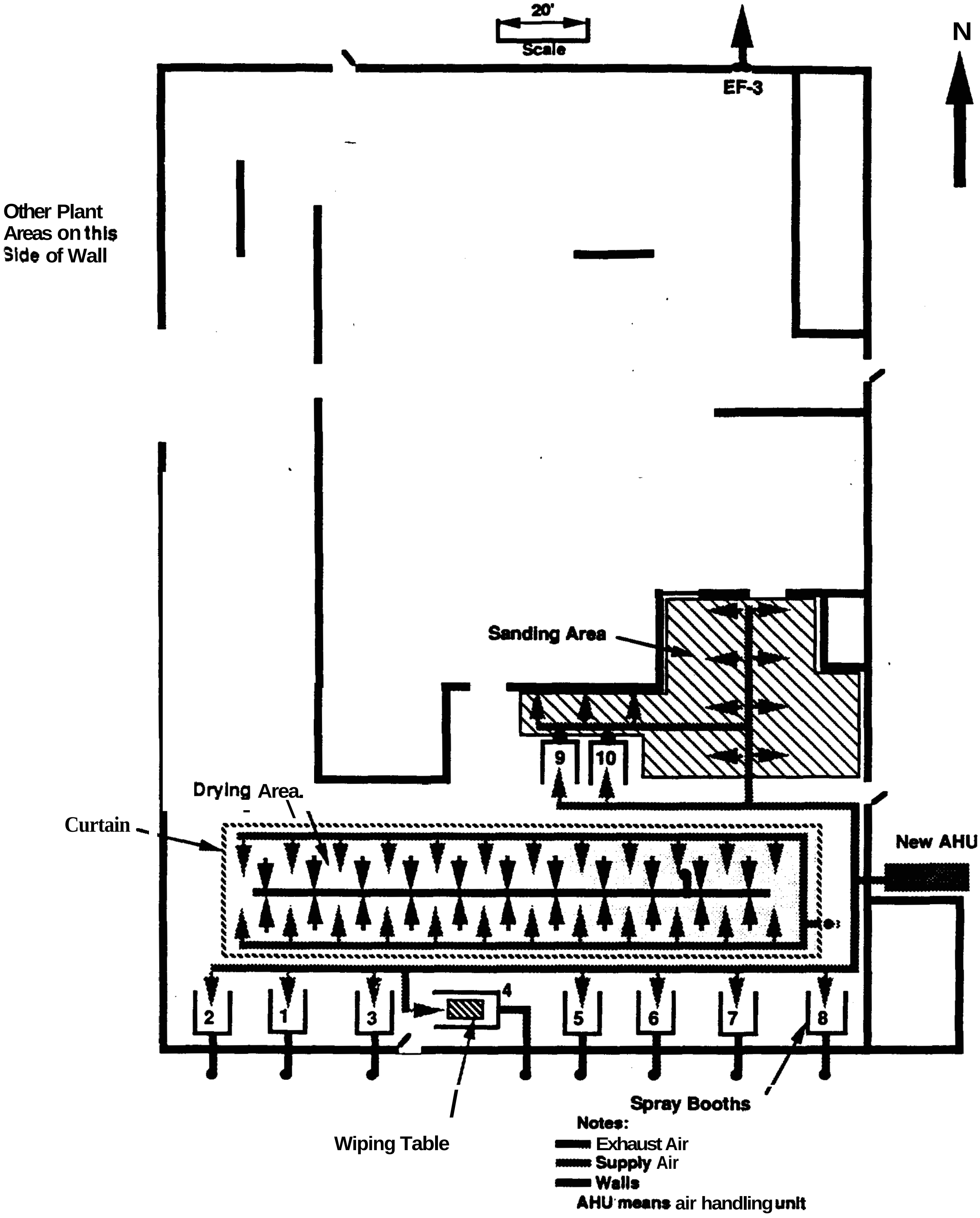
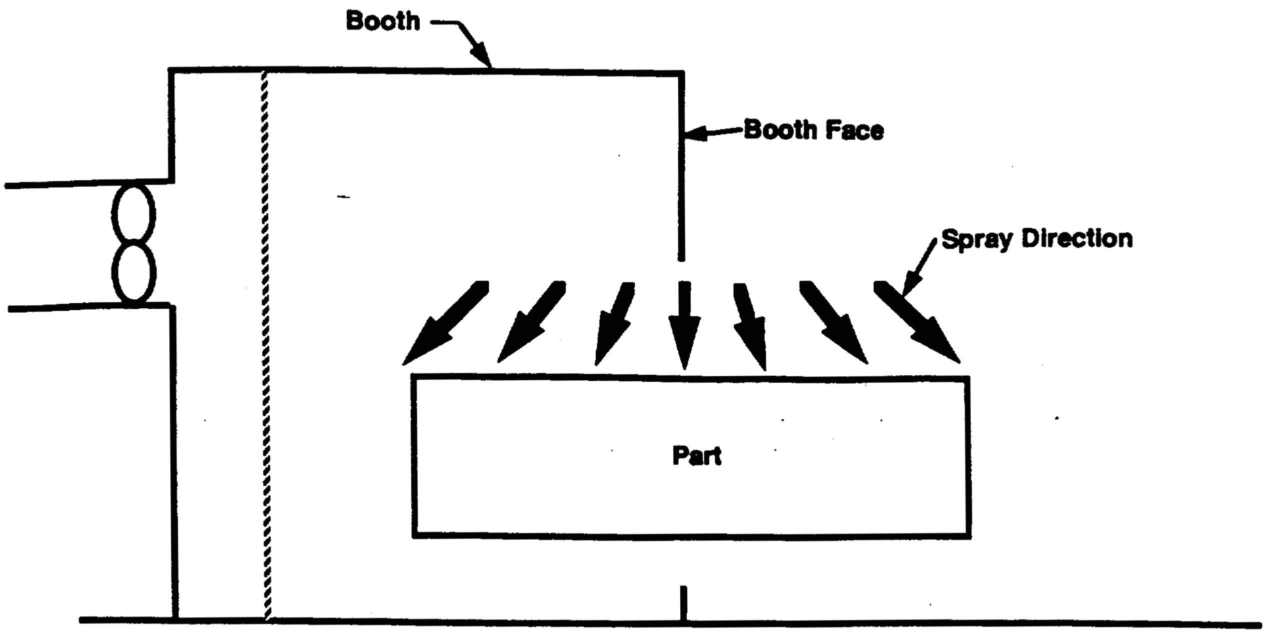
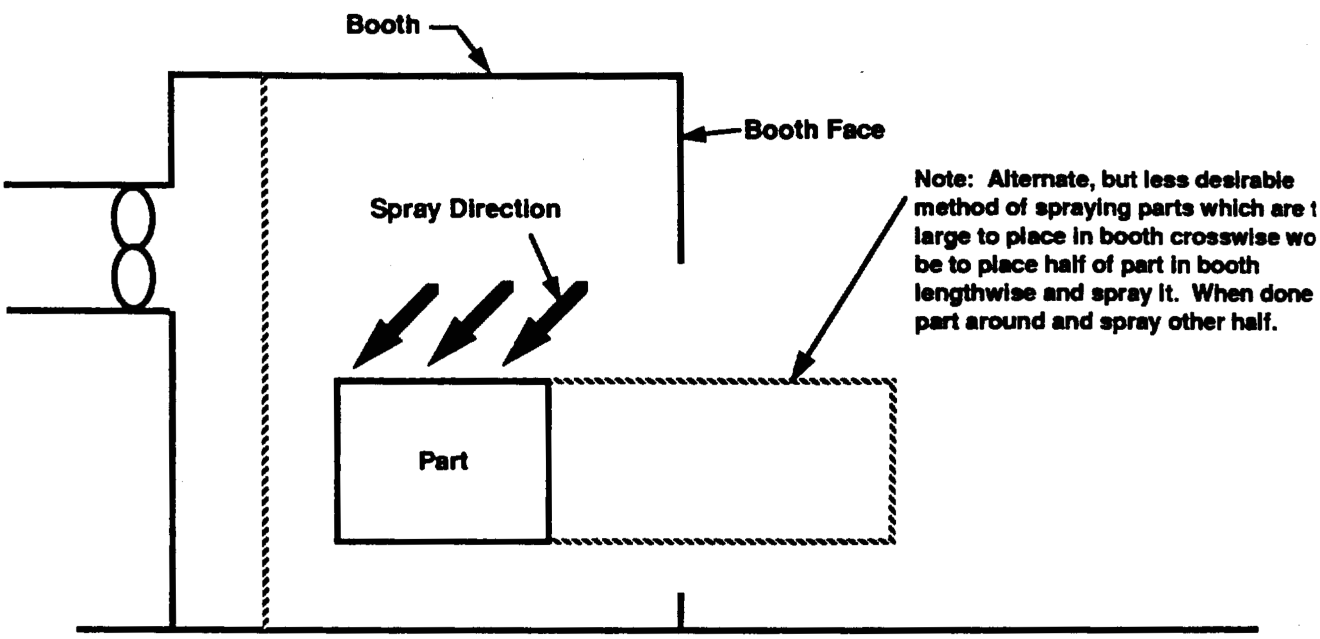


Figure 4. Proposed Ventilation Changes to Finishing Area
Schmidt Cabinet Co.
New Salisbury, IN
HETA 88-068



Side View

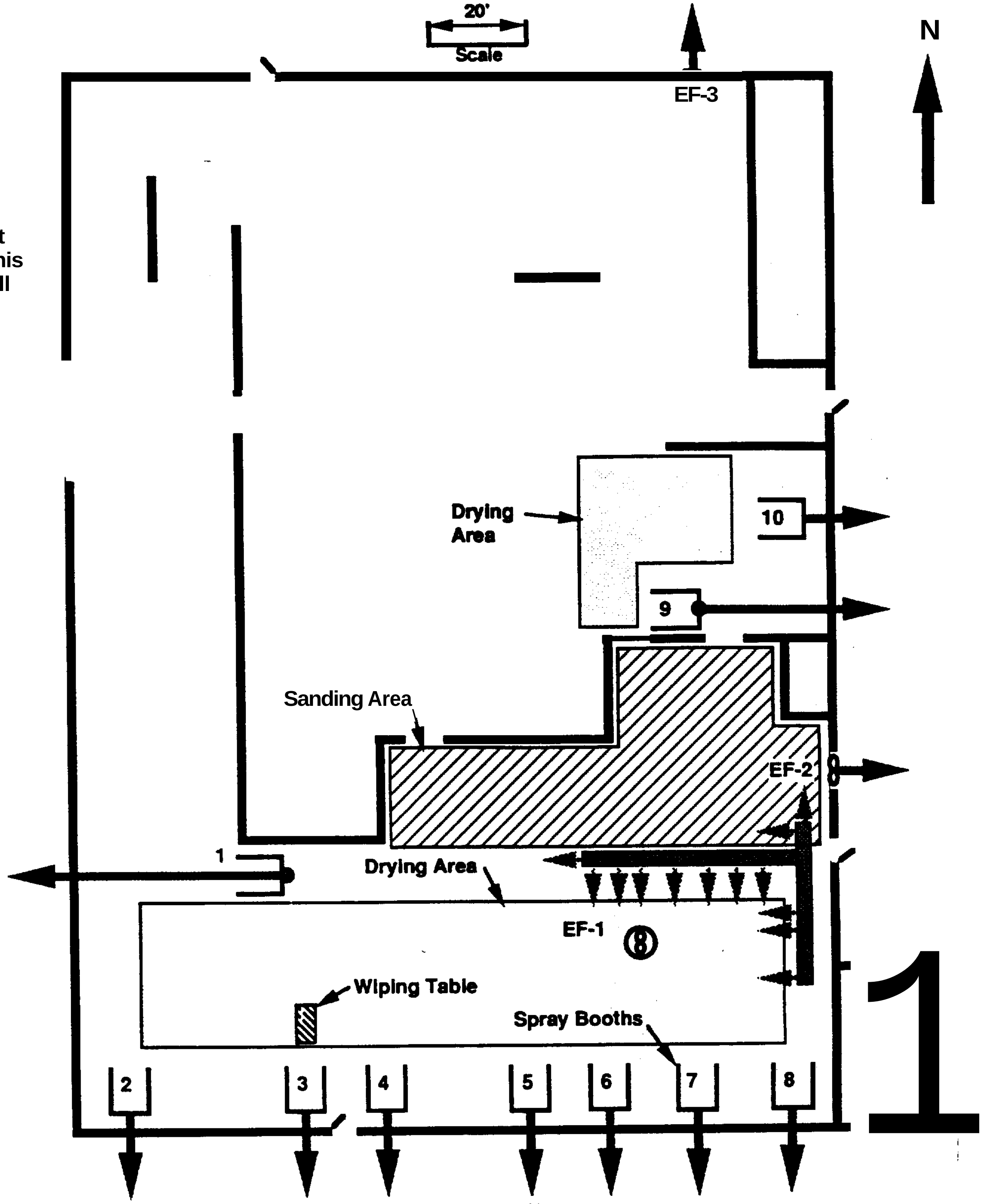
Current Method for Spraying Large Parts



Side View

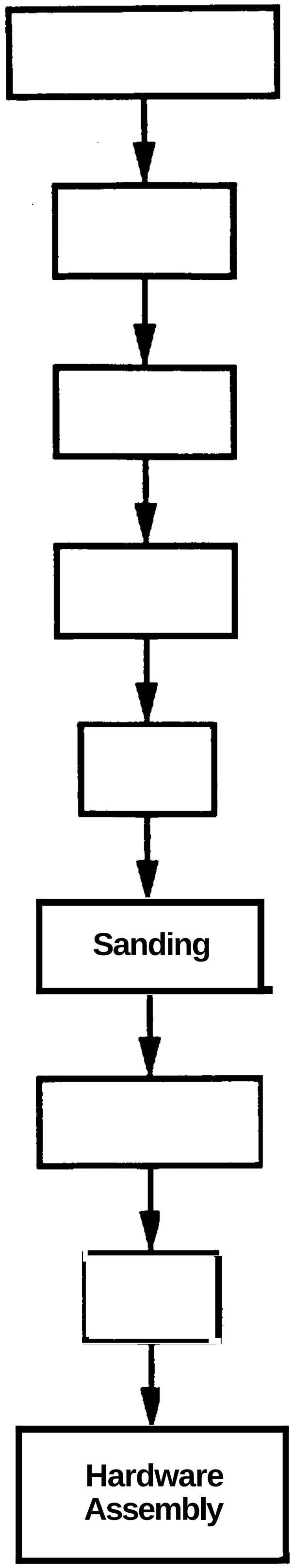
Proposed Method for Spraying Large Parts

Figure 5. Methods for Spraying Large Parts.
Schmidt Cabinet Co.
New Salisbury, IN
HETA 88-068



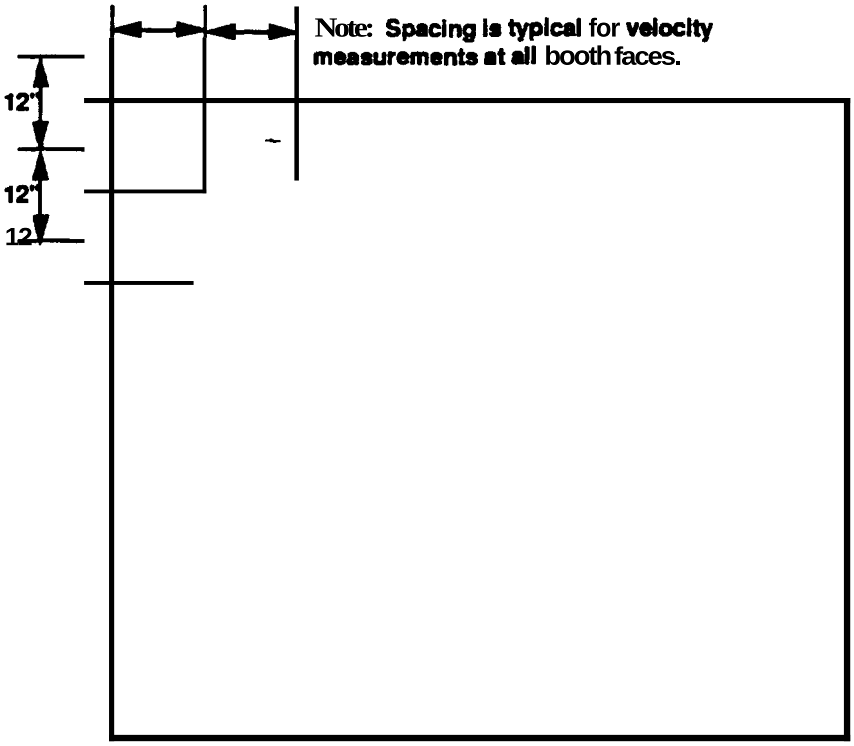
Notes:
Exhaust Air
Supply Air
Walls
EF means exhaust fan.
Drying and sanding areas are aproximate.
All booths have elbows at exits. Elbows a-n round smooth and two-foot in diameter, have a two-foot s of duct attached, and have a turning radius to the centerline of two feet.

Figure 2. Finish Room Floor Plan
Schmidt Cabinet Co.
New Salisbury, IN
August 25,1988
HETA 88-068



Note: Assembly and Hardware Assembly are not considered to be part of the finishing process in this report.

Figure 1. Process Flow
Schmidt Cabinet, New Salisbury, IN
HETA 88-068

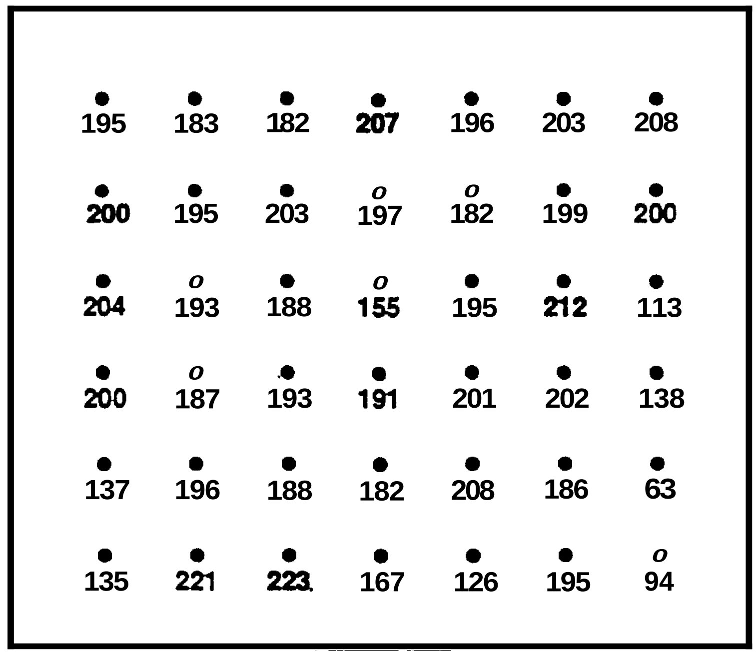


Booth B1

56	125	89	118	119	160	160
94	119	113	109	163	164	60
105	121	111	91	180	138	31
99	113	107	42	153	58	32
156	141	124	114	159	129	36
140	134	126	133	173	148	56

Booth B3

Figure **3.** Spray Booth Face Velocities.
Schmidt Cabinet, New Salisbury, IN
HETA 88-068



Booth B5

Figure 3. Spray Booth Face Velocities.
Schmidt Cabinet, New Salisbury, IN
HETA 88-068

Table 4. Exhaust Air Flows (acfm) Under Varying Conditions
Schmidt Cabinet Co.
New Salisbury, IN
HETA 88-068

Booth/ Exhaust Fan	Condition							
	1	2	3	4	5	6	7	8
B-1	6748	6804	6895	6918	6710	6785	6878	6908
B-2	7035	7111	7215	7251	7017	7093	7197	7234
B-3	7072	7125	7196	7220	7042	7096	7168	7192
B-4*	7011	7090	7198	7236	7011	7090	7198	7236
B-5	7398	7484	7474	7641	7310	7400	7518	7559
B-6	7179	7261	7373	7412	7106	7190	7302	7341
B-7*	7014	7093	7200	7238	7014	7093	7200	7238
B-8	7200	7282	7394	7433	7151	7234	7347	7386
B-9	6562	6622	6698	6723	6548	6609	6686	6711
B-10	5618	5742	5898	5948	5593	5720	5877	5928
EF-1**	7024	8032	9436	9940	7024	8032	9436	9940
EF-2**	20372	22428	25355	26397	20372	22428	25355	26397
Total	96,233	100,074	105,332	107,357	95,898	99,770	105,162	107,070

Condition	Plant Doors	Makeup Air from Air Handler	Booth Filters
1	All closed	no	new
2	All closed	yes	new
3	All open	no	new
4	All open	yes	new
5	All closed	no	used
6	All closed	yes	used
7	All open	no	used
8	All open	yes	used

*These booths not used on the day of the survey, so filters remained clean. Flow rate shown for Conditions 5 [illegible]

Volatile Organic Carbon Exposure Results
Schmidt Cabinet Company
New Salisbury, Indiana

August 25, 1988
HETA 88-068

Job Description/Sample Location		Sample Duration	Sample Volume (L)	Acetone (ppm)	Ethyl Acetate (ppm)	Ethyl Alcohol (ppm)	Ethylene Glycol Monobutyl Ether (ppm)	Methyl Alcohol (ppm)	Methyl Isobutyl Ketone (ppm)	Naphtha (ppm)	Toluene (ppm)	Xylene (ppm)	Combined mixture exposure to exposure criteria
Stain Sprayer	P P	0700-1123 1125-1532	50.2 45.4	ND ND	(0.1 0.2	(0.1 0.3	(0.1) (0.1)	ND ND	ND 0.3	4.9 2.4	0 0	0.8 1.3	0.05
Stain Wiper	P P	0700-1120 1121-1532	51.9 49.5	ND (0.1	(0.2 0.3	ND 0.4	(0.1 0.4	ND ND	ND 0.8	7.7 6.3	0.7 1.8	0.8 0.4	0 13
Sealer/Sander	P P	0702-1126 1126-1532	50.9 46.7	ND ND	ND ND	ND (0.1)	(0.1) ND	ND ND	ND ND	2.6 (1.4)	0.6 0.4	0.5 0.5	0.03
Drying Area by booth	A A	0713-1112 1115-1532	48.9 50.2	ND (0 3	ND (0.2	ND 0 1)	ND (0 1	ND ND	(0.1) (0.1)	2.7 6.6	0.8 1.1	0.7 2.7	0.08
Drying Area near Ceiling Exhaust Fan	A A	0757-1117 1118-1532	39.7 49.7	(0.2) 0.3	ND (0.2	ND (0 1	ND (0 1)	ND ND	(0.1) (0.1)	6.7 6.3	1.1 1.1	2.2 2.4	0 10
Limit of Detection Limit of Quantitation				0.09 0.3	0.05 0.2	0.11 0.3	0.04 0.1	0.16 0.5	0.05 0.2	0.45 1.4	0.05 0.2	0.05 0.1	
Exposure Criteria OSHA		8-hr TWA STEL		750 1000	400	1000	25	200	50	100	100 150	100 150	
ACGIH		8-hr TWA STEL		750 1000	[illegible]00	1000	25	200 250	50 75	100	100 150	100 150	
NIOSH		10-hr. TWA Ceiling		250				200 15 min 800			100 10 min 200	100 10 min 200	

ND = none detected
() = Values in parenthesis are between the limit of detection and limit of quantitation
*see text for calculation.
STEL = Short Term Exposure Limit
TWA = Time Weighted Average