HETA 89-170-2100
FEBRUARY 1991
NORTHWEST VOCATIONAL SCHOOL
CINCINNATI, OHIO

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I. SUMMARY

On March 20, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Director of Vocational Programs for the Northwest School District to conduct a Health Hazard Evaluation (HHE) at the Northwest High School Vocational Center, Cincinnati, Ohio. The requestor was concerned about potential formaldehyde exposures to students and instructors in the Cosmetology Laboratory.

On May 3, 1989, an initial walk-through survey of the Cosmetology Laboratory was conducted. On May 17 - 18, 1989, long-term and short-term general-area air samples for formaldehyde were collected. The highest measurable concentration was a short-term sample collected during the preparation of the cabinet fumigant from 37% formalin. This sample showed 2.9 parts of formaldehyde per million parts of air (ppm) and exceeded the Occupational Safety and Health Administration (OSHA) short-term exposure limit (STEL) of 2.0 ppm. Long-term general-area air samples collected throughout the Cosmetology Laboratory and Classroom ranged from 0.013 ppm to 0.9 ppm. Temperature and relative humidity measurements were also collected and all measurements were within the American Society of Refrigeration and Air-Conditioning Engineers (ASHRAE) guidelines for thermal comfort.

On March 23, 1990, NIOSH was requested to examine the Cosmetology Laboratory heating, ventilation and air-conditioning (HVAC) system. On April 4, 1990, NIOSH investigators conducted air flow, carbon dioxide (CO_2), temperature and relative humidity measurements to evaluate the HVAC system. The results showed that inadequate amounts of fresh outside air were being delivered to the occupied space (floor to 6 foot height) and CO_2 measurements within the Cosmetology Laboratory ranged from 1000 to 1300 ppm, exceeding the ASHRAE guidelines for Acceptable Indoor Air Quality.

On the basis of the data obtained during this investigation, it was determined that a health hazard existed during the preparation of formaldehyde cabinet fumigants and that the use of formaldehyde cabinet fumigants contributed to the airborne formaldehyde concentrations within the Cosmetology Laboratory. Based on air flow and CO_2 measurements, it was also determined that inadequate amounts of fresh outside air were being supplied to these areas and there was poor air distribution within the Cosmetology Laboratory and Classroom.

KEYWORDS: SIC 8249 (Vocational School, Not Elsewhere Classified), formaldehyde, fumigants, beauty schools, cosmetology, cosmetologists, hairdressers.

II. INTRODUCTION

On March 20, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Director of Vocational Programs for the Northwest School District to conduct a Health Hazard Evaluation (HHE) at the Northwest High School Vocational Center, Cincinnati, Ohio. The requestor was concerned about potential formaldehyde exposures to students and instructors from the use of formaldehyde cabinet fumigants in the Cosmetology Laboratory.

On May 3, 1989, an initial walk-through survey of the Cosmetology Laboratory was conducted. On May 17 - 18, 1989, industrial hygiene samples were collected and included long-term and short-term general-area air samples for formaldehyde along with temperature and relative humidity readings. The results of this survey were transmitted to the Director of Vocational Programs for the Northwest School District via written correspondence on September 25, 1989.

On March 23, 1990, the Director of Vocational Programs for the Northwest School District requested that NIOSH examine the Cosmetology Laboratory heating ventilation and air-conditioning (HVAC) system. On April 4, 1990, NIOSH investigators, conducted airflow measurements to evaluate the HVAC system serving the Cosmetology Laboratory and Classroom. Additionally, carbon dioxide (CO_2), and temperature and relative humidity readings were collected throughout the Cosmetology Laboratory area and the adjoining Cosmetology Classroom. The results of this survey were transmitted to the Director of Vocational Programs for the Northwest School District via written correspondence on August 9, 1990.

III. PROCESS DESCRIPTION

The Northwest High School Vocational Center is located in a single building behind Northwest High School. The school opened at the beginning of the 1969-70 school year. The vocational school district serves all schools within the Northwest School District of Hamilton County, Ohio. The building is served by six separate HVAC systems. The Cosmetology Laboratory, which is located in the west-central part of the building, includes a reception area, a girls locker room/restroom, the laboratory area, and the dispensary room, and classroom. These areas are all served by a single dedicated HVAC system.

Prior to December 1989, the Ohio State Board of Cosmetology Sanitary Rules (Form B5-2, Revised 06/85, State Board of Cosmetology, Columbus, Ohio) required that "Every beauty salon shall be equipped with at least one wet sanitizer and at least one cabinet sanitizer which must contain an effective fumigant. Sanitized instruments, combs and appropriate items must be stored in a closed cabinet containing an effective fumigant." The stated purpose of this regulation was to prevent the growth of microorganisms and to insure the sterility of stored towels and equipment.

To comply with this regulation students enrolled in the Northwest High School Cosmetology Program prepared a cabinet fumigant from 37% formalin and placed the preparation in all cabinets and drawers where towels or cosmetic equipment was stored. Formalin is a solution of about 37% by weight of formaldehyde gas in water.[1] The procedure for preparing the cabinet fumigant involved placing a cotton swab in a small open cup, adding one teaspoon of Borax® and one teaspoon of 37% formalin. Students did not wear respiratory protection or skin protection during the preparation of the cabinet fumigants.

An inspection of the HVAC system showed that one air handling unit (AHU) served Room 307 (the Cosmetology Classroom) and Room 309 (the Cosmetology Laboratory, Reception Room, and Dispensary), and was dedicated to serving only these areas. The HVAC system mechanical drawings did not contain a statement about the design intent of the HVAC system and a review of the mechanical drawings did not help clarify the intent. Therefore, the following description of the HVAC system is based on speculation of the designers intent. Air was supplied by a constant volume system and the spaces served by this AHU appeared to be split into two air supply zones. Air was supplied to the two zones through two stub ducts in the ceiling plenum, which was formed by the roof and suspended ceiling. Air was supplied to the largest zone, which apparently included the Cosmetology Laboratory and Reception Room, through a stub duct which ends at the wall separating the Mechanical Room from the Cosmetology Laboratory. Air supply to the other zone, which included the Dispensary and Classroom, was through a stub duct which ends at the wall separating the Dispensary from the Cosmetology Laboratory. The perimeter of each supply zone was formed by floor to roof concrete block walls. However, the wall separating the Dispensary and Classroom from the Reception Room and the Cosmetology Laboratory ended just above the suspended ceiling which allowed air to migrate between zones in the ceiling plenum. Air distribution to the rooms was through 1/8 x 1-1/2 inch slots in the suspended ceiling tiles and was returned through floor registers along the walls of the areas served by this AHU.

IV. EVALUATION DESIGN AND METHODS

A. Industrial Hygiene Sampling

On May 3, 1989, an initial walk-through survey of the Cosmetology Laboratory was conducted. On May 17 - 18, 1989, long-term and short-term general-area air sampling for formaldehyde was conducted along with temperature and humidity readings.

Formaldehyde samples were collected using impingers (containing an aqueous 1% sodium bisulfite solution) connected via Tygon tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 1 liter per minute (LPM). Sodium bisulfite solutions were analyzed for formaldehyde by reaction with chromotropic acid and subsequent visible absorption spectrophotometry in accordance with NIOSH Method No. 3500.[2]

Temperature and humidity readings were collected throughout the Cosmetology Laboratory areas and Cosmetology Classroom using a Vista Scientific Corporation psychrometer (Model #784).

B. Ventilation Measurements

On April 4, 1990, NIOSH investigators, conducted airflow measurements to evaluate the HVAC system serving the Cosmetology Laboratory and Classroom. Additionally, carbon dioxide (CO_2), and temperature and relative humidity readings were collected throughout the Cosmetology Laboratory area and the Cosmetology Classroom.

Air velocities were measured at the two stub duct outlets using a Shortridge Velprobe and meter (MN 86BP) equipped with a temperature probe to compensate for temperature. This instrument also compensates for barometric pressure. Ceiling tiles had to be removed to obtain the required air flow measurements potentially resulting in lower fan resistance and calculation of a higher air flow.

A visual inspection of accessible parts (mixed air chamber and filter) of the AHU was also conducted and smoke tube traces were used to visualize air flow patterns within the spaces served by the AHU.

Indoor CO_2 concentrations were obtained in Room 307 (Cosmetology Classroom) and Room 309 (Cosmetology Reception Room, Cosmetology Laboratory, and Cosmetology Dispensary). For comparison, ambient CO_2 samples were collected outside the building. CO_2 samples were obtained using a Gastech direct reading Portable CO_2 Monitor (Model RI411), set in the 60 second average mode.

V. EVALUATION CRITERIA

A. Environmental Evaluation Criteria

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 Recommended Exposure Limits (RELs),[3] 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[4] and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards.[5] The OSHA standards may be 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 required by the Occupational Safety and Health Act of 1970 (29 USC 651, et seq.) 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 (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

B. Formaldehyde

Formaldehyde is a colorless gas with a strong, pungent odor detectable at low concentrations. It is commonly utilized as formalin, an aqueous solution containing 37-50% formaldehyde by weight.[6] It is widely used in the production of resins, in the manufacture of many other compounds, as a preservative, as a sterilizing agent, and as an embalming fluid.[7]

Exposure to formaldehyde can occur through inhalation or skin absorption.[8] The primary non-carcinogenic effects associated with formaldehyde exposure are irritation of the mucous membranes of the eyes and respiratory tract, and allergic sensitization of the skin. The first signs or symptoms noticed on exposure to formaldehyde, at concentrations ranging from 0.1 to 5 ppm, are burning of the eyes, tearing, and general irritation of the upper respiratory passages. There does, however, appear to be a great deal of variation among individuals, both in terms of their susceptibility and tolerance.

Dermatitis due to skin contact with formaldehyde solutions and formaldehyde-containing resins is a well-recognized problem. Both primary skin irritation and allergic dermatitis have been reported.[6] Dermatitis may appear a few days following the commencement of work or may not appear for a number of years following exposure.[8]

In two separate studies, formaldehyde has induced a rare form of nasal cancer in rodents following repeated inhalation exposure.[9,10] Concern over the possible human carcinogenicity of formaldehyde has prompted several epidemiologic studies of workers exposed to formaldehyde. An association between formaldehyde exposure and cancer of the upper respiratory passages in humans has recently been reported.[11] In this proportionate mortality study of workers exposed to formaldehyde in the garment industry, a statistically significant excess in mortality from cancers of the buccal cavity and connective tissue was found. No cases of nasal cancer were observed, however. In a reanalysis of a National Cancer Institute study, "a statistically nonsignificant but suggestive increase for age-adjusted relative risk for buccal and pharyngeal cancer among employees with greater than 0.5 ppm average exposure in plants manufacturing formaldehyde resins" was found.[12]

In 1984, Ulsamer et al. reviewed four animal inhalation studies. No teratogenic effects were reported in these studies.[13] No birth defects were reported in a study which involved the application of formalin to the backs of pregnant hamsters.[14] No data were found linking formaldehyde with teratogenic effects in humans. There was one report in which an increased incidence of menstrual disorders and of complications of pregnancy and delivery was reported among women workers exposed to formaldehyde at a textile factory in the USSR.[15] The relevance of these findings has been criticized, however, due to a lack of information regarding the suitability of the control group and potential confounding factors.[16]

In April 1981, NIOSH issued Current Intelligence Bulletin 34, "Formaldehyde: - Evidence of Carcinogenicity", DHHS (NIOSH) Publication No. 81-111.[17] In this bulletin, NIOSH recommends that formaldehyde be handled as a potential occupational carcinogen and that appropriate controls be used to reduce worker exposure to the lowest

feasible level. This recommendation is based primarily on a study in which nasal cancers developed in rats and mice following repeated inhalation exposures of approximately 15 ppm formaldehyde. In December, 1987, OSHA published an amended formaldehyde standard, 29 CFR 1910.1048. This standard reduced the PEL from 3 ppm to 1 ppm, as an 8-hour TWA.[18] In addition, a 15-minute short term exposure limit (STEL) was set at 2 ppm. ACGIH has given formaldehyde an A2 designation, indicating that ACGIH considers formaldehyde a suspected human carcinogen. The ACGIH TLV for formaldehyde is 1 ppm as an 8-hour TWA and 2 ppm as a 15-minute STEL.[4] ACGIH has recently proposed a ceiling limit of 0.3 ppm formaldehyde in their notice of intended changes for 1989-1990.[4] This value will be reconsidered for the adopted TLV list after 2 years.

C. Heating Ventilating and Air-Conditioning (HVAC) Systems

The outside air ventilation criteria recommended by NIOSH are those published by the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) in the ASHRAE Standard on Ventilation for Acceptable Indoor Air Quality (ASHRAE 62-1989).[19] Table 2 of that document specifies outdoor (fresh) air requirements for ventilation in commercial facilities. ASHRAE recommends a fresh air ventilation rate of 25 CFM/person for Beauty Shops.

D. Temperature and Relative Humidity

The majority of references addressing temperature and humidity levels as they pertain to human health frequently appear in the context of assessing conditions in hot industrial environments. However, ASHRAE has published guidelines describing thermal environmental conditions for comfort (ASHRAE Standard 55-1981, Thermal Environmental Conditions for Human Occupancy).[20] These guidelines are intended to achieve thermal conditions that will be found acceptable or comfortable by at least 80% of the populations. Development of a "comfort" chart by ASHRAE presents a comfort zone considered to be both comfortable and healthful. This zone lies between 73° and 77° F (23° and 25° C) and 20% to 60% relative humidity.

E. Carbon Dioxide

Carbon dioxide (CO_2) is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate if adequate quantities of fresh air are being introduced into a building. For example, the outdoor ambient concentrations of CO_2 is usually 250-300 ppm. If the indoor CO_2 concentration was determined to be 1000 ppm, or 3-4 times the outdoor level, inadequate ventilation would be suspected. Carbon dioxide concentrations are generally higher inside than outside, even in a well ventilated building. It is not uncommon to find the inside levels twice the outside levels in a building with no reported health complaints. The CO_2 concentration itself is not responsible for the complaints. However, a high concentration of CO_2 may indicate that other contaminants in the building may also be increased. When the inside CO_2 concentrations are 3 or more times the outside CO_2 concentrations, complaints of headache, eye irritation, and fatigue can be expected. If CO_2 concentrations are maintained below 600 ppm, with comfortable temperature and humidity levels, complaints about air quality should be minimal unless there is a specific contaminant source that requires additional control such as, certain cosmetology products.[21]

VI. RESULTS

A. Industrial Hygiene Survey

The results of general-area and source air sampling for airborne formaldehyde collected during the May 1989 survey are presented in Table I. These results show airborne formaldehyde concentrations ranging from a low of 0.013 parts of formaldehyde per million parts of air (ppm) to a high of 2.9 ppm. The highest concentration was a short-term exposure collected at the location where a student was preparing the formaldehyde fumigant. Because the sample media used was an impinger solution, the sample was not attached to the students breathing zone, but was located as near as possible to the breathing zone. During the fumigant preparation procedure, the student remained in one location; therefore, this sample was expected to provide a good estimate of personal exposure. All other samples were general-area or source air samples and, therefore, do not necessarily represent personal exposures. The highest general-area air sample showed a formaldehyde concentration of 0.73 ppm in the dispensary. Source air samples from inside equipment drawers and towel cabinets ranged from 0.18 ppm up to 0.55 ppm. The lowest concentration (0.013 ppm) was a sample collected outside the building in the football field bleachers and could be considered to be the ambient formaldehyde level.

B. Ventilation Survey

Results of HVAC measurements collected during April 1990 are presented below. The cosmetology laboratory was occupied by 13 to 15 students plus an instructor (full capacity is 20 students plus and equal number of patrons) during the time measurements were collected. Shown are the measured average air velocities supplied at the two stub ducts in feet per minute (fpm) and the calculated volumetric flow in actual cubic feet per minute (acfm).

Supply air	Average Velocity	Calculated Flow
Cosmetology Laboratory	758 fpm	2526 acfm
Dispensary and Classroom	584 fpm	681 acfm
Total		3207 acfm

The Cosmetology Laboratory AHU provided a total air flow of 3207 cfm to the spaces served by this unit. The total volume of the entire area served by the AHU was used to calculate the air exchange rate, 8.4 air changes per hour.

Based on the total number of air distribution slots and area of each slot, the air velocity from each slot was calculated to be 954 fpm (actual slot velocities were not measured). However, smoke tube traces showed that air movement in the occupied zone (floor to 6 foot height) was relatively stagnant (very slow, idle or no movement). Where air movement was observed, air moved toward the return air registers. Smoke tube traces

also showed that air from the hallway flowed into the Reception Room and Classroom, and from the Reception Room and Dispensary into the Cosmetology Laboratory.

During the ventilation survey, temperature readings within the Cosmetology Laboratory and Classroom ranged from 73° F to 77° F and relative humidity readings ranged from 29% to 31%. All temperature and relative humidity measurements were within the ASHRAE comfort zone.[20] However, a few occupants complained of the temperature being too warm. Carbon dioxide measurements within the Cosmetology Laboratory ranged from 1000 parts of CO_2 per million parts of air (ppm) up to 1300 ppm. The CO_2 concentration was 300 ppm outdoors and 775 ppm in the hallway outside the Cosmetology Classroom and Reception Room.

VII. DISCUSSION

The main focus of this investigation was the use of formaldehyde cabinet fumigants in towel cabinets, equipment drawers and student cosmetic kits, as required by the State of Ohio, Board of Cosmetology. At the time of the May 1989 survey, the Ohio State Board of Cosmetology required the use of an "effective" fumigant (i.e. formaldehyde) inside towel cabinets, equipment drawers, and student cosmetic kits. Because formaldehyde has been shown to cause cancer in laboratory animals and is considered by OSHA, NIOSH and the ACGIH to be a potential occupational carcinogen, NIOSH had previously recommended that the Board (letter of January 10, 1989) review its regulations to determine if the use of formaldehyde cabinet fumigants was necessary. Since that time the Board has issued new regulations (effective December 16, 1989) regarding the use of formaldehyde cabinet fumigants. The new rules removed the requirement that "an effective fumigant" be used in equipment storage cabinets, but do not specifically ban their use, and offer no explanation as to why this requirement was removed from the Sanitary Rules. In effect the new rules make the use of "an effective fumigant" in storage cabinets and equipment drawers optional.

The cabinet fumigant being used in the Northwest High School Cosmetology Laboratory was prepared by the students from a 37% formalin solution and Borax®. Students preparing the cabinet fumigants did not wear respiratory or skin protection during the procedure and the procedure was not performed within a local exhaust ventilation hood. Sample results showed that the highest detectable airborne formaldehyde concentration (2.9 ppm) occurred during preparation of the cabinet fumigant. Other air sampling results showed airborne formaldehyde concentrations inside towel cabinets were more than ten times above background. The relatively high concentrations detected inside these enclosed spaces indicate a potential for short peak exposures above background concentrations when opening the cabinets or other storage spaces. General-area airborne formaldehyde concentrations detected in the dispensary on the second day were about 75% of the OSHA PEL of 1.0 ppm. Lower concentrations were detected in the other work areas of the Cosmetology Laboratory. These sample results also indicate that formaldehyde vapors migrated from the dispensary, where most equipment is stored and the cabinet fumigant was prepared, to the surrounding areas.

Although sample results show high airborne formaldehyde concentrations within towel cabinets, it must be understood that these samples were collected inside the enclosed spaces of the towel cabinets and do not represent actual employee exposures. However, while no one is actually exposed to the formaldehyde concentrations detected within these enclosed spaces, the measured concentrations do indicate the potential for brief exposures (when opening towel cabinets and drawers) to concentrations substantially greater than the average

levels measured in the occupied work areas. It should also be noted that the use of formaldehyde cabinet fumigants are clearly intended to release formaldehyde vapors and that the use of these types of products do contribute to the overall airborne formaldehyde concentrations within the areas where they are used. Formaldehyde is an irritant and short peak exposures at the concentrations identified could possibly result in mild discomfort, and eye and throat irritation. The risk of developing nasal cancer from these exposures is not known.

Formaldehyde cabinet fumigants are not the only source of formaldehyde within beauty salons and are not the only source of chemical exposures. Cosmetologists are potentially exposed to a multitude of other chemical compounds in their daily work, many capable of causing dermatitis, irritation, sensitization, and other symptoms through inhalation and dermal absorption.

Any products or fixtures containing formaldehyde can contribute to airborne formaldehyde concentrations within the work environment. Therefore, the use of all products containing formaldehyde or any suspected or confirmed carcinogen should be discontinued where possible. In instances where this is not feasible, personnel should be protected by the use of engineering controls (e.g. ventilated cabinets). If engineering controls are used rather than product substitution, towel cabinets and equipment drawers could be equipped with a local exhaust ventilation system which is actuated when the cabinet or drawer is opened. The system should be designed to remove the air in the space, thereby removing formaldehyde vapors before they can escape into the general workroom air.

The results of the ventilation survey showed that all CO_2 measurements collected in the Cosmetology areas exceeded the ASHRAE recommendation of 1000 ppm. This indicates that inadequate amounts of fresh outside air were being supplied to the Cosmetology areas. Although all temperature and relative humidity measurements collected during the two surveys were within the ASHRAE comfort zone, visual observation of smoke tube traces showed air movement in the occupied zone of the work areas was stagnant; indicating poor air distribution within the Cosmetology areas which may account for verbal complaints of discomfort. Additionally, smoke tube traces showed that even though the spaces served by the cosmetology AHU were under negative pressure relative to other areas of the building air moved out of the dispensary and into the laboratory areas.

ASHRAE recommends an outside air supply of 25 cfm/person for beauty salons and 15 cfm/person for classrooms. However, it should be noted that these recommendations are only guidelines. If additional outside air should be provided if needed to control odors and contaminants. When determining the amount of outside air supplied, the flow rates should be based on actual air flow measurements taken inside the duct, not on the position of the damper. The outside air is also required to meet EPA ambient air standards or the outside air should be cleaned (e.g. filtered) to meet the EPA standards. Because the use of cosmetology products introduces several chemical contaminants into the indoor environment, the dedicated HVAC system in the Cosmetology Laboratory was appropriate.

When determining the proper amount of outside air to be supplied to the Cosmetology areas, the total number of occupants (i.e. cosmetologists and patrons) generally expected in all spaces served by the AHU should also be considered, in addition to the general ASHRAE recommendations for this type space. Normal occupancy rates for the Cosmetology Laboratory are dependent upon the number of students enrolled in the Cosmetology Program during a given school year. The reported maximum capacity for this Program is 20 juniors

and 20 seniors plus one instructor for each group. Only one group occupies the Cosmetology Laboratory at a time. The groups rotate at lunchtime with the morning group going to other classes and the afternoon group returning from classes to the Cosmetology Laboratory. If there is a full program, the minimum occupancy rate of the Cosmetology Laboratory would be about 21 persons, and, if every student was working on a patron, the maximum occupancy rate would about 41 persons. The Cosmetology Classroom is also served by the same AHU and is occupied about 3/4 of the day by about 20 students plus the instructor.

Because the Cosmetology Laboratory is occupied throughout the day by either the junior or senior class, the design minimum amount of outside air to be provided to the Laboratory areas should be 525 cfm based on 21 occupants. Ideally, the amount of outside air provided to the Cosmetology Laboratory should be increased by 25 cfm for each additional person entering the Cosmetology Laboratory areas. So the design total outside air flow for the Cosmetology Laboratory should be at least 1025 cfm based on a theoretical maximum of 41 occupants (20 students, one instructor and 20 patrons). The amount of outside air flow needed for the Classroom should be based on 21 occupants or 315 cfm. Therefore, the entire system should be constructed to provide a design total outside air flow of at least 1340 cfm (1025 cfm for Laboratory areas plus 315 cfm for Classroom).

Reportedly the Cosmetology Program has never been filled to capacity and it is unlikely that every student will be working on a patron at the same time. Therefore, the likelihood of the Cosmetology Laboratory being filled to capacity is low; therefore, the actual amount of outside air required at any given time will probably be less. To compensate for this, the outside air damper can be adjusted periodically (e.g. at the beginning of the school year) and the HVAC system may be equipped with a control system to provide the proper amount of outside air, based on actual space usage. School officials should discuss these options with a controls designer to determine if an economically feasible system is available. For a detailed description of three systems with varying levels of control, please see the attached appendix.

Normally, a velocity of 25-50 fpm is recommended for the occupied zone,[22] but the exact velocity is dependent upon the temperature and relative humidity of the air in the space. Occupant complaints about the temperature being too warm despite the temperature and relative humidity being within ASHRAE guidelines is believed to be primarily due to poor air distribution. To generate greater air movement, the present air distribution system should be changed. The present ceiling plenum air distribution system is not very effective and can easily be compromised by the removal of a single ceiling tile which would open an area larger than the total area of all the air distribution slots in the Cosmetology Laboratory ceiling. Furthermore, these systems are subject to loss of supply air to the areas above the ceiling. A distribution system using direct ducting and diffusers would be far more effective. During this survey, temperature measurements within the Cosmetology Laboratory rose from 74° F to 77° F during the day even though outside temperatures were less than 60° F all day. This indicates that either the AHU is not properly sized to handle the heat load in the Cosmetology Laboratory and surrounding areas or that the control systems were not operating the cooling system effectively.

During visual inspection of the AHU, end wrappers used for application of permanents were observed in the unit downstream of the filter bank. End wrappers were found impacted on the heating coil indicating that the filter bank has a serious leak or that filters are not being properly maintained. The fact that end wrappers are getting past the registers into the return air plenum also indicates the need for a finer grate at the return registers. Inspection of the

AHU cooling coil and pan showed that accessibility of these components was difficult, which creates a problem for efficient cleaning and maintenance.

The Cosmetology Laboratory areas should be under negative pressure relative to other areas of the building to prevent odor migration. The use of smoke tube traces demonstrated that this was the case during our survey. But more importantly, the Dispensary should be under negative pressure relative to the Cosmetology Laboratory to prevent heavy odor migration should a spill occur. To accomplish this, an exhaust fan should be installed in the Dispensary and the air should be exhausted above the roof of the building. Exhaust flow from the Dispensary should be at least 10% greater than the supply flow to the Dispensary.

Changes in the present HVAC system could potentially change the amount of outside air presently provided to the areas it serves, which could potentially result in these areas being placed under positive pressure. If these areas were under positive pressure, this would result in odors migrating to other parts of the building. The flowrate of air exhausted by the current (Bathroom) and proposed (Dispensary) exhaust fans will affect air flow in the Dispensary and Cosmetology Laboratory areas, and will determine if these areas are under positive or negative pressure. To prevent placing these areas under positive pressure several criteria relative to the exhaust systems should be considered when designing the system. For more detailed information regarding the design considerations of such an exhaust system, please refer to the recommendations section of this report.

VIII. CONCLUSIONS

Based on the data collected, it has been determined that a health hazard from exposure to airborne formaldehyde within the Cosmetology Laboratory, Dispensary, and Classroom existed at the time of this survey. Formaldehyde exposures in excess of the OSHA Ceiling limit of 2.0 ppm were documented during the preparation of cabinet fumigants and general-area air samples showed concentrations above background levels throughout the cosmetology areas.

Based on HVAC measurements, CO_2 measurements, and a visual inspection of the AHU supplying the Cosmetology Laboratory, Dispensary, Reception Room, and Classroom, it has been determined that inadequate amounts of fresh outside air are being supplied to these areas. Additionally, employee complaints indicated that thermal comfort problems may exist even though all temperature and relative humidity measurements collected during the survey were within the ASHRAE recommendations for thermal comfort. These complaints may be the result of poor air distribution and mixing in the lower region of the occupied spaces.

IX. RECOMMENDATIONS

1. The present air distribution system should be evaluated to determine if the existing ceiling plenum system can be converted to a ducted supply/diffuser system that is capable of generating a velocity 25 to 50 fpm in the occupied zone.

2. The present AHU should be evaluated to determine if it is capable of supplying a minimum of 1340 cfm of outside air to the Cosmetology Laboratory, Reception Room, Dispensary, and Classroom. This figure is based on the maximum capacity of the Cosmetology Laboratory and Classroom (for more detailed information see Appendix). The amount of outside air being supplied to the Cosmetology Laboratory areas should be based on the ASHRAE standard of 25 CFM of fresh outside air per person.

3. If the current system is not capable of supplying at least the recommended amount of air, then the system should be redesigned.

4. The system should be designed with a control system capable of increasing the amount of outside air to meet the requirements of the occupants in the space, please see Appendix.

5. The air supply and exhaust systems for the Bathroom and Dispensary should be designed so that these areas remain under negative pressure relative to all other spaces served by this AHU. Additionally, the system should be designed so that all spaces served by the Cosmetology AHU are under negative pressure relative to the remainder of the building.

6. The exhaust air-flow from the Dispensary should be 10% greater than the supply-air flow rate into this room (i.e., through the ceiling diffusers). Similarly, this requirement applies to the Bathroom exhaust.

7. The combined exhaust air-flow from the Bathroom and the Dispensary exhaust systems should always be 10% greater than the outside-air-intake flowrate to the AHU.

8. The design-specification exhaust air flow capacity of the Bathroom and the Dispensary exhaust systems should be selected to be a total of 1475 cfm, which is 10% greater than the outside-air flowrate of 1340 cfm required for the space under the greatest-expected occupancy projected (as discussed previously in this section). The design specification intake-air flow capacity of the AHU must be at least 1340 cfm.

9. The intake-air flow rate may then be adjusted (e.g. with a damper) to match actual occupancies expected in the foreseeable future (e.g. upcoming school year). The total of the two exhaust-system airflow rates must than, of course, be adjusted (e.g. also with dampers) to ensure that the criteria outlined in items #1 and #2 above, are fulfilled. To re-emphasize, if a damper system is used, the dampers will have to be adjusted whenever the amount of outside air flows to the Dispensary or Cosmetology Laboratory are changed.

10. Rather than using manually adjusted dampers, air flowrates may be simultaneously changed using a control system (as also discussed previously in this section). If such a control system is used, it must be able to ensure that the combined actual exhaust flow is 10% greater than the actual outside-air-intake flowrate in use.

11. If the current AHU is not replaced, it should be thoroughly cleaned; including all coils. Condensate pans should be checked for debris and standing water, drains should be checked for proper operation, and all pans should tilt toward the drain.

12. Cleaning of all AHUs within the building should be performed on a regular maintenance schedule. A record of all cleaning performed should be kept and any potential problems reported to the school administration. The maintenance record should be reviewed periodically to insure that these services are being performed.

13. Return registers should be backed with hardware cloth to prevent debris from entering the return system and any accumulated debris removed when found. To prevent clogging of the return registers, floor wax should be prevented from contacting the registers.

14. An inventory of all products used in the Cosmetology Laboratory should be conducted and Material Safety Data Sheets (MSDSs) of all products used in the Cosmetology Laboratory should be obtained from the manufacturer or distributor. An assessment of the toxicity of the individual products should then be conducted and the employees and students informed of the potential hazards involved and trained about the proper precautions necessary when using these products.

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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. Director of Vocation Programs
2. Principal Northwest Vocational School
3. Northwest Vocational Cosmetology Instructors
4. The Ohio State Board of Cosmetology
5. OSHA, Region V

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 I

General-Area and Source-Air Sample
Concentrations of Airborne Formaldehyde

Northwest High School Vocational Center
Cincinnati, Ohio
HETA 89-170

Room No./Location	Sample Time (minutes)	Sample Volume (liters)	Formaldehyde (ppm)
	May 17, 1989		
Cosmetology dispensary	8:14a - 2:13p	359	0.19
Manicuring supplies cabinet	8:14a - 2:13p	359	0.55†
Facial room shelve	8:15a - 2:13p	358	0.18
Facial room, inside cabinet	8:15a - 2:13p	358	0.50†
Cosmetology Lab, west end	8:20a - 2:13p	353	0.46
Cosmetology Lab, east end	8:20a - 2:14p	354	0.15
Cosmetology reception desk	8:21a - 2:14p	353	0.053
Cosmetology classroom #307	8:22a - 2:13p	351	0.18
Formaldehyde fumigant mixing	9:19a - 9:30a	11	2.9*
Cosmetology dispensary	1:05p - 2:13p	68	0.90
	May 18, 1989		
Cosmetology dispensary	8:16a - 2:15p	359	0.73
Manicuring supplies cabinet	8:17a - 2:15p	358	0.18†
Facial room shelve	8:55a - 2:16p	321	0.11
Facial room, inside cabinet	8:18a - 2:16p	358	0.52†
Cosmetology Lab, east end	8:20a - 2:16p	356	0.18
Cosmetology Lab, west end	8:20a - 2:15p	355	0.11
Cosmetology reception desk	8:21a - 2:15p	354	0.064
Cosmetology classroom #307	8:21a - 2:17p	356	0.11
Counselor's office	8:21a - 2:17p	349	0.037
Football field bleachers	8:36a - 2:21p	345	0.013
ENVIRONMENTAL CRITERIA	NIOSH REL		LFL
	ACGIH TLV		1.0
	ACGIH STEL		2.0
	OSHA PEL		1.0
	OSHA Ceiling		2.0

Abbreviations:
ppm - parts of formaldehyde per million parts of air.
LFL - lowest feasible level
* - Short-term exposure in excess of ACGIH STEL and OSHA Ceiling Limit
† - Source air sample

APPENDIX

Ventilation Evaluation

Northwest High School
Vocational Center
Cincinnati, Ohio
HETA 89-170

April 1990

VENTILATION CONTROL SYSTEMS

Several methods can be used to control the required amount of outside air provided to the Cosmetology Laboratory, Reception Room, Dispensary, and Classroom. A constant amount of outside air may be supplied to these areas based on the maximum number of occupants (students, instructors and patrons) or a control system may be installed to provide varying amounts of outside air depending on the number of occupants present in these areas at any given time. The choice of which type of control system to install will depend on the amount of money the school is willing to budget for this project.

l. The least expensive system is a constant volume system which opens the outside air damper to a preset position when the AHU is turned on. This preset level should be based on the maximum number of occupants and should provide enough outside air to meet the ASHRAE recommendations. Although this type of system is the least expensive to install, it is the most expensive to operate because the outside air provided needs to be tempered and generally, the system would provide more outside air than needed to meet the ASHRAE recommendations.

2. The next level of control has two preset levels. The outside air damper opens to the first preset level when the AHU is turned on and a timer circuit opens the damper to a second preset level during the hours when the Cosmetology Classroom is occupied. The first preset level should be based on the maximum number of occupants (including patrons) expected in the Cosmetology Laboratory, Reception Room and Dispensary. The second preset level should be based on the maximum number of occupants expected when both the Cosmetology Laboratory areas and the Cosmetology Classroom are occupied. While this control system is more energy efficient than the system described above (item l), energy is still wasted tempering air for patrons who may not be in the space.

3. The highest level of control requires the outside air damper to be opened to a preset level determined by the maximum number of students and instructors present in the Cosmetology, Dispensary and Reception areas. This control system is equipped with a timer control system to increase the amount of outside air provided when the Cosmetology Classroom is occupied. The amount of outside air supplied to the Cosmetology Laboratory areas is increased by the use of a manual switch located in the Cosmetology Laboratory. The switch allows the outside air damper to open wider and can be either an incremental or on-off switch. The instructor should be the person responsible for determining if more outside air is needed due to increased numbers of patrons, odors, etc. Since this is a manual switch, a warning device should be used to remind the instructor to reset the switch to the original position or reset the warning device if more time is needed.