HETA 86-421-1956
APRIL 1989
CINCINNATI PUBLIC SCHOOLS
CINCINNATI, OHIO

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I. SUMMARY

On June 16, 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from the Assistant Superintendent of Business Services for the Cincinnati Public Schools to evaluate the indoor air quality in rooms 430, 431, and adjacent areas of the Hughes Vocational School. Numerous health complaints, including upper respiratory problems, eye irritation, sores in the mouth, unusual odors, headaches, and fatigue, reported by the Department of Practical Nursing personnel were cited in the request.

Several site visits were made by the NIOSH medical officer during the week of July 17, 1986, with follow-up industrial hygiene surveys performed on July 28, 1986, and October 15, 1986. Industrial hygiene sampling was conducted to evaluate exposure to ethylene oxide, formaldehyde, hydrocarbons, and bioaerosols. Carbon dioxide, temperature, relative humidity, and ventilation measurements were also made to evaluate the heating, ventilation, and air conditioning system (HVAC) which services the Department of Practical Nursing.

Area samples collected for ethylene oxide, formaldehyde, hydrocarbons, and bioaerosols were below all relevant criteria. Temperature and relative humidity levels were within accepted comfort ranges. Carbon dioxide levels (500-1000 parts per million (ppm) inside, 300 ppm outside) and visual examination of the HVAC system (all outside air dampers were totally shut) indicated that inadequate amounts of fresh air were being delivered to classrooms 431 and 432.

The symptoms reported (8 of 9 persons with upper respiratory problems, 1 or more members of the staff with eye irritation, irritation or sores in the mouth, unusual odors, headaches and fatigue) are not suggestive of a specific cause, but some of them are frequently encountered in indoor environments in which there is inadequate ventilation.

Based on these results, inadequate ventilation was determined to be the most likely cause for the symptoms and complaints among students and staff within the Department of Practical Nursing (classrooms 431 and 432) at Hughes Vocational School. Recommendations to improve ventilation are included in Section IX of this report.

KEYWORDS: SIC 8249 (Vocational Schools), ventilation, indoor air quality, carbon dioxide, temperature, relative humidity, bioaerosols, formaldehyde, hydrocarbons, ethylene oxide.

II. INTRODUCTION

On June 16, 1986, NIOSH received a request from the Assistant Superintendent of Business Services for the Cincinnati Public Schools, to evaluate the indoor air quality of the Hughes Vocational School located at 2515 Clifton Avenue, Cincinnati, Ohio. Assistance was requested because the Assistant Superintendent had received numerous health complaints (upper respiratory problems, eye irritation, sores in the mouth, unusual odors, headaches, fatigue) from the Department of Practical Nursing staff members.

During the week of July 17, 1986, several site visits were made by the NIOSH medical officers to interview teachers and review written statements by nursing students.

On July 28, 1986, NIOSH industrial hygienists conducted a follow-up survey. During this survey, temperature, humidity, carbon dioxide, and ventilation measurements were made to evaluate the performance of the ventilation system. Deficiencies in the outside air damper operation and drainage of condensate drain pans were noted in an interim report, forwarded to the Assistant Superintendent on August 18, 1986.

On October 15, 1986, NIOSH industrial hygienists returned to the school to perform air monitoring for ethylene oxide, formaldehyde, hydrocarbons, and bioaerosols. Results from this survey were presented in an interim report forwarded on February 25, 1987.

III. BACKGROUND

The Hughes Vocational School, located in central Cincinnati, is a six-story brick building (approximately 125,000 square feet) attached to the Hughes High School. Classrooms 431 and 432, with adjoining offices 430 and 431, occupy approximately 2150 square feet on the fourth floor of the building, as part of the Department of Practical Nursing.

Each floor of the Hughes Vocational School has its own heating, ventilating, and air-conditioning (HVAC) system. Tempered air is supplied to the rooms through louvered ceiling diffusers. The air is returned through grilles also located in the suspended ceiling. The space above the suspended ceiling is utilized as the return air plenum. Cooling of the building is accomplished by pushing air through chilled-water cooling coils located in the HVAC units. Supply air is heated by reheat coils located in the variable air volume (VAV) boxes.

Although the ventilation system was originally designed as a VAV system, it was never operated as such. The ventilation system is operated as a constant air volume system, which maintains a constant flow of air to the classroom areas, while varying the temperature.

IV. METHODS AND MATERIALS

A. Ethylene Oxide

Concerns expressed by several individuals regarding introduction of ethylene oxide into the vocational school's ventilation system from a nearby hospital, prompted air sampling for ethylene oxide. The air samples for ethylene oxide were collected by drawing air through a glass tube containing 150 milligrams of HBr-coated charcoal using calibrated, battery-operated sampling pumps, at a flowrate of 0.05 liters per minute (lpm). Each sample was analyzed according to NIOSH Method #1614 using a Hewlett-Packard 5880 gas chromatograph equipped with an autosampler, 20-meter-DB-1 capillary column, and an electron capture detector. The analytical limit of detection was 0.9 micrograms per sample.

B. Formaldehyde

The air samples for formaldehyde were collected by drawing air through a glass midget impinger containing 20 milliliters of a 1% sodium bisulfite solution at a flowrate of 1.0 1pm using calibrated, battery-operated sampling pumps. Analysis was by visible absorption spectrophotometry according to NIOSH Method #3500. The analytical limit of detection for this method was 0.5 micrograms per sample.

C. Hydrocarbons

The air samples for hydrocarbons were collected by drawing air through a glass tube containing 150 milligrams of activated charcoal at a flowrate of 1.0 1pm (qualitative samples) and 0.2 1pm (quantitative samples) using calibrated, battery-operated sampling pumps. The samples were desorbed with 1 ml of carbon disulfide and analyzed by gas chromatography (GC) with a flame ionization detector. Additionally, one of the samples was concentrated and analyzed by GC using a mass spectrometer for major compound identification.

D. Bioaerosols

The sampling protocol and analytical procedures used in this evaluation were basically consistent with those outlined by the ACGIH Committee on Bioaerosols.[1] All samples were collected on 100 mm x 15 mm plastic Petri dishes (plates) containing 45 ml of culture media. Air samples were collected by placing the agar plate into a single-stage Andersen viable air sampler, the agar surface being situated at a fixed distance from 400, 0.25 mm diameter orifices through which ambient air is introduced. The sampler was connected to a vacuum pump calibrated to provide an air flow of 28.3 lpm through the sampler. The media used for the detection of fungi consisted of V-9 agar (a mixture of potato dextrose agar and V-8 juice).[2] Trypticase soy agar was the media used to detect both thermophilic actinomycetes and bacteria. Samples for each of these classes of microbes were collected for 2, 4, and 8 minutes at each location. "Bracketing" of sampling periods was done to ensure that at least one of the culture plates would contain colonies within a range suitable for accurate counting. To avoid potential cross-contamination of samples, the samplers were disinfected after each use.

This was accomplished by cleaning the samplers with 70% isopropanol and then allowing them to air dry. All culture plates were kept on ice before and after use. At the completion of the site visit, the samples were placed into insulated shipping containers and sent via overnight express service to a contract microbiology laboratory. Upon receipt at the laboratory, the samples were incubated. The temperatures and duration of incubation was different for each of the three classes of microorganisms.

Samples for fungi were incubated at 25ºC. Plate examinations, sub-cultures, and colony counts were performed at 4 and 10 days after incubation. All plates were held for 22 days to permit sporulation of the slowest growing fungi.

Bacterial samples were incubated at 35ºC. Plate examinations, colony counts, and gram stains were performed at 3, 5, and 10 days after incubation.

Samples for thermophilic actinomycetes were incubated at 50ºC. Plate examinations were performed at 2, 3, and 9 days after incubation.

E. Carbon Dioxide

Colormetric detector tubes were used to measure carbon dioxide (CO_2).

F. Temperature and Relative Humidity

Temperature and relative humidity were measured with a battery-powered psychrometer.

G. Ventilation Measurements

Air flow measurements were made at all air supplies and returns using a flow hood.

V. EVALUATION CRITERIA

The primary sources of air contamination criteria generally consulted include: (1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs), (2) the American Conference of Governmental Industrial Hygienist's (ACGIH) Threshold Limit Values (TLVs*), (3) the U.S. Department of Labor (OSHA) federal occupational health standards, and (4) the indoor air quality standards developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The first three sources provide environmental limits based on airborne concentrations of substances to which most workers may be occupationally exposed in the workplace environment for 8 to 10 hours per day, 40 hours per week for a working lifetime without adverse health effects. The ASHRAE guidelines specify outside air quantities to maintain acceptable indoor air quality and minimum ventilation rates which should be acceptable to the majority of human occupants and not impair health.

Indoor air should not contain concentrations of contaminants known to impair health, or to cause discomfort to a majority of the occupants. For application to the general population, ASHRAE recommends that concentrations of

these contaminants not exceed one-tenth of the limits which are used in industry. The rationale for this approach is that the general population is more varied than the industrial population in susceptibility to injury due to greater variation in age and health status. In addition, the industrial population is often under greater health supervision than the general population. In some circumstances using one-tenth of the industrial standards may not be adequate because of odor, irritation, sensitization, or other health effects. At this time, NIOSH does not have an official position regarding the appropriateness of the ASHRAE recommendations or regarding the use of occupational exposure limits in non-industrial settings.

A. Ethylene Oxide

NIOSH recommends that ethylene oxide (EtO) be regarded as a potential occupational carcinogen and that exposure to EtO be controlled to the lowest feasible level (LFL). In 1983, NIOSH recommended to OSHA that an 8-hour time-weighted average (TWA) be set lower than 0.1 ppm, because even at 0.1 ppm, according to available risk assessments, the risk of excess mortality is not completely eliminated. NIOSH also recommended 5 ppm as a ceiling concentration and that this ceiling not be exceeded for more than 10 minutes in any work day.[3,4]

The current OSHA PEL for EtO is 1 ppm for an 8-hr TWA exposure. The standard also established an "action level" of 0.5 ppm as an 8-hour TWA concentration, above which employers must initiate certain compliance activities, such as periodic employee monitoring and medical surveillance. This standard is based on the animal and human data showing that exposure to EtO presents a carcinogenic, mutagenic, reproductive, neurologic, and sensitization hazard to workers. Included in the present OSHA standard are requirements for methods of controlling EtO, personal protective equipment, measurement of employee exposures, training, and medical surveillance of the exposed employees.[5]

B. Formaldehyde

Formaldehyde and other aldehydes may be released from a variety of common materials including; foam plastics, carbonless paper, particle board, plywood and textile fabrics. Symptoms of exposure to low concentrations of formaldehyde include irritation of the eyes, throat, and nose; headaches; nausea; congestion; asthma; and skin rashes. It is difficult to ascribe specific health effects to specific concentrations of formaldehyde to which people are exposed, because they vary in their subjective responses and complaints. Irritative symptoms may occur in people exposed to formaldehyde at concentrations as low as 0.1 ppm, but more frequently in exposures of 1.0 ppm and greater. Some sensitive children or elderly, those with preexisting allergies or respiratory diseases, and persons who have become sensitized from prior exposure may have symptoms from exposure to concentrations of formaldehyde between 0.05 and 0.10 ppm. Formaldehyde-induced asthma and bronchial hyperreactivity developed specifically to formaldehyde are uncommon.[6]

Formaldehyde vapor has been found to cause a rare form of nasal cancer in Fischer 344 rats exposed to a 15 ppm concentration for 6 hours per day, 5 days per week, for 24 months. Whether these results can be

extrapolated to human exposure is the subject of considerable speculation in the scientific literature. Conclusions cannot be drawn with sufficient confidence from published mortality studies of occupationally exposed adults as to whether or not formaldehyde is a carcinogen. Studies of long term human occupational exposure to formaldehyde have not detected an increase in nasal cancer. Never the less, the animal results have prompted NIOSH to recommend that formaldehyde be handled as a potential occupational carcinogen and that workplace exposures be reduced to the lowest feasible level.[7] OSHA has recently reduced its permissible exposure limit (PEL) for formaldehyde to 1.0 ppm.[8]The fact that formaldehyde is found in so many home products, appliances, furnishings and construction materials has prompted several agencies to set standards or guidelines for residential formaldehyde exposure. ASHRAE has recommended, based on personal comfort, that exposure to formaldehyde be limited to 0.1 ppm. This guideline has also been adopted by NASA, and the federal governments of Canada, West Germany, and the United Kingdom.[9] An indoor air formaldehyde concentration of less than 0.05 ppm (0.06 mg/m^3) is of limited or no concern, according to the World Health Organization.[10]

C. Bioaerosols

There are currently no published standards of risk associated with exposure to saprophytic bioaerosols.[1] Viable air samples were taken during this survey as an investigative method to compare complaint and non-complaint areas with ambient bioaerosols levels. This technique was utilized by the NIOSH investigators in an effort to determine if a point source of microorganisms exists, and to aid in identifying the point source so that effective corrective action can be recommended.

D. Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath, and, if monitored in the indoor air, can often be used as a screening technique to evaluate whether adequate quantities of fresh outdoor air are being introduced into a building or work area. The outdoor, ambient concentration of CO_2 is usually 250 to 350 ppm. Typically the CO_2 level is higher inside than outside (even in buildings with few complaints about indoor air quality). However, if indoor CO_2 concentrations are more than 1000 ppm (3 to 4 times the outside level), there is probably a problem of inadequate outside air or poor distribution of air within the building, and complaints such as headache, fatigue and eye and throat irritation are frequently found to be prevalent. Although the CO_2 is not responsible for these complaints, a high level of CO_2 does indicate that other contaminants in the building may also be increased and could be responsible for symptoms among building occupants.

The OSHA Permissible Exposure Limit (PEL) and the ACGIH TLV* for CO_2 is 9,000 ppm for and 8-hour TWA.[5,11] The NIOSH Recommended Exposure Level (REL) is 10,000 ppm for a 10-hour TWA.[12] These industrial limits, however, are not relevant to the much lower exposures commonly encountered in office buildings. 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 environments. 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 percent relative humidity.[13]

F. Ventilation

Neither NIOSH nor OSHA have developed ventilation criteria for general offices. Criteria often used by design engineers are the guidelines published by ASHRAE. Until recently, the ASHRAE Ventilation Standard 62-73 (1973) was utilized, but recommendations were based on studies performed before the more modern, air-tight office buildings became common. These older buildings permitted more air infiltration through leaks in cracks and interstices, around windows and doors, and through floors and walls. Modern office buildings are usually much more airtight and permit less air infiltration. Due to the reduced infiltration, ASHRAE questioned whether the 1973 minimum ventilation values assured adequate outdoor air supply in modern, air-tight buildings.

Subsequently, ASHRAE revised its standard and published ASHRAE 62-1981, "Ventilation for Acceptable Indoor Air Quality".[14] This standard is based on an occupant density of 7 persons per 1000 square feet (ft^2) of floor area, and recommends higher ventilation rates for areas where smoking is permitted. ASHRAE also recommends that contaminants, such as various gases, vapors, microorganisms, smoke, and other particulate matter, be controlled so that concentrations known to impair health or cause discomfort to occupants are not exceeded. However, the threshold levels for health effects from these exposures are poorly documented. For classrooms where smoking is not permitted, the rate recommended by 62-1981 is 5 cubic feet per minute (cfm) of outdoor air per person. Higher ventilation rates (25 cfm per person) are recommended for spaces where smoking is permitted because tobacco smoke is one of the most difficult contaminants to control at the source. Areas that are nonsmoking may be supplied at the lower rate (5 cfm/person), provided that the air is not recirculated from, or otherwise enters from, the smoking areas.[14]

ASHRAE Standard 62-1981 also provides ventilation requirement guidelines for a wide variety of commercial, institutional, residential, and industrial facilities and should be consulted for application to the specific situation under evaluation. It should, however, be noted that in 1989 this standard is expected to be replaced with ASHRAE Standard 62-1981R.[15] The revised standard is expected to increase the outside air requirements needed over its predecessor to 15 cfm per person.

VI. RESULTS

A. Ethylene Oxide

Samples for ethylene oxide were taken in classrooms 431 and 432 (Table I). Both were below the NIOSH limit of detection (0.03 ppm).

B. Formaldehyde

The air sampling results for formaldehyde are presented in Table II. Formaldehyde was detected in all the samples and ranged from 0.01-0.02 ppm. Since furnishings, rugs, drapes, and some building construction materials can emit formaldehyde, it is not unusual to find small amounts in buildings.

The concentrations found during the NIOSH survey were very low and would not be expected to cause noticeable effects in most people.

C. Hydrocarbons

Table III lists the hydrocarbon vapors that were identified in classrooms 431 and 432. The air samples indicate that trace amounts of isopropanol, toluene, and perchloroethylene were present within the areas. These substances would not be expected to cause noticeable effects in most people at the levels detected.

D. Bioaerosols

Viable air sampling results from our survey for fungi, bacteria, and thermophilic actinomycetes, as well as total viable microorganisms, are presented by sampling location in Table IV. For each of the three microbial classes, airborne levels (in colony-forming units per cubic meter of air, CFU/M^3) are presented as a sum total of individual species. Only the 4-minute duration samples are reported, as these provided the highest colony counts within an optimum range for accurate counting.

Airborne levels of total viable microorganisms (TVM), representing the sum total count measurements for fungi, bacteria, and actinomycetes ranged from 89 to 569 CFU/M^3. The outdoor TVM level was 694 CFU/M^3. All of the indoor levels were below the outdoor level. Air samples for fungi were taken in four locations inside the Hughes High School and Vocational School, and ranged from 53 to 258 CFU/M^3. The outdoor level was 632 CFU/M^3. The major fungal genera identified in these air samples were Cladosporium and Penicillium, both of which are commonly found in the environment. All of the indoor fungal levels were well below the outdoor level. It is interesting to note that the highest fungal concentrations were found in an area of no complaints (Hughes High School - Room 110), that was selected as a comparison area.

Bacteria represented by 5 common genera (Brevibacterium, Streptomyces, Bacillus, Micrococcus, Streptococcus) were isolated in the samples taken inside the buildings and outdoors. Concentrations of bacteria ranged from 9 to 311 CFU/M^3 in the indoor samples and 62 CFU/M^3 outside. Concentrations in classrooms 431 and 432 (areas of complaint) were both below outdoor levels. Again, the comparison areas (Room 110-Hughes High School and Room 336-Hughes Vocational School) had the highest levels of mesophilic bacteria.

E. Carbon Dioxide

The CO_2 data are presented in Table V. The CO_2 outside was 300 ppm and ranged from 500-1000 inside. A measurement of 1000 ppm probably indicates that inadequate amounts of fresh air are being delivered to classrooms 431 and 432. During this survey (July 28, 1986) only a small number of people were in the building relative to the normal school year population. Therefore, the CO_2 levels would be expected to be higher during full occupancy.

F. Temperature and Relative Humidity

Temperature and relative humidity levels are presented in Table V. The temperature ranged from 71 to 76°F in the four rooms monitored during our survey. The outside temperature was 83°F. The relative humidity ranged from 51-56% in the rooms and was 68% outside. The temperature and relative humidity levels on the day we measured were in a range where more than 80% of the occupants would be expected to feel comfortable according to the criteria contained in ASHRAE Standard 55-1981.

G. Ventilation

To evaluate the adequacy of the ventilation system, the total measured air flow in a room was divided by the number of people in that area, and the result multiplied by factors of 0.5, 0.3, 0.2, and 0.15, corresponding to 50%, 30%, 20%, and 15% outside air (OA) introduced into the ventilation system. These data are presented in Table VI. For example, the total measured air flow to Classroom #432, 750 CFM, if divided by the number of occupants (20) results in approximately 38 CFM/person. If the air supply was 100% OA, the OA ventilation rate was 38 CFM/person. If the OA dampers were set at 50% the OA ventilation rate decreased to 19 CFM/person, and so on for 30%, 20% and 15% OA settings. These results were then compared to the ASHRAE ventilation criteria.

During our visual inspection of the ventilation system, it was noted that the outside air dampers were completely closed causing a total recirculation of air. A comparison of the data in Table II with the current ASHRAE Standard reveals that the OA dampers need to be set at 15% OA during non-smoking conditions. If smoking is allowed the dampers will need to be opened wider, possibly up to 50% OA.

It was also noted during our visual inspection of the ventilation system that complete drainage of water from the condensate drain pans cannot occur because of the location of the drain lines. Also, if dirt is allowed to collect in the drain pans it can provide a substance which fosters the growth of microorganisms. These microorganisms could then be carried into the occupied building spaces by the ventilation air.

H. Medical

The Hughes High School Vocational Nursing Program has a staff of 12, including two secretaries and 10 fulltime teachers. The NIOSH investigation focused on the teaching staff since the two secretaries infrequently entered the classroom areas. During site visits made during the week of July 17, 1986, all available members of the teaching staff (9 of the 10) were interviewed in a non-directed fashion. Written statements collected by teaching staff from vocational nursing students during the summer and fall terms of 1986 were also reviewed.

Symptoms reported by the teaching staff were diverse. The most frequent symptoms (8 of 9 persons interviewed) related to the upper respiratory tract and included sinus congestion, rhinitis, cough, and a perceived increase in the numbers of upper respiratory infections and sore throats. Eye irritation, irritation or sores in the mouth, unusual odors, headaches, and fatigue were also noted by 1 or more members of the staff. Most of the teachers felt their reported symptoms were either possibly or probably related to work, and 5 of 9 cited a specific pattern of symptoms disappearing or decreasing away from work. Statements collected from 33 summer- and 53 fall-term students described many symptoms similar to those reported by the teaching staff. Frequent complaints included eye and throat irritation, sinus congestion, dizziness, headaches, and drowsiness. Students also frequently described feeling that the room was "stuffy", "lacked oxygen" or had "poor air circulation". Complaints of odors were focused on a specific incident on September 23, 1986, when a gas leak was thought to have occurred in the building.

VII. CONCLUSIONS

Carbon dioxide levels and inspection of the HVAC system indicates that the Department of Practical Nursing is inadequately ventilated.

Based on data collected to date, we have not found evidence of any toxic agent in the Hughes Vocational School at levels which may be injurious to health.
The symptoms reported are not suggestive of a specific cause, but some of them are frequently encountered in indoor environments in which there is inadequate ventilation.

VIII. RECOMMENDATIONS

1. The deficiencies in the ventilation system (outside air damper operation, condensate drain pain drainage) that were noted in the NIOSH August 18, 1986, interim report, should be corrected.

2. A ventilation contractor experienced with the type of HVAC system at the Hughes Vocational School should evaluate the system to ensure that it is operating properly, and within design specifications. ASHRAE guidelines (62-1981) should be consulted for outdoor air requirements.

3. Any future complaints related to indoor air quality should be evaluated and documented by instituting a formal written employee complaint procedure.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from 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 NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1) Harold T. Flaherty, Assistant Superintendent of Business Services, Cincinnati Public Schools.

2) Judith L. Moss, Coordinating Teacher, Cincinnati Public School of Practical Nursing.

3) NIOSH, Cincinnati Region

4) 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

Ethylene Oxide Samples
Hughes Vocational School
Cincinnati, Ohio
HETA 86-421

October 15, 1986

Location	Sample Type	Sampling Period	Exposure Concentration (ppm)
Classroom - 431	Area	08:40 - 14:15	ND
Classroom - 432	Area	08:40 - 14:15	ND
Evaluation Criteria (NIOSH)			LFL

ND = None Detected. The limit of detection is 0.9 ug/sample, which would correspond to an atmospheric concentration of 0.03 ppm (sample air volume of 17.3 liters).

LFL = Lowest Feasible Level. NIOSH regards EtO as a human carcinogen. No safe level of exposure to carcinogens has been demonstrated for man. Therefore, NIOSH recommends that exposure to EtO be controlled to the lowest extent possible.

Table II

Formaldehyde Samples
Hughes Vocational School
Cincinnati, Ohio
HETA 86-421

July 28, 1986

Location	Sample Type	Sampling Period	Exposure Concentration (ppm)
Classroom - 431	Area	08:25 - 14:00	0.02
Classroom - 432	Area	08:30 - 14:00	0.01
Office - 431	Area	08:35 - 14:00	0.02
Office - 430	Area	08:35 - 14:00	0.02
		(NIOSH)	LFL
Evaluation Criteria		(ASHRAE)	0.1
		(WHO)	0.05

The limit of detection was 0.5 ug/sample, which would correspond to an atmospheric concentration of 0.001 ppm (sample air volume of approximately
330 liters).

LFL = Lowest Feasible Level. NIOSH regards formaldehyde as a potential carcinogen. NIOSH recommends that workplace exposure be reduced to the lowest feasible limit.

Table III

Hydrocarbon Samples
Hughes Vocational School
Cincinnati, Ohio
HETA 86-421

October 15, 1986

	Concentrations (ppm)		
Location	Isopropanol	Toluene	Perchloroethylene
Classroom - 432	0.1	(Trace)	0.017
Classroom - 431	0.6	(Trace)	(Trace)
ASHRAE Evaluation Criteria*	40	20	LFL

ppm = parts per million
* = Based on the ASHRAE recommendation of using 1/10 of the industrial evaluation criteria for indoor applications. NIOSH currently has no indoor air evaluation criteria.
LFL = Lowest Feasible Limit. NIOSH recommends that perchloroethylene should be handled in the workplace as if it were a human carcinogen.
(Trace) = Substance was present in trace quantities, between the limit of detection (2 ug/sample) and limit of quantitation (8 ug/sample). This would correspond to an atmospheric concentration range of 0.008-0.03 ppm (toluene) and 0.004-0.017 ppm (perchloroethylene), assuming an air sample volume of 66 liters.

Table IV

Concentrations of Airborne Fungi, Bacteria, and Thermophilic Actinomycetes
Hughes Vocational School
Cincinnati, Ohio
HETA 86-421

October 15, 1986

Location	Concentrations (CFU/M^3) Fungi	Bacteria	Thermophilic Actinomycetes	Total Viable Microorganisms* (CFU/M^3)
Classroom - 431**	71	53	ND	124
Roof - Outdoors	632	62	ND	694
Classroom - 336	53	107	ND	160
Classroom - 432**	80	9	ND	89
High School Room 110***	258	311	ND	569

* = Sum of total concentrations measurements for 25°C fungi, 35°C bacteria, and 55°C actinomycetes.
ND = None Detected. No thermophilic actinomycotic bacteria were isolated from any of the plates.
CFU/M^3 = Colony-forming units per cubic meter of air.
** = area of complaints
*** = control area.

Table V

Indoor Air Measurements
Hughes Vocational School
Cincinnati, Ohio
HETA 86-421

July 28, 1986

Room No./Area	Time	Carbon Dioxide (ppm)	Temperature (°F)	% Relative Humidity	No. of Occupants
430/office	9:00	500	73	53	0
"	11:30	500	71	56	0
431/office	8:15	500+	74	53	1
"	11:00	500	71	56	0
431/classroom	8:40	1000	74	50	25
"	11:04	700	72	53	25
"	11:35	600+	-	-	0
432/classroom	8:50	500*	76*	51	20
"	11:15	1000**	74**	53	20
"	14:11	600***	76***	51	20
outside air	11:45	300	83	68	0

ppm = parts per million

* = Classroom door to hallway and adjoining laboratory was open. Since the hallway was much warmer than the classroom it is possible that this accounted for the higher temperature (thermostat near door) and could have affected the CO_2 buildup by more than normal dilution.

** = Doors closed causing increase in CO_2 and decrease in temperature.

*** = Doors opened causing decrease in CO_2 and increase in temperature.

Table VI

Ventilation Measurements
Hughes Vocational School
Cincinnati, Ohio
HETA 86-421

July 28, 1986

Room No./Area	No. of People	Measured Supply Air Flow, CFM	CFM/Person Ventilation at 50% OA	30% OA	20% OA	15% OA
430/office	3	550	92	55	37	28
431/office	3	630	105	63	42	32
431/classroom	25	1780	36	21	14	11
432/classroom	20	750	19	11	8	6

CFM = cubic feet per minute
OA = outside air introduced into ventilation system