U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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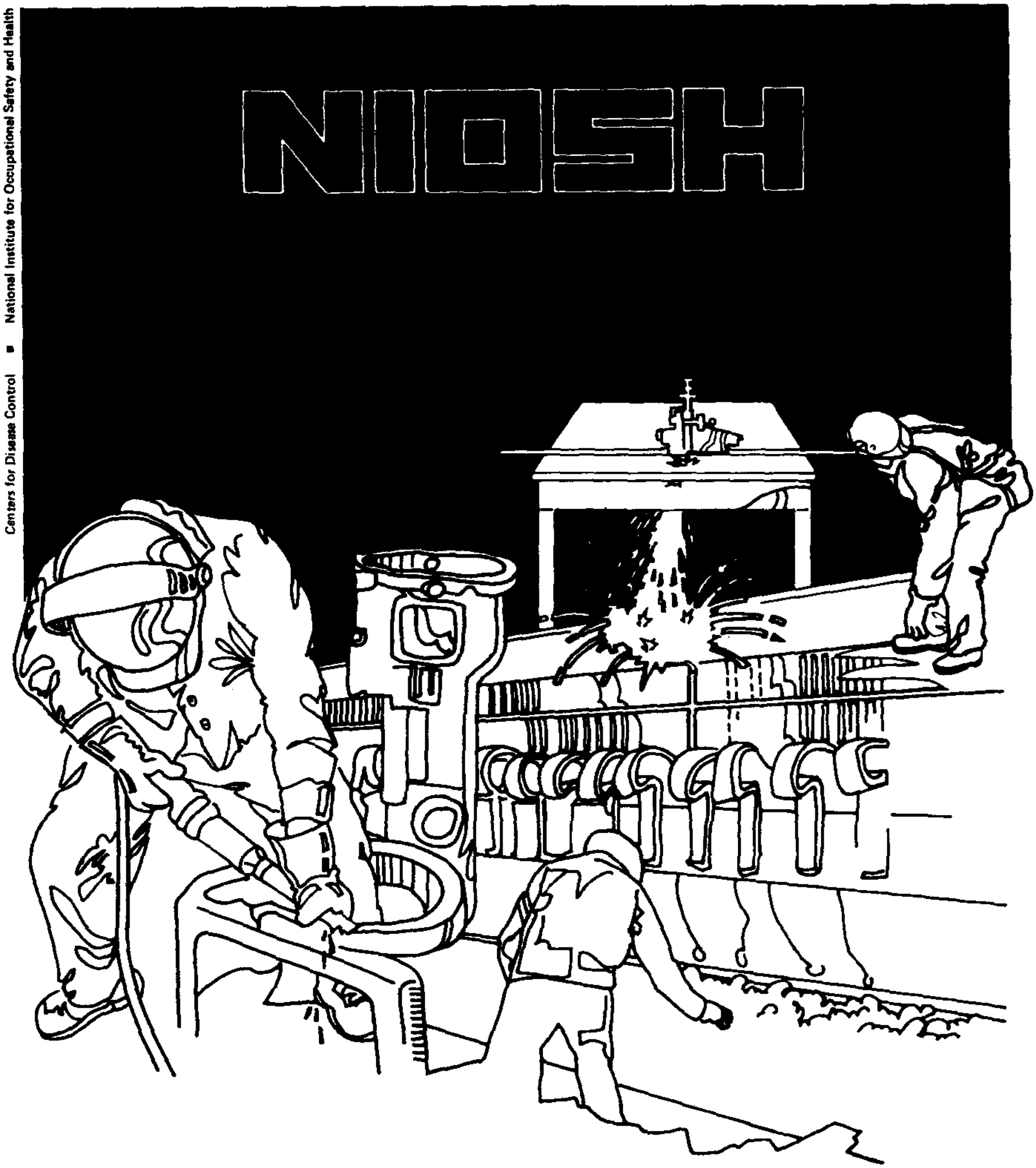

Health Hazard Evaluation Report

HETA 87-387-2050
ITHACA COLLEGE
ITHACA, NEW YORK

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.

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I. SUMMARY

On August 21, 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from an authorized representative of the employees of Ithaca College, Ithaca, New York. The requestor stated that dissections of primates embalmed and fixed in formalin solutions conducted in the basement of the Science Building were causing students and teaching personnel to experience irritation of the eyes and nose, headaches, and nausea.

On October 27-29, 1987, an initial survey which included an opening conference and walk-through tour of the Science Building was conducted. Detector tube samples collected in the Anatomy Laboratory, the refrigeration room, and in the hallway separating these two rooms showed no detectable concentrations of formaldehyde or phenol. On December 7-10, 1987, medical questionnaires were administered and industrial hygiene sampling and ventilation measurements were collected during times when laboratory activities were conducted. Industrial hygiene sampling included personal and general area air sampling throughout the building to assess exposures of faculty, staff, and students to ethylene glycol, formaldehyde, phenol, and other organic chemicals resulting from working with formaldehyde-preserved monkey cadavers. The ventilation evaluation focused on the systems serving the Anatomy Laboratory (Room S-1), the remainder of the basement area, and Room 208. A medical questionnaire developed to assess the frequency of certain symptoms compatible with formaldehyde exposure was administered to 49 students from one Anatomy Class and 40 faculty and staff members working in the Science Building.

Laboratory analyses of 22 samples collected for airborne formaldehyde ranged from nondetectable to 0.12 ppm. Fourteen of these samples contained concentrations of formaldehyde above the analytical limit of detection (LOD); but only two showed quantifiable concentrations; the remaining 12 showed trace quantities of formaldehyde between the LOD and the analytical limit of quantitation (LOQ). The two samples showing quantifiable concentrations of formaldehyde were collected in the Anatomy Laboratory. One was a personal breathing zone sample collected on the Anatomy Laboratory graduate assistant during set-up and preparation of Anatomy Laboratory for the final exam, this sample showed a concentration of 0.12 ppm. The second was collected near the center of the Anatomy Laboratory during the final exam and showed a concentration of 0.06 ppm. All sample results for phenol and ethylene glycol collected at the same locations as the formaldehyde samples were nondetectable.

Ventilation measurements showed that supply airflow to the Anatomy Laboratory met the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) standards and other reference recommendations. However, air distribution and exhaust within the laboratory was not conducive to minimizing occupant exposure to contaminants and only under one set of exhaust conditions was the room under negative pressure. Measurements and visual observations in other areas within the building indicated that the ventilation was inadequate.

Symptom prevalences among faculty and staff were 48% headache, 45% sinus congestion, 43% odors in the office, 28% sore throat, and 20% itching and burning eyes. Symptom prevalences among students were 59% headache and odors, 47% sinus congestion, 38% cough, 37% eye symptoms, and 33% sore throat. Employee symptom prevalences were not associated with location (formaldehyde was used in the basement and first floor, but not on the second and third floors) and symptoms were comparably prevalent at home and at work.

On the basis of the data obtained during this investigation, it has been determined that exposures to low levels of airborne formaldehyde existed in the Anatomy Laboratory at the time of this survey. The formaldehyde levels measured during this survey, however, were not high enough to account for the high prevalence of symptoms reported. The ventilation for the entire building should be reevaluated and a single-purpose containment laboratory design should be considered when designing a ventilation system for the dissecting laboratory. Ventilation design recommendations and recommendations for reducing exposures and improving worker safety and health are presented in Section IX and the appendix of this report.

KEYWORDS: SIC 8221 (Colleges, Universities, and Professional Schools), formaldehyde, phenol, ventilation, anatomy laboratory

II. INTRODUCTION

On August 21, 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from an authorized representative of the employees of Ithaca College, Ithaca, New York. The requestor stated that dissections of primates embalmed and fixed in formalin solutions were being conducted in the basement of the Science Building and that students and teaching personnel were experiencing irritation of the eyes and nose, headaches, and nausea.

On October 27-29, 1987, a NIOSH investigator visited Ithaca College and held an opening conference with the requestor and a representative of the College Administration. A walk-through tour of the Science Building was conducted during which airborne samples for formaldehyde and phenol were collected using detector tubes. Samples were collected in the Anatomy Laboratory, the refrigeration room, and the hallway separating these two rooms. Material safety data sheets (MSDSs) for the primate embalming and fixing solutions were obtained. Blueprints of the ventilation systems were reviewed and the outside air intakes, air supply, air return, and exhausts were examined. The results of previous detector tube sampling for formaldehyde conducted by the Ithaca College Office of Safety and Security were obtained and reviewed. Additionally, seven employees who either conducted labs in the Anatomy Laboratory room or conducted lectures in other rooms in the basement of the Science Building were interviewed.

On December 7-10, 1987, NIOSH investigators conducted a followup environmental survey of the Anatomy Laboratories (Room S-1 and Room 208) to assess exposures of faculty and students to ethylene glycol, formaldehyde, phenol, and other organic chemicals resulting from working with formaldehyde-preserved monkey cadavers. An evaluation of the ventilation systems serving the Anatomy Laboratory (Room S-1), the remainder of the basement area, and Room 208 was also conducted. Additionally, on December 9th and 10th, a medical questionnaire developed to assess the frequency of certain symptoms compatible with formaldehyde exposure was administered to 49 students from one Anatomy Class and 40 faculty and staff members working in the science building.

On February 12, 1988, initial survey results were transmitted via written correspondence to all parties involved. On February 24, 1989, complete results of all environmental samples were reported via written correspondence and in September 1989 an interim report of the ventilation measurements was issued.

III. PROCESS DESCRIPTION

Ithaca College was founded in 1892 as a music conservatory and became a private college in 1931. In the 1960's the College moved from scattered buildings located in downtown Ithaca to its present location on South Hill overlooking the city. The new campus has over fifty buildings, all built since 1960; the Science Building was built in 1963.

Anatomy Laboratory classes are held in the basement of the Science Building in Room S-1. Monkey cadavers preserved in formalin are used for identification of anatomical parts. Formalin is a solution of formaldehyde gas in water and generally contains 37% formaldehyde gas or the equivalent of 37 grams of gas in 100 ml of water. Since 1986, Ithaca College required that primate specimens be rinsed in Caro-Safe® before teachers or students are allowed to work with the primates. Caro-Safe® is a holding fluid containing ethylene glycol. Holding fluids are solutions used to store or rinse preserved materials. Although most holding fluids do not initially contain formalin, the leaching of formalin from inside the specimen to the holding fluid itself will naturally occur. The reason for rinsing or treating formalin fixed specimens with holding fluids is to remove any excess formalin.[1]

The original ventilation system for the Science Building was designed with only one air handling unit (AHU) to serve the entire basement area and this system has been altered many times since. A detailed description, history, and schematics of these ventilation systems is contained the attached appendix (Ventilation Evaluation).

IV. EVALUATION DESIGN AND METHODS

A. Industrial Hygiene Sampling

Airborne sampling for formaldehyde, phenol, and ethylene gylcol was conducted by placing sets of three sampling pumps equipped with the appropriate sampling media for each of these three substance in various locations throughout the Science Building. While the majority of samples collected were general area samples, a few personal breathing zone samples were also collected. Personal samples were collected by placing the appropriate sample media near the breathing-zone of a faculty staff member. General area air samples were placed in areas where faculty or students were likely to be present.

Formaldehyde samples were collected by passing air through an impinger containing a 20-milliliter (ml) solution of 1% sodium bisulfite connected via Tygon® tubing to battery-powered pumps calibrated at 0.2 liters per minute (LPM). These samples were analyzed according to NIOSH Method No. 3500.[2]

Phenol samples were collected on solid sorbent tubes impregnated with XAD-7 resin connected via Tygon® tubing to battery-powered pumps calibrated at 0.1 LPM. The XAD-7 tubes were analyzed for phenol via gas chromatography/mass spectroscopy (GC/MS) according to OSHA Method No. 2040.[3]

Ethylene glycol samples were collected on solid sorbent silica gel tubes preceded by a glass fiber filter and connected via Tygon® tubing to battery-powered pumps calibrated at 0.2 LPM. The filters and silica gel tubes were analyzed according to NIOSH Method No. 5500.[2]

B. Ventilation

The ventilation survey focused mainly on the system serving the Anatomy Laboratory (Room S-1), Air Handling Units (AHUs) 1 and 4. This room was used as a classroom and for dissection of monkey cadavers. Because the ventilation system serving the Anatomy Laboratory was connected to the system for the entire basement area, ventilation measurements in other rooms of the basement area were also made. Additionally, a cursory evaluation of the ventilation in Room 208 was conducted because dissections of fetal pig cadavers preserved in formalin were performed in this room. For a complete detailed description of the methods used to evaluate the ventilation systems, please see the attached appendix.

C. Medical Evaluation

NIOSH investigators distributed a self-administered questionnaire to the 43 current faculty, staff, and office workers in the Science Building who were available for interview. The same questionnaire was given to 49 of the 62 students attending an introductory Anatomy Class. The purpose of this questionnaire was to ascertain the prevalence of symptoms compatible with formaldehyde exposure.

Since Ithaca College does not maintain medical records of staff and faculty and has no medical surveillance program, a medical record review was not conducted.

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),[4] 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[5] and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards.[6] Often, the NIOSH RELs and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH RELs and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH 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.[7] 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.[8]

Exposure to formaldehyde can occur through inhalation or skin absorption.[9] 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.[7] Dermatitis may appear a few days following the commencement of work or may not appear for a number of years following exposure.[9]

In two separate studies, formaldehyde has induced a rare form of nasal cancer in rodents following repeated inhalation exposure.[10,11] 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.[12] 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 were 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.[13]

In 1984, Ulsamer et al. reviewed 4 animal inhalation studies. No teratogenic effects were reported in these studies.[14] No birth defects were reported in a study which involved the application of formalin to the backs of pregnant hampsters.[15] 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, were reported among women workers exposed to formaldehyde at a textile factory in the USSR.[16] 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.[17]

In April 1981, NIOSH issued Current Intelligence Bulletin 34, "Formaldehyde: - Evidence of Carcinogenicity", DHHS (NIOSH) Publication No. 81-111.[18] 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.[7] This recommendation was 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.[19] 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.[20] ACGIH has recently proposed a ceiling limit of 0.3 ppm formaldehyde in their notice of intended changes for 1989-1990.[20] This value will be reconsidered for the adopted TLV list after 2 years.

VI. RESULTS

A. Environmental sampling results

During the initial survey of October 1987, the results of detector tube samples collected for formaldehyde and phenol in the Anatomy Laboratory, the refrigeration room, and the basement corridor did not show any detectable concentrations of either substance. However, it should be noted that detector tubes are not capable of detecting airborne concentrations of formaldehyde below 0.2 ppm. Results of detector tube sampling for formaldehyde by the Ithaca College Office of Safety and Security on January 21, 1986, showed airborne concentrations of formaldehyde of 2 ppm and 2.5 ppm in the refrigeration room. However, it should be noted that a change in procedures have been initiated since that time. The primate specimens are now rinsed in a solution of Caro-Safe® before teachers or students are allowed to work with the primates. Additionally, a new ventilation system which supplies air to the Anatomy Laboratory and the refrigeration room has been installed and is operational, and a local exhaust ventilation unit has been installed in the Anatomy Laboratory.

Results of airborne sampling for formaldehyde in December 1987, are presented in Table I. Laboratory analyses of 22 samples collected for airborne formaldehyde ranged from nondetectable to 0.12 ppm. Fourteen of these samples contained concentrations of formaldehyde above the analytical limit of detection (LOD), but only two of these contained quantifiable concentrations; the other 12 showed trace quantities of formaldehyde between the LOD and the analytical limit of quantitation (LOQ). The two samples showing quantifiable concentrations of formaldehyde were collected in the Anatomy Laboratory (Room S-1). One was a personal breathing zone sample collected on the Anatomy Laboratory graduate assistant and showed a concentration of 0.12 ppm. This sample was collected the morning of December 12, during set-up and preparation of the laboratory for the final exam. The other sample was a general area air sample collected near the center of the Anatomy Laboratory during the final exam and showed a formaldehyde concentration of 0.06 ppm. All side by side samples for phenol and ethylene glycol collected at the same time and locations as the formaldehyde samples showed no detectable concentrations.

B. Questionnaire results

1. Faculty

Forty of 43 (93%) individuals completed and returned the questionnaire. Thirty (75%) of the respondents were identified as teaching staff, and the remaining 10 were employed in other staff positions. Twenty-eight (70%) of the individuals were male and the mean and medium age of the group was 46 years. Seven of the respondents identified themselves as current cigarette or pipe smokers. Twelve of the forty (30%) reported that their job duties included working with formaldehyde. Eight of 11 (73%) of second floor employees worked with formaldehyde in contrast to 2 of 19 (11%) on the first floor and 1 of 8 (13%) on the third floor (two persons did not report their work location). The mean time working with formaldehyde was 2 hours/week, with a range from 0-9 hours/week. Five individuals (13%) work with both ethylene glycol and phenol for an average of 7 hrs/week (median = 3). Eight individuals (20%) reported work with Caro-Safe® for an average of 6 hours/week.

Overall, 48% of the group reported headaches, 45% reported sinus congestion, and 43% complained of foul or unusual odors in the office. Sore throats were noted in the past month by 28% and 20% complained of eye irritation. A comparison of symptoms between floors is presented in Table II.

Since the maximum exposures to formaldehyde occurred in the basement Anatomy Laboratory and the 1st floor science room, one would expect the concentration of formaldehyde to be lower on the upper floors. One might equally expect that, depending on the ventilation system, exposures would be similarly lower on floors 2 and 3 compared to floor 1. The fact that some workers may move from their office (presumably an unexposed area) to one of the laboratories which use formaldehyde was not accounted for in the analysis.

There was, however, no consistent association between symptoms prevalence and location (Table II). Headaches, eye discomfort, and shortness of breath had comparable prevalences on floors 1 and 2 and lower prevalences on floor 3. Floor 2, on the other hand, had the highest prevalence sinus congestion and the lowest prevalence of sore throat, with floor 1 having, in each case, a somewhat higher prevalence than floor 3. For burning nose, the prevalence was highest on floor 1, lower on floor 2, and not reported at all on floor 3.

There were no significant differences between home and office with respect to occurrence of sore throat, burning nose, burning or itching eyes, shortness of breath, or headaches were compared. There was an increased frequency of complaints of foul or unusual odors in the office (Relative Risk = 4.25, 95% Confidence Interval: 1.79 - 10.08).

2. <u>Students and Laboratory Workers</u>

Forty-nine of the 62 students in an introductory Anatomy Laboratory Class participated in the survey. Nineteen (39%) were male and 25 (51%) were female. The remaining 10% did not indicate name or sex. The mean and median age of the group was 18 years. Only two students (4%) were smokers. Students reported spending a mean of 1 hr/week in the laboratory.

Headaches and unusual or foul odors were reported by 59% of the students, sinus congestion by 47%, cough by 38%, eye irritation by 37%, and sore throat by 33%. A comparison of students, laboratory workers, and the results of a prior NIOSH study of an Anatomy Laboratory can be found in Table III.[21] There is a parallel between the rates of reported symptoms between the two student groups. The lower prevalence of symptoms among the staff may represent more careful work practices, tolerance to the irritant effects, or selection bias (workers intolerant or hypersensitive to the chemicals may have sought other career paths).

C. Ventilation

Ventilation measurements in the Anatomy Laboratory showed that to maintain this room under negative pressure, both the general exhaust and the wall exhaust fan are needed, and the wall exhaust fan must be on the high speed setting. Under all other conditions, the room is under positive pressure and air is pushed out of the room into the corridor. Scented smoke released in the middle of Anatomy Laboratory diffused rapidly throughout the room indicating that contaminants are distributed uniformly throughout the room. The smell of smoke and visual observation of smoke patterns also verified that the laboratory was under positive pressure when the wall exhaust fan was on low speed.

Smoke released in the corridor outside Anatomy Laboratory was somewhat idle until the double doors leading to the stairway next to the Machine Shop were opened. When these doors were opened smoke moved rapidly to and up the stairs showing that contaminants seeping into the corridor can be spread to other floors of the building.

For a more detailed discussion of the ventilation results see the attached appendix.

VII. DISCUSSION

A. Industrial Hygiene

The results of airborne sampling for formaldehyde show that the potential for exposure to low levels of formaldehyde does exist in the Anatomy Laboratory. While only two of the 22 airborne samples collected showed concentrations above the LOQ for formaldehyde, 12 others indicated that quantities between the LOD and LOQ were present in the Anatomy Laboratory air. The highest concentration detected was in a personal breathing zone sample collected during set-up of the Anatomy Laboratory for the final exam. The set-up of the Anatomy Laboratory lasted about 2 1/2 hours and involved removing 14 monkey cadavers from the refrigeration room, placing the cadavers around the room at 14 different locations and placing pins in the monkeys to identify specific anatomical parts. The analytical results clearly indicate that the Caro-Safe® rinse procedure does not completely remove all formaldehyde from the monkey cadavers. Residual formaldehyde remains in the tissue of the monkey cadavers and therefore, the potential for personal exposures to formaldehyde does exist.

Chemicals used to preserve specimens are the primary source of airborne contaminants in Anatomy Laboratory. The odor of the chemical preservatives could be detected in the Anatomy Laboratory indicating that the contaminants are diluted but not controlled. The use of scented smoke indicated that contaminants are dispersed evenly and rapidly throughout the room. Furthermore, the basement area was designed to be under positive pressure and the addition of AHU 4 resulted in increased positive pressure. The resulting positive pressure can cause contaminants from the Anatomy Laboratory to move into the corridor and up the stairway to other floors. The contaminants then spread throughout the building via the other ventilation systems. This is especially true when the exhaust fan in the Anatomy Laboratory is not operating at high speed.

Control of airborne contaminants can be achieved through several methods including product substitution and ventilation. Alternatives to using formaldehyde-preserved specimens include freeze-dried specimens which are rehydrated prior to use, or specimens preserved in odorless, nontoxic solutions.[22]

Local exhaust ventilation (i.e. a local exhaust hood) should be used when dissecting[23] formaldehyde-preserved specimens (also, see Figure 4 of the attached appendix). If a local exhaust hood is not feasible, a displacement ventilation system is another method of controlling airborne contaminants (see the attached appendix, Figure 3 and Section VIII).

B. Medical

The irritant effects of formaldehyde have been documented in previous medical studies. More controversial, however, is the concentration of formaldehyde necessary to cause symptoms in the adult population. In a 1959 study, Bourne and Sefarian reported the evaluation of a dress shop where workers complained of burning and itching eyes, headaches, and nose and throat irritation.[24] Airborne sampling for formaldehyde revealed concentrations of only 0.13 to 0.45 ppm. More recently, Tierbig and Trautner, et.al. studied 53 medical students in an Anatomy Laboratory.[25] Cadavers were fixed with a solution of 20% formol (40% formaldehyde), 20% carbol (90% phenol), and 60% ethanol. Airborne sampling for formaldehyde revealed concentrations ranging from 0.32 ppm to 0.58 ppm (0.39 and 0.69 mg/m^3). Only nine of the participants voiced complaints; these included three with headaches, three with eye irritation, two throat irritations, and one with breathing difficulties. The students spent approximately 3 hours per session in the laboratory.

Hovarth, et. al. studied 109 workers and concluded that a dose-response relationship existed between the formaldehyde concentration and irritative symptoms.[26] Furthermore, they suggested that such a relationship exists at levels below 3 ppm. Skin reactions to formaldehyde have been attributed to two mechanisms.[27]

In this study, there was no apparent association between measured formaldehyde exposures and prevalence of symptoms by floor. Nor were symptoms more likely to occur at work than home. The lack of association between symptoms and formaldehyde is not surprising, given that at the levels measured, all less than 0.15 ppm and all but one (0.06 ppm) less that 0.05 ppm, most adults would not have appreciable symptoms.

It should be noted that there are many other chemicals present in the science building and exposures to some of these may also cause irritant effects. Questionnaire data cannot distinguish the different etiologies.

Finally, allergic symptoms such as sinus congestion, itchy nose, and eye irritation can be found in approximately 10% of the general population.[28] The high background rate, together with the differing susceptibility of individuals to a particular environmental agent, make interpretations of the data difficult.

VIII. CONCLUSIONS

The results of airborne sampling for formaldehyde show that the potential for exposure to low levels of formaldehyde did exist in the Anatomy Laboratory at the time of our survey. A personal breathing zone air sample collected on the lapel of the Anatomy Laboratory graduate assistant measured a concentration of 0.12 ppm, and a sample collected near the center of the Anatomy Laboratory during the final exam measured a formaldehyde concentration of 0.06 ppm.

Medical findings indicated: 1) no significant difference between the study symptom prevalence in the offices when compared to symptom prevalences at home, suggesting that the symptoms were not due to an exposure limited to the Science Building; 2) students in the Anatomy Class reported a high prevalence of symptoms compatible with the known irritant effects of formaldehyde; and 3) first floor workers had an increased prevalence of headaches and sinus congestion, but not eye, nose, or throat irritation, when compared to 2nd and 3rd floor workers. The suggestion that faculty and staff symptoms are due, in general, to formaldehyde exposure is not supported by the questionnaire or air sampling data.

Ventilation measurements indicated that problems controlling contaminants were not limited to the Anatomy Laboratory (Room S-1). Numerous other uncontrolled contaminant sources existed in other laboratories, storage areas, and outside the building where contaminants are exhausted. The current ventilation system is inadequate for a laboratory setting as determined by the ventilation measurements and review of the literature.

IX. RECOMMENDATIONS

A. Industrial Hygiene

The following recommendations were included in previous correspondence and are still applicable, if they have not already been implemented.

1. Specimens preserved by means other than formaldehyde (e.g. freeze-dried) should be considered.

2. A Safety and Health Committee for the Science Building should be established and should consist of members from the faculty and administration.

3. Members of the Safety and Health Committee should receive training in laboratory safety.

4. If ventilation is selected as the primary method for controlling airborne formaldehyde, then preparation of biological specimens (i.e. rinsing of fetal pigs) should be done within an exhaust hood to prevent the migration of chemical vapors to other areas of the building.

5. All employees responsible for preparing biological specimens should be issued appropriate protective gloves to prevent skin contact with chemical substances used in the preparation of these specimens.

6. All employees working with potentially toxic chemicals should be trained in proper handling and use of specimens and should be warned of the potential toxic effects of working with the chemicals used to treat the specimens.

7. All chemicals used in the building should be properly stored to prevent spills.

B. Ventilation

Overall, the ventilation system for the Anatomy Laboratory and all other laboratories within the Science Building should be reevaluated. Specifically, the Anatomy Laboratory should be designed as a containment laboratory. For a complete discussion of the ventilation recommendations, please refer to the attached appendix.

C. Medical

1. Medical surveillance of workers exposed to formaldehyde should include a pre-employment medical evaluation. The medical history should include information about prior formaldehyde exposure, hypersensitivity to formaldehyde, and allergic conditions such as asthma or eczema. Applicants or employees having medical conditions such as dermatitis, which would be directly or indirectly aggravated by exposure to formaldehyde should be counseled on the increased risk of impairment of their health from working with formaldehyde.

2. Employees should receive appropriate training in the hazards associated with the chemicals to which they might be exposed.

3. There is a wide range in individual susceptibility to the effects of formaldehyde. Symptomatic individuals should be encouraged to report any ill effects and should receive appropriate medical referral.

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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. The requestor
2. Margaret Ball, Ithaca College
3. Tom Brown, Ithaca College

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

Sample results for airborne concentrations of formaldehyde

Ithaca College
Ithaca, New York
HETA 87-387

December 7-10, 1987

Room No./Location	Sample Time (minutes)	Sample Volume (liters)	Formaldehyde (ppm)
	December 7, 1987		
S-1/Anatomy Lab	11:08a - 12:04p	11.1	ND
"	1:59p - 3:49p	22.0	(0.032)
S-6/Refrigeration room	11:15a - 12:24p	13.5	ND
"	1:58p - 3:49p	22.4	(0.031)
S-1/Hallway	11:19a - 12:24p	12.4	ND
"	1:58p - 3:49p	21.6	ND
1st Floor/Outside Physics Off.	11:23a - 4:43p	61.1	(0.016)
2nd Floor/Outside Lecture Aud.	11:29a - 4:19p	58.4	(0.017)
S-6B/Twincubator room	11:39a - 4:50p	54.8	(0.013)
	December 8, 1987		
Anatomy instructor	11:08a - 12:51p	20.7	(0.097)
Graduate assistant	10:34a - 12:53p	22.0	0.12
S-1/Anatomy Lab	1:05p - 4:53p	46.5	(0.022)
ENVIRONMENTAL CRITERIA		NIOSH REL	LFL
		ACGIH TLV	1.0*
		OSHA PEL	1.0

Abbreviations:
ppm - parts of formaldehyde per million parts of air.
LFL - lowest feasible level

Note: values falling between the analytical limit of detection (LOD) and the analytical limit of quantitation (LOQ) are reported in parentheses.

* - the ACGIH has issued a Notice of Intended change of 0.3 ppm as a 15-minute ceiling value

Table I (continued)

Sample results for airborne concentrations of formaldehyde

Ithaca College
Ithaca, New York
HETA 87-387

December 7-10, 1987

Room No./Location	Sample Time (minutes)	Sample Volume (liters)	Formaldehyde (ppm)
	December 8, 1987		
S-1/Anatomy Lab	5:15p - 9:44p	52.3	0.06
S-1/Hallway	5:15p - 10:00p	56.9	(0.035)
S-6/Refrigeration room	5:15p - 10:12p	59.0	(0.017)
S-6B/Twincubator room	5:26p - 10:23p	58.7	(0.015)
1st Floor	5:36p - 9:38p	48.5	(0.021)
2nd Floor, Outside Auditorium	5:43p - 9:30p	44.8	(0.016)
	December 10,1987		
Room 208/Back	9:08a - 11:11a	24.6	ND
Room 208/Front	9:08a - 11:11a	24.9	ND
2nd Floor, outside auditorium	9:08a - 11:11a	23.6	ND
3rd Floor, hanging from railing	9:08a - 11:11a	24.7	ND
ENVIRONMENTAL CRITERIA		NIOSH REL	LFL
		ACGIH TLV	1.0*
		OSHA PEL	1.0

Abbreviations:
ppm - parts of formaldehyde per million parts of air.
LFL - lowest feasible level

Note: values falling between the analytical limit of detection (LOD) and the analytical limit of quantitation (LOQ) are reported in parentheses.

* - the ACGIH has issued a Notice of Intended change of 0.3 ppm as a 15-minute ceiling value

Table II

Symptom Prevalence by Floor

Ithaca College
Ithaca, New York
HETA 87-387

December 7-10, 1987

	1st Floor	2nd Floor	3rd Floor	All Floors
Number of Respondents	19	11	8	40
Headaches	58%	64%	13%	48%
Sinus Congestion	37%	82%	25%	45%
Unusual/Foul Odors in Office	53%	36%	38%	43%
Sore Throat	42%	9%	25%	28%
Itching Eyes	21%	27%	13%	20%
Burning Eyes	21%	27%	13%	20%
Burning Nose	21%	9%	0	13%
Short of Breath	11%	9%	0	7%

Table III

Ithaca College
Ithaca, New York
HETA 87-387

December 7-10, 1987

This table compares symptoms among the students and those faculty and staff members who identified themselves as working with formaldehyde. For comparison purposes, the results of a previous NIOSH evaluation are presented. The earlier study of medical students in an anatomy laboratory was conducted in conjunction with environmental monitoring. Personal breathing zone sampling of students in the prior NIOSH study revealed formaldehyde concentrations ranging from .02 to 2.8 ppm (0.02 to 3.3 mg/m3).

Symptom	Students	Staff	Previous Study
No. of respondents	49	12	23
Unusual/Foul Odors	59	17	-
Headache	59	17	-
Sinus Congestion	47	42	-
Sore Throat	33	8	26%
Cough	39	25	-
Itchy Eyes	37	8	34%**
Burning Eyes	27	25	- **
Short of Breath	14	8	4%
Rash	8	17	8%
Dizzy	35	17	17%

**Reported as eye irritation

APPENDIX

Ventilation Evaluation

Ithaca College
Ithaca, New York
HETA 87-387

December 1987

I. INTRODUCTION

A survey of the ventilation systems serving the basement and Room 208 in the Science Building was conducted as part of the environmental survey.

The main concern of the ventilation survey in the Science Building was the Anatomy Laboratory (Room S-1). This room, at the time of the survey, was used as a classroom and dissection room for monkey cadavers. In addition, there were complaints that the contaminants from the cadavers were infiltrating to other parts of the building.

The major emphasis of the ventilation survey was to evaluate the ventilation for Room S-1. However, because Room S-1's ventilation was part of the ventilation for the entire basement area of the Science Building, measurements of the ventilation for other rooms in the basement were made. Additionally, a cursory evaluation was made of the ventilation in Room 208 because this room was added as part of the environmental survey. At the time of the survey, fetal pig cadavers preserved in formalin were dissected in Room 208.

II. DESCRIPTION OF THE VENTILATION SYSTEM

Schematics of the air supply, return and exhaust systems for the basement are shown superimposed on a layout of the basement in Figures 1 and 2. The original ventilation system was designed with only one air handling unit (AHU) to serve the entire basement area. AHU 1 was to supply air to each room of the basement through a single register located on the corridor side of the rooms. The basement air supply system was later changed by replacing the registers with louvered (square or circular) diffusers and moving the diffusers to the locations shown in Figure 1.

Return air for AHU 1 is pulled through either the ceiling plenum or the corridor to the mechanical room. Air flow into the ceiling plenum is through grilles located above the door of each room and into AHU 1's mechanical room through an opening in the room wall. Air flow into the corridor is through louvres in, and leaks around, the doors of the rooms and into AHU 1's mechanical room through the louvres and openings of the mechanical room door. Only Rooms S-2, S-3, S-10, and the bathrooms had open louvres; panels had been placed over the louvres of the other doors.

Over time, the basement ventilation system was altered. Alterations in Room S-1's ventilation included: addition of an exhaust fan on the outside wall; conversion of the return air system into a general exhaust system (as shown in Figure 2); and changing the supply air from AHU 1 to a new unit AHU 4. The exhaust fan has a three position switch; off and two fan speeds. Air is pulled through a backdraft damper and is exhausted at ground level through a mushroom vent cap. Instructors using Room S-1 were responsible for setting the required exhaust flow.

The general exhaust system for Room S-1 was altered by connecting an existing exhaust duct for Room S-4B into a plenum installed over Room S-1's former return opening. General exhaust for Room S-4A and a hood in Room S-5B were also added to the exhaust system. Room S-4A and Room S-4B are used as animal quarters for rats. The hood in Room S-5B appeared to be used primarily to control ether vapors used to anesthetize rats.

Because Room S-1 and the exhaust hood in Room S-5B are not in use continuously, a pneumatic damper system was added to switch the exhaust between the hood and Room S-1's general exhaust. The control switch for the dampers is located in Room S-1; the instructors are responsible for operating the switch. When classes are held in Room S-1, the instructor is responsible for turning the switch to the "S-1" position which opens the damper to Room S-1 and closes the hood's damper. When classes end, the instructor is responsible for turning the switch back to the "S-5" position.

AHU 4 was added in 1987, evidently to provide additional makeup air to Room S-1. The ducting for AHU 4 was connected to the main branch for AHU 1 (see Figure 1), but a manual damper (in the closed position during the survey) separates the two systems. The existing ductwork into Room S-1 was used, but the location of the supply air diffusers was changed.

Other branches from AHU 4 ran into the Machine Shop and Room S-6A, a storage area. The branch going to Room S-6A runs through Room S-6, the area containing the cold storage units for the monkey cadavers. At the time of our survey, an improvised opening in the duct in Room S-6 existed. Neither Room S-6 or Room S-6A had an exhaust system.

III. VENTILATION EVALUATION METHODS

The ventilation survey focused mainly on the system serving the Anatomy Laboratory (Room S-1). This room was used as a classroom and for dissection of monkey cadavers. Because the ventilation system serving the Anatomy Laboratory was connected to the system for the entire basement area, ventilation measurements in other rooms of the basement area were also made. Additionally, a cursory evaluation of the ventilation in Room 208 was conducted because dissections of fetal pig cadavers preserved in formalin were performed in this room.

Most ventilation measurements in the basement area concentrated on Air Handling Units (AHUs) 1 and 4. The following methods were used to evaluate the ventilation systems in the Science Building:

A. Total air flows from the supply air diffusers in all of the basement rooms were measured using an Alnor Balometer (MN 6465).

B. To find the minimum outside air flow entering AHU 1, velocity measurements were made using an Alnor hot wire anemometer (MN 8500). Measurement were made through three existing holes in the outside air duct upstream of the damper on AHU 1 with the outside air damper set in the minimum outside air position. The measurements were made at one inch increments across the duct diameter.

C. The flows from the hood in Room S-5B and the exhaust register in Room S-4B were calculated from velocity pressure measurements made in the duct attached to the hood and the register using an Alnor microanemometer (MN 8520) and pitot tube. Figure 2 shows the relative location of the measurement. Since the air flow into the exhaust register in Room S-4B could be measured with the Balometer, the register's flow was subtracted from the duct flow to get the hood flow.

D. To determine how contaminants disperse throughout a room or migrate to other parts of the building, and how well the exhaust systems would remove the contaminants, air patterns in Room S-1, in the corridor outside Room S-1 and Room S-5, and in Room 208 were visualized using the Roscoe Fog Machine (MN 1500). Smoke tubes were also used to show the flow of air into or out of basement rooms.

E. To determine the relative humidity and dry bulb temperature of the air in the basement, wet and dry bulb temperature measurements were made with a Psycron psychrometer (MN 566) at various locations in the basement in the morning and evening of the second day of sampling.

IV. VENTILATION RESULTS

A. Ventilation in the Anatomy Laboratory (Room S-1)

1. Measurements

Ventilation measurements of the supply, return and exhaust are shown in Figures 1 and 2. Air balance results for Room S-1 are summarized below in cubic feet per minute (CFM):

Supply air only	1640
Supply air less general exhaust w/ switch set on "S-1"	1430
Supply air less general exhaust w/ switch set on "S-5"	1400
Supply air less fan exhaust w/ switch set on "Lo"	540
Supply air less fan exhaust w/ switch set on "Hi"	40
Supply air less general & fan exhausts w/ switches on "S-1" & "Lo"	330
Supply air less general & fan exhausts w/ switches on "S-1" & "Hi"	(170)
Supply air less general & fan exhausts w/ switches on "S-5" & "Lo"	300
Supply air less general & fan exhausts w/ switches on "S-5" & "Hi"	(200)

These results show that the wall exhaust fan in Room S-1 determines whether the room is under positive or negative pressure relative to the corridor. When the wall exhaust fan is on high speed, the room is under negative pressure and air is pulled into the room. Under all other conditions, the room is under positive pressure and air is pushed out of the room into the corridor--no matter what position the general exhaust switch is in ("S-1" or "S-5"). However, both the general exhaust and the exhaust fan together are needed to maintain the room under negative pressure.

2. Smoke Patterns

Scented smoke was released in the middle of Room S-1 and diffused rapidly throughout the room indicating that, no matter where the source is in the room, contaminants are distributed uniformly throughout the room. The use of smoke verified the air balance measurements for Room S-1. When the wall exhaust fan was on low speed, smoke could be detected by smell in the corridor outside Room S-1 even when the door was closed. Smoke could be seen moving toward the wall exhaust fan at all fan speeds but little movement toward the general exhaust was observed.

Smoke released in the corridor outside Room S-1 was somewhat idle until the double doors leading to the stairway next to the Machine Shop were opened. When these doors were opened smoke moved rapidly toward the stairs showing that contaminants seeping into the corridor can be spread to other floors of the building. Despite the fact that these doors were equipped with automatic closers they can be locked in the open position and contaminants can be pushed up the stairs to other floors of the building. Smoke released directly into the stairwell area travelled rapidly to the third floor.

3. Other Findings

The switch controlling the general exhaust damper in Room S-1 operated opposite of the way it was labeled. In the "S-5" position, the damper to the local exhaust hood in Room S-5 was in fact closed and the general exhaust damper in Room S-1 was open. In the "S-1" position, the opposite was true. This problem could be easily corrected by relabeling the switch.

The damper switch for the general exhaust also did not have a stop when turned counter-clockwise. In fact, the knob could be turned until it came out. Deciding how far to turn the switch to fully actuate the damper was difficult. A switch equipped with a stop or a solid two position feel is needed.

Instructors conducting classes in Room S-1 were responsible for setting the exhaust fan speed and general exhaust damper position. Improper operation of the exhaust systems was noted and may have been a result of lack of training. For example, one teaching assistant operated the exhaust fan only on slow speed (which puts the room under positive pressure). He stated that he was told by an instructor that, on the high speed, air was blown into the room by the fan. This was not found to be true.

The diffuser for the supply air outlet in Room S-1 was missing. Reportedly, the existing diffuser had been removed to improve the room conditions. Without a diffuser, there is no control on the direction of the air entering the room resulting in abnormal turbulence and spreading of contaminants in the room.

The exhaust from Room S-1 was discharged directly beneath the windows of the classroom above. These windows were reportedly opened at times making it possible to draw the exhausted contaminants into the classroom.

The general exhaust for Room S-1 is discharged on the roof. The stack height was not adequate to push contaminated air above the air envelope of the roof. Because most of the air intakes for the building are located on the roof, a strong possibility for recirculation of contaminated air exists.

B. Ventilation in Other Rooms

1. Measurement Results

The air balance (supply less exhaust, if any), in cfm, for the other rooms is tabulated below:

S-2	425
S-3 (including Booth area)	575
S-4A	100
S-4B	(50)
S-5A	175
S-5B (switch in "S-1" position)	(6)
S-5B (switch in "S-5" position)	118
S-5C	275
S-5D	185
S-5E	155
S-6A	200

2. Smoke Patterns:

Smoke released in the corridor outside Room S-5 traveled about halfway down the hall to the wall between Room S-2 and Room S-3 and then returned to Room S-5's end of the corridor. Moreover, the air in the corridor had so little movement the smoke stratified into layers. After about 15 minutes, the smoke did not dissipate to any degree. When the double doors (next to Room S-5) leading to the outside were opened, the smoke dissipated rapidly.

Smoke was released in the middle of Room 208 with the door and several windows open to simulate conditions during times when classes were being held. Air is supplied to the room from a ceiling plenum through small (about 1/8" wide) slots located in the suspended ceiling framing. A ceiling grille for a ducted air return was located near the middle of the wall containing the door.

The smoke diffused throughout Room 208 as rapidly as in Room S-1. Primary movement of the smoke was across the ceiling of the room where it merged with air entering through the windows. The air then moved rapidly across the room and out the door into the middle section of the building. Some smoke was observed to be pulled into the room's return air grille.

3. Other findings

On the first day of the survey it was noted that the damper motor for the hood in Room S-5B was disconnected and in the open position. The damper system was accessible to others besides maintenance personnel and reportedly, had been disconnected several months. The damper was reconnected the next day.

A bottle of ether was found stored in the hood in Room S-5B and bottles of formaldehyde and glycol were stored on open tables in Room S-6A. Room S-6A only had a vent into the Machine Shop.

The air supply duct passing through Room S-6 had an rough opening cut into it by non-maintenance personnel and there was no method for controlling the flow of air from the opening. Evidently, air was desired in the room to dilute the smell of preservatives coming from the refrigerators. Reportedly, the odor increases when the monkeys are retrieved from the refrigerators.

During the survey, a laboratory technician executed some rats in Room S-4B by placing them in a plastic garbage container with ether soaked rags. This procedure is reportedly done about once a semester. The tech wore only a paper dust mask while performing this job and reported that the job made him dizzy. A heavy ether odor was noted in the corridor outside Room S-4A after this procedure. Ventilation measurements showed that this could be expected since Room S-4 is under positive pressure and the odor persisted for a long time because of the stagnant air in the corridor outside Room S-4A.

Two open duct connections were found in the ceiling above Room S-3 (see Figure 1). The connections appeared to be for disconnected diffusers in two booths. Although the connections had manual dampers, neither damper was closed resulting in short-circuiting of the ventilation system.

C. Psychrometric Readings

The psychrometric readings in Table II show that the average dry bulb temperature was 74° and 76°F in the late morning and evening, respectively. The corresponding relative humidity was 28% and 36%, respectively. The temperatures and relative humidities throughout the basement area were relatively consistent. The relative humidity in Room S-1 in the evening was lower than the rest of the basement. But, this trend did not show up in measurements taken in the morning.

The average dry bulb temperature in the basement is in the middle of ASHRAE's comfort zone for sedentary individuals.[1] However, the humidity is in the lower part of the comfort zone. This means that although the temperature may be acceptable to most individuals, the humidity level may cause them to feel uncomfortable. Low humidities could result in such problems as chapped lips, or a feeling of dry mouth or tightness in the throat.

On the other hand, ASHRAE states that winter conditions of 71°F dry bulb and 26% to 72% relative humidity are acceptable for laboratories.[2] Summer conditions can be 76°F dry bulb and 22% to 62% relative humidity. However, Clifford recommends conditions of 76°F temperature, 40% relative humidity, and an air velocity of 45 fpm--about the middle of the ASHRAE comfort zone.[3] Other commonly accepted recommendations are for a dry bulb temperature around 75°F, humidity of 40% to 60% and an air velocity between 25 and 50 fpm.

V. DISCUSSION

A. Ventilation in the Anatomy Laboratory (Room S-1)

Chemicals used to preserve specimens are the primary source of contaminants in Room S-1. The odor of the preservative could be detected in Room S-1 indicating that the contaminants are diluted but not controlled. The use of scented smoke showed that contaminants are dispersed evenly and rapidly throughout the room. Furthermore, the entire basement area was designed to be under positive pressure and the addition of AHU 4 resulted in increased positive pressure. The resulting positive pressure can cause contaminants from Room S-1 to move into the corridor and up the stairway to other floors. The diluted contaminants then mix with clean air and are spread throughout the building through the other ventilation systems. This is especially true when the exhaust fan in Room S-1 is not operating at high speed.

Therefore, contaminant sources in the building need to be controlled. There are several ways this can be achieved. One way is to control the contaminants at the source. A second way is to break the path between the source and the person.

One way of stopping the contaminant at the source is to substitute specimens so there are no contaminants. Korky mentions using freeze-dried specimens which are rehydrated prior to use or specimens which are preserved in alternate materials.[4] The source Korky mentions for the freeze-dried specimens is Ward's Natural Science. The sources for specimens preserved in an odorless, nontoxic solution are Nassco Co. and Carolina Biological Co.

Ventilation can be used to affect the path of the contaminants from the source to the person. The best place to affect the path is as near to the source as possible. Degenhardt and Pfost present a design recommendation for a local exhaust hood that can be used for dissecting.[5] Their design has been adapted for the hood discussed further in the Recommendations.

If local exhaust ventilation is not feasible, then displacement ventilation can be used to intercept contaminants as they travel from the source to the person. With displacement ventilation, low velocity air is used to intercept the contaminant at the source and direct the contaminant away from the breathing zone to an exhaust system. Unfortunately, no specific recommendations could be found in references or sources investigated in a literature search. However, some sources contained information on designs which may be adaptable.

To describe displacement ventilation, both the supply air and exhaust air systems need to be discussed. The first item to consider when designing a displacement system is outside air requirements for the supply air. Normal class size was reported to be about 20 students plus one to two instructors, but Room S-1 has ten benches, each with the capacity for about four students. Therefore, the room is capable of handling 40 students plus one to two instructors. The outside air requirements for Room S-1 for a full class are 840 cfm (20 cfm/person) according to the current ASHRAE standard for laboratories in educational facilities (ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality").[6] Since AHU 4 supplies 100% outside air to Room S-1, the amount of outside air being pumped into Room S-1 (1640 cfm) far exceeds that called for in the current standard.

The ASHRAE standard cited in the above paragraph was determined for an estimated maximum occupancy of 30 people per 1000 ft^2 of floor space. The calculated floor space for the laboratory is 1015 ft^2. Therefore, the maximum number of occupants would be 30 and the outside air requirements would be 600 cfm under the current standard. Since the current supply of outside air is more than five times that required by the current standard, the laboratory may be able to have 42 occupants if the supply air can handle the thermal load.

Another aspect of the problem in Room S-1 is the desire to minimize occupant exposure to contaminants and to contain the contaminant within the laboratory. This criteria tends to be similar to that for a containment laboratory. In containment laboratory design, the important criteria is the number of air changes, maintaining the laboratory under negative pressure or air flow, and having a non-recirculating system.

Several sources had recommendations which are believed to be suitable to the criteria for a dissecting laboratory in the Science Building. Both Fisher and Myers recommend that the air flow necessary for containment laboratories should be 12 to 15 air changes per hour.[7,8] Fisher further states that this air flow is higher than that required for a conventional laboratory. The American Institute of Architects (AIA) recommends 12 air changes for an autopsy room in a hospital or medical facility, 6 for an isolation room or general laboratories, and 10 for an isolation alcove.[9] Based on the measured supply air flow into Room S-1 and assuming an 8-foot ceiling height, the number of air changes at the time of the survey was 12.1.

The method of supplying air to Room S-1 leads to the dispersion of contaminants throughout the room. Air was supplied at a high velocity causing turbulence and mixing of the supply and room air. Using a low-velocity, widely dispersed air supply reduces turbulence and mixing of air in the space, and thus the dispersion of contaminants. Air supplied at low velocity also maintains the dispersed air pattern and velocity as it flows through the space. One manufacturer was found which has a diffuser that can provide the kind of supply air pattern needed in a dissecting laboratory (Krueger, Tucson, AR). In fact, the applications for the diffusers listed in the company's product literature include laboratories and animal rooms. The application of the diffuser to Room S-1's ventilation system is demonstrated in the "Recommendations" section.

The exhaust system is the next area to consider when designing a displacement ventilation system. In industrial environments, common recommendations are for areas to have an air deficit of 10% to prevent the escape of contaminants to adjacent areas. Based on this recommendation the exhaust air flow for Room S-1 should be about 1800 cfm (1640 + 164).

On the other hand, Fisher states that the negative airflow should be approximately equal to 20% per minute of the cubic volume of the laboratory.[7] Following Fisher's examples, a deficit flow of 1624 (0.20 x 8120) cfm would be needed. This means the total exhaust flow from the room would need to be 3264 (1624 deficit flow + 1640 supply flow). Assuming that there are no other air leaks into the room other than the door and that the door opening is 21 ft^2 (3' x 7'), the air velocity through the door would be about 155 fpm.

If there were no leaks into the room other than through the door, a velocity of 155 fpm appears to be extreme for the laboratory in the Science Building. A velocity at the door of about 75 to 100 fpm should be adequate. This works out to be about a 1575 to 2100 cfm deficit flow (21 ft^2 x 75 and 100 fpm, respectively). The total exhaust air flow for the room then should be 3215 to 3740 cfm (1640 + 1575 and 2100, respectively).

Maintaining the laboratory, or any laboratory, under negative air is a matter of great concern. In addition, when the door to the laboratory is closed, the area for the air to enter the room is reduced so the velocity of the air into the room increases. In some cases, this velocity can cause whistling through openings into the laboratory. Furthermore, this high velocity through the leaks is not necessary and is an energy waste.

Control systems which maintain a constant pressure differential between the laboratory and adjacent space are available. These systems sense the room pressure and increase the exhaust flow when the pressure in the room becomes less negative as it would if a door were opened. These systems or others which monitor the air flows of supplies and exhausts are also used for laboratories which have variable flow fume hoods. A listing of manufacturers can be found under the heading, "Controls, Laboratory Pressurization," in the HPAC (Heating, Piping and Air Conditioning) Infodex.[10] Note that other articles have pointed out problems with the control systems when they are not maintained.

Installation of any controls will require training the users of the rooms about the control systems so they know how the control systems work and can assure that the systems are working correctly. Misuse of Room S-1's current control systems is a direct result of lack of training. Pressurization controls are much more sophisticated than the current controls. Therefore, training will be needed.

Keimig conducted a study on the effect of door swing on the escape of contaminants.[11] The author concluded that the door should swing into the room, should be located away from contaminants so the waving effect of the door does not increase contaminant escape, and should be equipped with a door closer to slow the closing of the door to minimize disrupting air currents by the door.

NIOSH as well as Fisher and the AIA recommend that air from laboratories not be recirculated. In addition, for autopsy rooms, ASHRAE does not recommend recirculation.[7,9]

The location of the wall exhaust fan dicharge could allow contaminants to enter open windows or expose people on the ground to the contaminants. This fan should have a duct which runs to the roof line. The exact height of the duct above the roof depends on the prevailing winds, building dimensions and surrounding terrain among other parameters. Although numerous papers have been written on stack design and placement, and exhaust gas velocity, the ASHRAE Handbook of Fundamentals summarizes the design parameters in one of its chapters.[12]

The same discussion can be used about stack design for the general exhaust for the room. But, this is discussed more in the Recommendations section.

B. Ventilation in Other Rooms

The combined air balance for Room S-4A and Room S-4B shows that the room is under positive pressure. This means that contaminants are being pushed into other areas and undoubtedly recirculated. ASHRAE discusses the design of the ventilation for laboratory animal quarters.[13] Several references for the ASHRAE material are excellent sources, in particular, "Laboratory Animal Housing" by The National Academy of Sciences. ASHRAE recommends that animal facilities be maintained under 0.1" water gage (w.g.) negative pressure.[14] This can be accomplished with a pressure control system similar to that for Room S-1. Again, recirculation of the air from the room is not recommended.

The exhaust hood in Room S-5B is similar to a laboratory hood and does not appear to be proper for its intended use. In which case, a commercial laboratory hood should be purchased because of the complexity of the design of the hood. If this hood is going to be used for rat killing, the hood should be a walk-in type or the rat-killing process should be changed to accommodate a regular laboratory hood.

Both Room S-6 and Room S-6A are not proper storage areas for chemicals. Contaminants from the rooms can be recirculated into the ventilation system because both rooms are under positive pressure. Air from the rooms is pushed into the Machine Shop and the corridor and can travel the same path as that for the contaminated air from Room S-1. A spill in either of these rooms could cause a problem with air-borne contaminants spreading to the rest of the building.

Shortly before the survey, Ithaca College representatives stated that it is going to use models instead of monkeys in the future. Additionally, in a phone conversation on March 23, 1989, a representative of the college stated that an Architect and Engineering firm had been hired to evaluate the ventilation system in the building to see if fixing the ventilation is feasible.

VI. CONCLUSIONS

While the Anatomy Laboratory ventilation does have its problems as far as controlling contaminants, there are more problems in the building than those in Anatomy. Numerous other uncontrolled sources were noted in the building in other classes and laboratories, and outside the building where contaminants are exhausted. Some of the uncontrolled sources were also formaldehyde problems such as that in Anatomy Laboratory.

Another aspect of the problems in the building is the fact that the ventilation system was probably either misapplied or out-dated from the time it was installed in the building. Currently, more energy efficient ventilation and control systems are available. Redoing the entire ventilation system may pay off in energy savings in the near future.

VII. VENTILATION RECOMMENDATIONS

1. The damper operating switch in the Anatomy Laboratory was incorrectly labeled and should be relabeled.

2. The total air flow for the general exhaust system for Room S-1, Room S-4A, Room S-4B, and the exhaust hood in Room S-5B was very low. A new fan capable of withstanding the pressure drop in the system should be installed. Prior to installing a new fan, a study of the use of the exhaust hood in Room S-5 should be made to determine if the hood should be put on-line permanently and the new fan should be sized accordingly. If the hood in Room S-5 is to be used intermittently, arrangements need to be made so that the hood is utilized when Room S-1 is not being used.

3. The wall exhaust fan in Room S-1 should be set in the "high" position if contaminants are being used in the room. This will put the room under negative pressure to prevent the escape of contaminants.

4. Windows above the exhaust fan outlet should be kept closed to prevent contaminants from reentering the building.

5. The improvised opening in the air duct in Room S-6 should be replaced with a register so that the air flow can be controlled.

6. The "rat kill" performed in Room S-4 should be done in an exhaust hood to prevent employee exposures to ether and to prevent the migration of ether to other areas of building.

7. Chemicals in Room S-6A and Room S-5 should be properly stored to prevent spills. Rooms with potential for chemical spills should be placed on a separate exhaust system from the HVAC systems to prevent migration of spill emissions to other areas of building. Such rooms should also be under negative pressure.

8. Designate one or two laboratories as strictly dissecting laboratories and concentrate efforts on designing an effective ventilation system designated to those laboratories. In these laboratories, all of the storage and preparation of specimens would occur along with storage of the chemicals used to prepare the specimens. The ventilation recommendations given in the discussion of Room S-1 and the sources in the bibliography should be used as guidelines in designing the ventilation system.

   Moreover, storage areas should be maintained at a pressure negative to the prep area and the prep area should be maintained at a pressure negative to the dissecting part of the laboratory in case of spills. A pressure differential of 0.1" w.g. is listed in the references as suitable, but the experience of the contractors should be the determining factor. Another recommendation is that specimens should not be transported to or through any other space not on the dissecting area's ventilation system.

9. A displacement ventilation system design with a single path air flow should be considered for the dissecting area(s). However, the design should be flexible enough so that local exhaust ventilation can be added later if necessary. The displacement system can be tried first. Based on the environmental sampling results, a displacement system is believed to be adequate for the dissecting laboratory. On the other hand, the college may select local exhaust ventilation as being the most feasible alternative or follow-up sampling may dictate that a local exhaust system needs to be installed.

   As far as design recommendations for the displacement system, unfortunately, no specific recommendations for dissecting laboratories could be found. However, assuming that the layout of the laboratory will not be much different than Room S-1's current design, a ventilation system could be installed where laminar air flow is supplied over the entire floor area from a ceiling plenum and exhausted through grates in a false floor. Currently, this type of system is used for clean rooms, but appears to be adaptable to this situation.

Still, other distribution methods may be feasible. One such alternative would be to supply the air from a plenum running down the center of the room and exhaust it from a baseboard slot hood. Figure 3 shows what such a system and its air distribution may look like. The plenum for this supply system could be suspended below the ceiling or its base flush with the ceiling. A laminar flow diffuser, such as the one manufactured by Krueger, or registers with opposed blade dampers and double deflection louvres could be used to distribute the air. For the latter, the opposed blade dampers would be used to distribute the air uniformly along the length of the room while the louvres would be used to get the air pattern demonstrated in the figure.

The goal for the distribution system is to get laminar flow through the breathing zones of the occupants so the supply air "sweeps" contaminants toward the exhaust system. A distribution system should be selected which minimizes mixing of room air with supply air. Mixing would cause contaminants to be distributed throughout the room instead of moving them toward the exhaust. If the decision is to use registers, special care must be taken because registers are usually designed to create turbulence. Again, low velocity, low turbulence air is the key to minimizing mixing.

The exhaust system for the room would consist of two slot plenums running the length of the room. Slot velocity should be at least 2000 fpm to get even distribution. The plenums should be located about 6 inches above the floor and constructed to take abuse because of their location and the slots. They should be equipped with screening to prevent materials from being thrown into them. Velocities in the exhaust duct is recommended to be at least 1000 fpm. Exhaust air must not be recirculated.

Note that there are four important points that must be considered when selecting space temperature, humidity, and air velocity. First, comfort charts should be used as a target for design purposes, but the actual environmental conditions should be those which satisfies a majority of the spaces' occupants a majority of the time. Second, the combination of temperature, humidity, and air movement determine comfort--a change in one parameter which makes conditions uncomfortable will require a change in one or both of the other parameters to restore comfort. Third, individuals can be comfortable over a range of conditions--individuals are comfortable at more than one combination of temperature, humidity and air movement. Fourth, the activities and clothing of the individuals in a space can impact their feelings of comfort--conditions which are comfortable to an individual now may not be comfortable if the individual changes clothing or activity levels.

As far as local exhaust ventilation, a system similar to that recommended by Degenhardt and Pfost is shown in Figure 4.[5] The main difference between Degenhardt and Pfost's design and that in the figure is that the figure is adapted for a dissecting bench instead of a single sink. In addition, Degenhardt and Pfost did not specify the slot and duct velocities. Note that, if local exhaust ventilation is used, special care needs to be taken in designing the make-up air system at the outset so that the laboratory remains under negative pressure relative to adjacent, non-laboratory areas and that the make-up air does not disrupt the local exhaust ventilation.

10. When hiring a ventilation design firm, previous experience in successfully designing chemistry laboratories and/or dissection laboratories should be considered. Ventilation for laboratories is not run of the mill and not all designers know the important parameters in designing such ventilation.

11. Designate one person in the Science Building as the interdepartmental coordinator for scheduling laboratory use. Because so many departments use the laboratories, scheduling the use of the laboratories could be troublesome with only one or two designated laboratories. If this job is performed by one person, the job becomes easier. More importantly, this person could be trained in the operations of the laboratory ventilation systems and in chemical handling so that proper operation of the ventilation systems is assured, and chemicals are handled and stored in a safe manner. A suggested person is the one who currently prepares specimens for the laboratories.

12. Develop a maintenance schedule for all ventilation systems in the building. Especially include maintenance of all control systems on the schedule. Record all maintenance on the ventilation systems.

13. Keep an operation manual for all of the ventilation systems in the building and in the maintenance department. Include information in the operation manual on both the ventilation system and its controls. More specifically, the manual should include all blueprints prints, a description of the operations of all systems and controls, the maintenance schedules, product literature on all components, documented changes to the systems, and any other information deemed important to the smooth and proper functioning of the environmental systems. Time and effort to up-date the manual needs to be taken whenever a change occurs with the systems. All systems have quirks and fine tuning or changes in the systems are necessary to assure that the systems work as designed. Furthermore, changes in the ventilation systems occur as building use changes. Valuable time is lost in learning the system should problems occur when changes or quirks are not recorded. The records also make for a smooth transition in operation whenever mechanics are changed.

14. Repeat environmental sampling and ventilation measurements on a regular basis, and after any changes in the ventilation systems, to judge whether contaminant levels are being controlled. In addition, audit maintenance records on a similar schedule to assure that all systems are being properly maintained.

15. Establish a formal complaint system about the building environment. Such a system should include who made the complaint, the nature of the complaint, the time, and any conditions linked to the possible problem. As part of the system, information about what was done about the complaint, by whom and when needs to be documented. Keep both the complaint and its resolution an organized file. One person or committee should be responsible for operating the complaint system. Hopefully, the same person or committee is responsible for the sampling and auditing maintenance records.

16. Contact suppliers of chemicals in the building about information on the safe storage of the chemicals. Their information should be used in designing and building chemical storage areas in the building. Additionally, make training on the handling and storage of chemicals mandatory for all instructors and TA's. A person or committee should make regular inspections of the storage facilities to assure that proper storage methods are being followed.

VIII. REFERENCES

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Table 1. Psychrometric data
Ithaca College Science Building
Ithaca, NY
HETA 87-387
December 9, 1987

Location	Time	Wet Bulb Temp (°F)	Dry Bulb Temp (°F)	Relative Humidity (%)
Middle of S-1	11:05 A	55	74	28
Next to corridor wall in S-1	11:07 A	55	74	28
Corridor outside of S-1	10:41 A	56	76	28
Corridor outside of S-3	10:42 A	55	73	30
Corridor outside of S-5	10:44 A	54	72	29
Middle of S-5E	10:46 A	53	72	27
Sampling location in S-6	10:48 A	55	75	26
Sample prep area	10:50 A	57	78	26
Beneath AHU 4	10:52 A	57	74	34
Average		55	74	28
Middle of S-1	5:35 P	54	75	23
Corridor outside of S-1	6:00 P	60	76	39
Corridor outside of S-3	6:01 P	58	74	38
Corridor outside of S-5	6:03 P	57	72	39
Sampling location in S-6	5:58 P	61	77	39
Sample prep area	5:56 P	62	79	38
Beneath AHU 4	6:04 P	60	76	39
Average		59	76	36

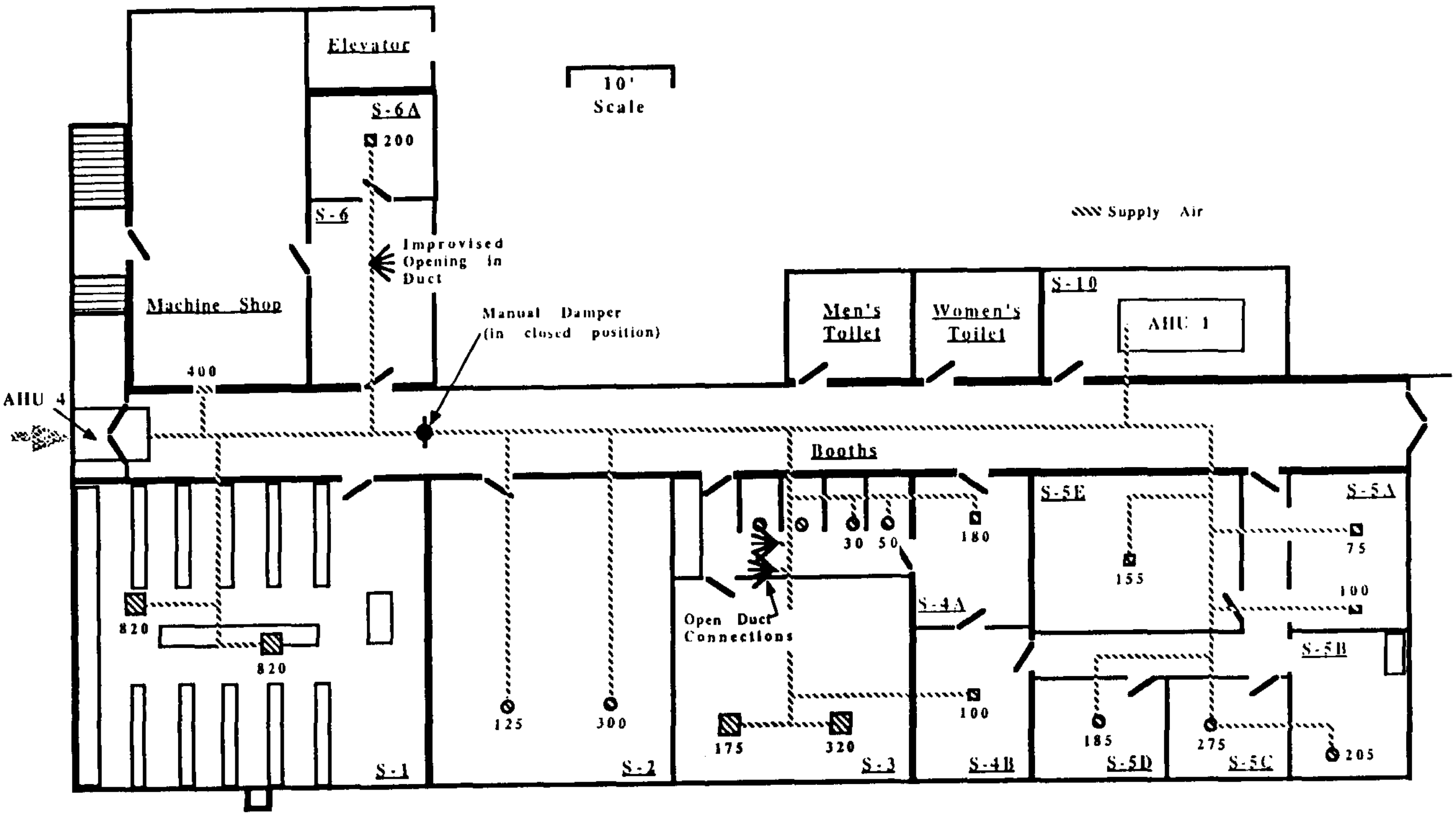

Figure 1. Schematic of supply air system and air flow measurements at supply air diffusers.
Ithaca College
Ithaca, NY
87-387

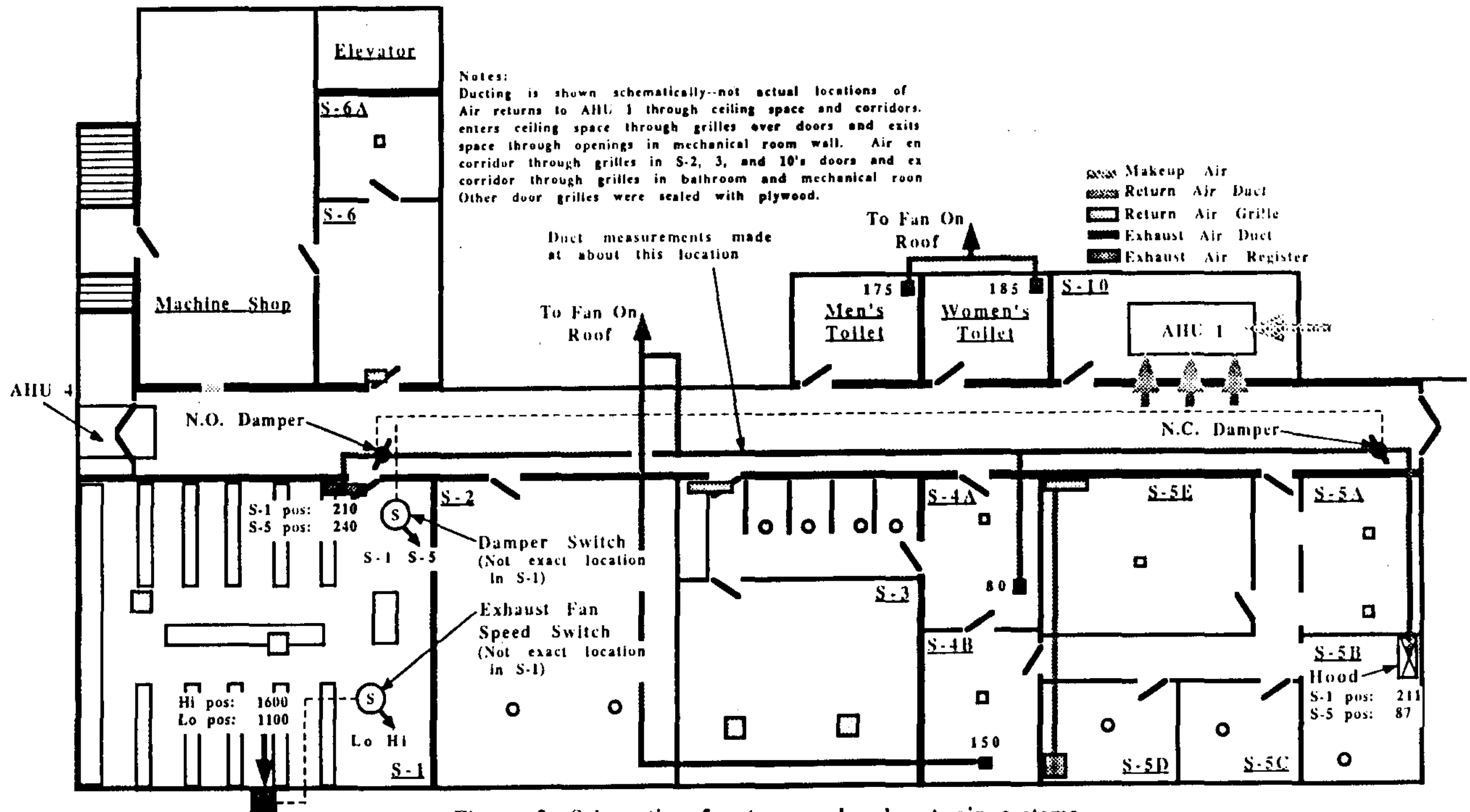

Figure 2. Schematic of return and exhaust air systems and exhaust air flow measurements.
Ithaca College
Ithaca, NY
HETA 87-387

Note: Exhaust plenum should be constructed to stand abuse because of location next to floor. Each plenum should run the entire length of the room, but may be split into several plenums to cover entire length.
If use, supply air registers should have double deflection louvres and opposed blade dampers. Louvres should be aimed to get approximate air flow pattern shown on right side of figure.

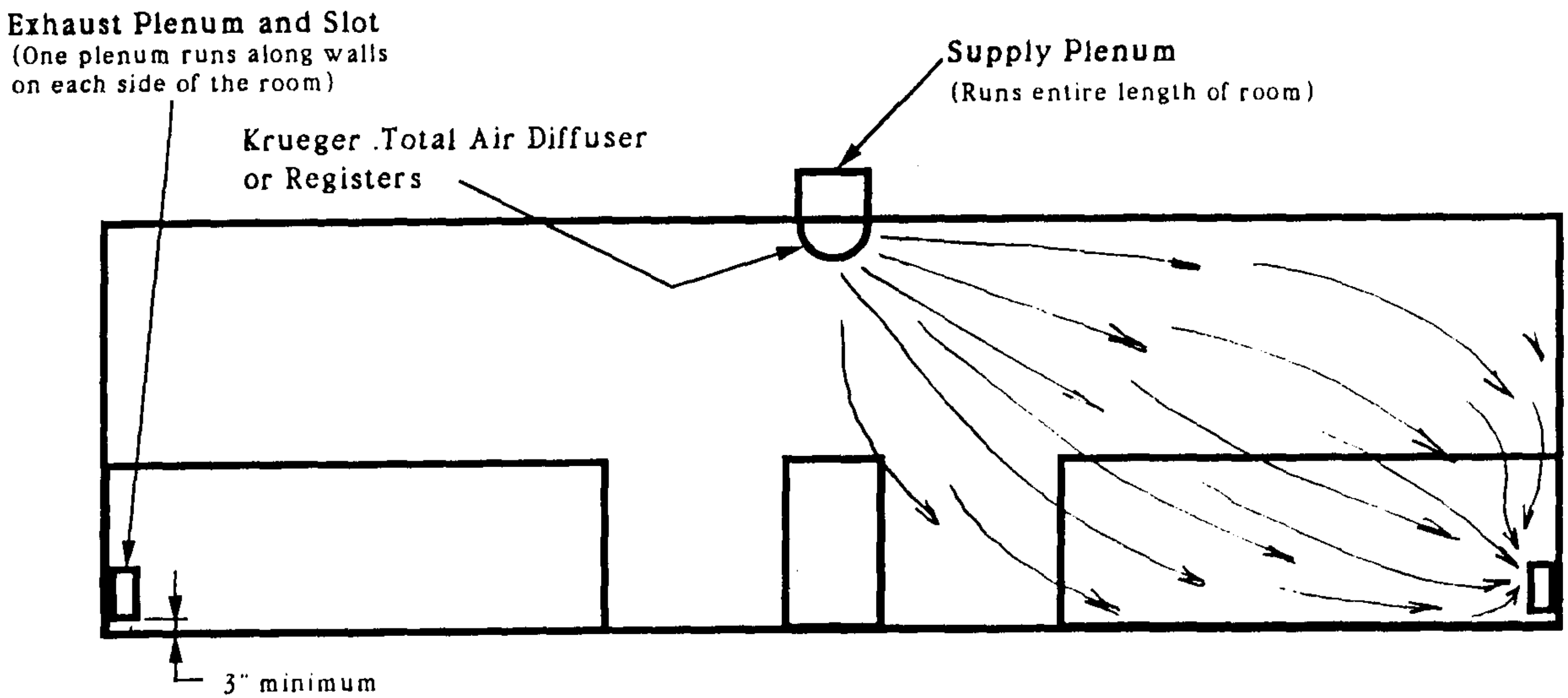

Figure 3. Proposed changes to ventilation system in S-1.
Ithaca College
Ithaca, NY
87-387

Notes: Minimum slot velocity is 2000 fpm. Minimum duct velocity is 1000 fpm. Recess top of cutting board about one inch below the top of the cutting board.

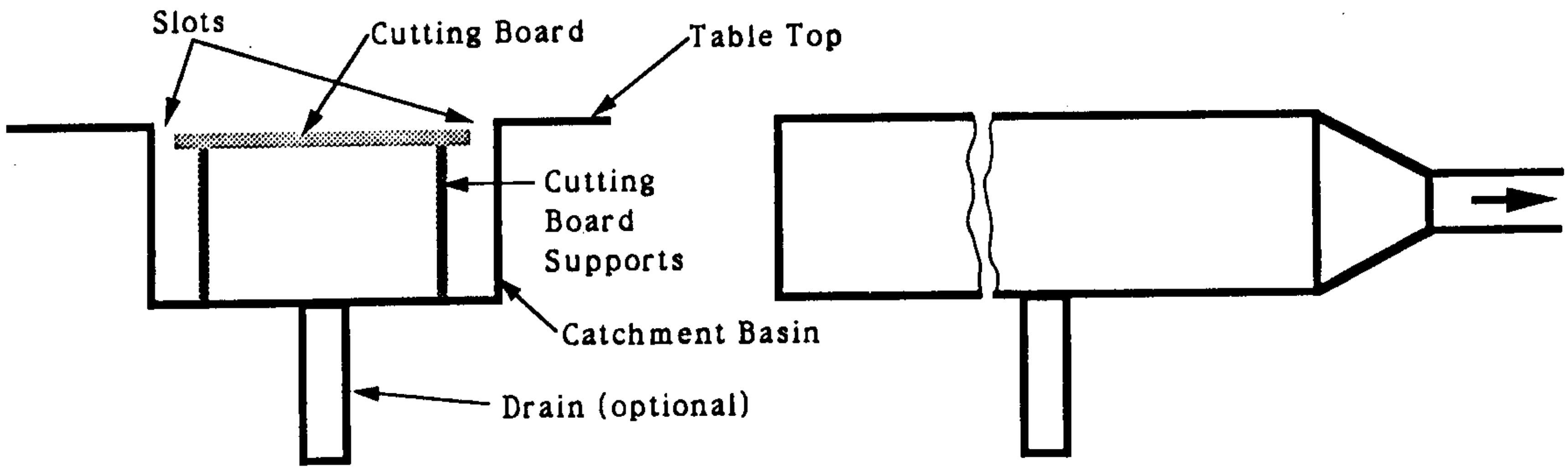

Figure 4. Dissecting Board Hood
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