PREFACE

The Hazard Evaluation 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. 660(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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

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

TABLE OF CONTENTS

HETA 94-0237
AUGUST 1994
H.E. McCRACKEN MIDDLE SCHOOL
HILTON HEAD ISLAND,
SOUTH CAROLINA

NIOSH Investigators:
Elizabeth A. Jennison, MD, MPH
Joseph E. Burkhart, CIH

SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) at the H.E. McCracken Middle School, Hilton Head Island, South Carolina, in response to a request from the Assistant Superintendent for Operations of the Beaufort County School District. This request was made because of concerns regarding the adequacy of the ventilation system, mold and mildew problems, and health symptoms employees were experiencing at the school. Two NIOSH industrial hygienists and a physician conducted an indoor environmental quality assessment at the school on May 9-10, 1994.

Teachers in the school were concerned about the adequacy of the ventilation in their work areas and about symptoms they were experiencing at work. In addition, parents of children who attend McCracken felt that their children were experiencing health problems related to the school. A questionnaire survey of school staff showed that many participants had experienced symptoms, which included fatigue, nasal congestion, headache, tension or nervousness, and back, neck, or shoulder discomfort while in the building. A substantial proportion of the symptomatic employees reported that their symptoms tended to resolve when they were away from the building. Among participants, 63% reported having experienced one or more such "building-related" symptoms during the 4 weeks preceding the administration of the questionnaire. The most common environmental complaint was that of high humidity, with 79% of respondents indicating that this had been a problem in the 4 weeks prior to the survey. Too little air movement was a frequent complaint and was reported by 74% of survey respondents. Temperature control was also a problem, with 53% of employees reporting being too hot and 18% reporting being too cold at work at some time during the 4 weeks preceding the survey.

During the morning measurement period, carbon dioxide (CO_2) concentrations ranged from 700 - 2,850 parts per million (ppm), and averaged 1,639 ppm. Afternoon concentrations ranged from 825 - 3,300 ppm, and averaged 1,948 ppm. Temperature measurements within the school recorded during the morning ranged from 73.1 - 79.2^{o}F, and averaged 75.6^{o}F. Afternoon measurements ranged from 73.6 - 76.5^{o}F, and averaged 74.9^{o}F. Relative humidity levels recorded within the school during the morning ranged from 52.8 - 71.6%, and averaged 62.3%. Afternoon measurements ranged from 58.1 - 74.4%, and averaged 65.8%. Overall, the majority of CO_2 measurements exceeded the 1,000 ppm level recommended by the American Society for Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE). Relative humidity levels also exceeded the 60% upper limit recommended by ASHRAE.

Based on the results of this investigation, the NIOSH investigators have concluded that during the time of this evaluation, a health hazard did not exist at H.E. McCracken Middle School. Carbon dioxide measurements used to assess the capabilities of the air handling systems suggest insufficient outside air is provided to occupied spaces that would affect occupant comfort. The principal recommendation made to address the indoor environmental quality issues at this school include modifying the ventilation system to provide sufficient outside air to the occupied spaces.

Keywords: SIC 8211 (Elementary and Secondary Schools): indoor environmental quality (IEQ), indoor air quality (IAQ), ventilation, carbon dioxide, relative humidity, temperature, biocides, microbiological.

INTRODUCTION

On April 21, 1994, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation (HHE) at the H.E. McCracken Middle School, Hilton Head Island, South Carolina. This request was made by the Assistant Superintendent for Operations of the Beaufort County School District because of concerns regarding the adequacy of the ventilation system, mold and mildew problems, and health symptoms employees were experiencing at the school.

On May 9-10, 1994, two industrial hygienists and a physician from NIOSH conducted a site-visit and indoor environmental quality (IEQ) evaluation at the H.E. McCracken Middle School. This report presents the findings of that investigation and provides recommendations for improving the IEQ at the school.

BACKGROUND AND DESCRIPTIVE INFORMATION

The H.E. McCracken Middle School was opened in the fall of 1991, and serves grades 6-8. During this investigation, there were approximately 1100 students, faculty, and support staff assigned to the school.

Construction materials of the approximately 131,000 square foot, single-story facility consist of exterior brick and cinder block perimeter walls. The roof is flat and is covered with a build-up of insulation, tar, and gravel. Interior walls are constructed of both cinder block and drywall. A suspended drop ceiling of fiberglass/mineral wool tiles is consistent throughout the facility. Carpeting is utilized throughout the facility, except in areas such as the dining area, gymnasium, and restrooms.

Figure 1 shows the typical floor plan for the school. Classrooms are grouped around a small room called the teachers' working room. Each classroom has its own heating, ventilating, and air-conditioning (HVAC) system which utilizes a heat pump to provide tempered air. These HVAC systems, for any particular classroom group, are located in a mechanical room in the teachers' working office.

Outside air is supplied to each HVAC system from roof mounted inlets. These roof inlets are connected to the HVAC system by a 10" flexible duct. The duct attaches to the return air side of the HVAC system. Outside air mixes with the return air from the classroom, passes through the filters, cooling/heating coils, and is then directed back to the classroom through a 21"x 9" supply duct. The sheet metal duct for both the return and supply air are lined with a fiberglass material for noise control. Supply air is typically discharged into a classroom through a single 21"x21" diffuser. A single 2'x2' vent is used to return air from the classroom back to the HVAC system.

The condensation from the HVAC system is drained to an open floor drain. This drain and the sink drain in the teachers' working room are connected together for discharge, and are vented through a single 4" pipe extending to the roof.

EVALUATION METHODS

Medical Evaluation

On May 10, 1994, the NIOSH Indoor Air Quality and Work Environment Symptoms Survey was distributed to all 90 individuals, including teachers and support personnel, employed at H.E. McCracken Middle School. The questionnaire asked if the employee had experienced, while at work on the day of the survey, any of the symptoms (irritation, nasal congestion, headaches, etc.) commonly reported by occupants of "problem buildings." The questionnaire also asked about the frequency of occurrence of these symptoms while at work in the building during the 4 weeks preceding the survey, and whether these symptoms tended to get worse, stay the same, or get better when they were away from work. The final section of the questionnaire asked about environmental comfort (too hot, too cold, unusual odors, etc.) experienced while the employees were working in the building during the 4 weeks prior to completing the questionnaire.

In addition, interviews were conducted with 19 (25%) of the 76 active teachers at H.E. McCracken Middle School. These interviews focused on observations the teachers had made over the past year regarding their students. Teachers were asked to estimate how many days in the last month, and in the last year, a child in their class had to leave school during the day because of illness, whether more than one child had ever had to leave in a given day, and the maximum number of children that had to leave early in a given day. Teachers were also asked to indicate whether classroom attendance in the past year had been higher, lower, or about the same, and whether student behavior had been better, worse, or about the same as that in other years that they had taught the same grade.

Environmental Evaluation

During the environmental evaluation, information was collected using standardized checklists and inspection forms. Descriptive information for the building (age, size, construction, location, etc.), the area to be evaluated (size, type of office space, cleaning policies, furnishings, pollutant sources, etc.), and the HVAC systems (type, specifications, maintenance schedules, etc.) were included.

In addition to collecting the standardized information described above, indicators of occupant comfort were measured. These indicators were carbon dioxide (CO_2) concentration, temperature (T), and relative humidity (RH). Chemical smoke was used

to visualize airflow in the evaluated area and to determine potential pollutant pathways to this area.

Real-time CO_2 concentrations were measured using a CEA Instruments Corporation, Model RI411A, portable CO_2 indicator. This portable, battery-operated instrument uses a non-dispersive infrared absorption detector to measure CO_2 in the range of 0-4975 parts per million (ppm), with a sensitivity of ±25 ppm. Instrument zeroing and calibration were performed prior to use with zero air and a known concentration of CO_2 span gas (1000 ppm).

Real-time temperature and humidity measurements were made using a Vaisala, Model HM 34, battery-operated meter. This meter is capable of providing direct readings for dry-bulb temperature and RH, ranging from -4 to 140 ^{o}F and 0 to 100% respectively.

The locations sampled during this investigation are also shown on Figure 1.
To evaluate the entire school, instead of focusing on only a few areas or classrooms, sampling sites were randomly selected before the start of the field investigation.

EVALUATION CRITERIA

Indoor environmental quality (IEQ) is affected by the interaction of a complex set of factors which are constantly changing. Four elements involved in the development of IEQ problems are:

- sources of odors or contaminants,
- problems with the design or operation of the HVAC system,
- pathways between contaminant sources and the location of complaints,
- and the activities of building occupants.

A basic understanding of these factors is critical to preventing, investigating, and resolving IEQ problems.

The symptoms and health complaints reported to NIOSH by non-industrial building occupants have been diverse and usually not suggestive of any particular medical diagnosis or readily associated with a causative agent. A typical spectrum of symptoms has included headaches, unusual fatigue, varying degrees of itching or burning eyes, irritations of the skin, nasal congestion, dry or irritated throats, and other respiratory irritations. Usually, the workplace environment has been implicated because workers report that their symptoms lessen or resolve when they leave the building.

A number of published studies have reported high prevalence of symptoms among occupants of office buildings.[1-5] Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are imprecisely defined characteristics of HVAC systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[8-13] Indoor environmental pollutants can arise from either outdoor sources or indoor sources.

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related than any measured indoor contaminant or condition to the occurrence of symptoms.[14-16] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[16-19]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potential building-related illnesses are allergic rhinitis, allergic asthma, hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, carbon monoxide poisoning, and reaction to boiler corrosion inhibitors. The first three conditions can be caused by various microorganisms or other organic material. Legionnaires' disease and Pontiac fever are caused by Legionella bacteria. Sources of carbon monoxide include vehicle exhaust and inadequately ventilated kerosene heaters or other fuel-burning appliances. Exposure to boiler additives can occur if boiler steam is used for humidification or is released by accident.

Problems NIOSH investigators have found in the non-industrial indoor environment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from furnishings, machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and RH conditions, poor lighting, and unacceptable noise levels; adverse ergonomic conditions; and job-related psychosocial stressors. In most cases, however, these problems could not be directly linked to the reported health effects.

Standards specifically for the non-industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[20-22] With few exceptions, pollutant concentrations observed in non-industrial indoor environments fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[23,24] The ACGIH has also developed a manual of guidelines for approaching

investigations of building-related complaints that might be caused by airborne living organisms or their effluents.[25]

Measurement of indoor environmental contaminants has rarely been helpful in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proven relationship between contaminants and specific building-related illnesses. The low-level concentrations of particles and mixtures of organic materials usually found are difficult to interpret and usually impossible to causally link to observed and reported health symptoms. However, measuring ventilation and comfort indicators such as CO_2, temperature, and RH, have proven useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems. The basis for measurements made during this evaluation are listed below.

Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath and, if monitored, may be useful as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space. ASHRAE's most recently published ventilation standard, ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 15 cubic feet per minute per person (cfm/person) for school classrooms. Maintaining the recommended ASHRAE outdoor air supply rates when the outdoor air is of good quality, and there are no significant indoor emission sources, should provide for acceptable indoor air quality.[23]

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 ppm). When indoor CO_2 concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased. It is important to note that CO_2 is not an effective indicator of ventilation adequacy if the ventilated area is not occupied at its usual level.

Temperature and Relative Humidity

Temperature and RH measurements are often collected as part of an IEQ investigation because these parameters affect perception of comfort in an indoor environment. The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. The American National Standards Institute (ANSI)/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[24] Assuming slow air movement and 50% RH, the operative temperatures recommended by ASHRAE range from 68→74°F in the winter, and from 73→79°F in the summer. The difference between the two is largely due to seasonal clothing selection. In separate documents, ASHRAE also recommends that RH be maintained between 30 and 60% RH. Excessive humidities can support growth of microorganisms, some of which may be pathogenic or allergenic.

MEDICAL RESULTS

Questionnaires were distributed in the mailboxes of all 90 individuals employed at H.E. McCracken Middle School. Thirty-eight questionnaires were returned for a response rate of 42%. There were 6 male and 31 female respondents and 1 individual who did not report gender. The age range of respondents was 36-45 years. Six currently smoked cigarettes, 13 were former smokers, and 18 had never smoked. Respondents worked at the school an average of 38 hours per week (range 6-70).

The questionnaire results concerning reported symptoms at work are shown in Table I. The first column of Table I shows the percentage of the 38 respondents who reported the occurrence of symptoms while at work on the day of the survey. Unusual fatigue, nasal congestion, headache, tension or nervousness, and back, neck, or shoulder discomfort were each reported by more than 40% of respondents.

The second column shows the percentage of employees who reported experiencing the respective symptom once a week or more often while at work during the 4 weeks preceding the survey. In addition to the symptoms listed above, more than 40% of respondents reported dry, itching, or irritated eyes. The symptom patterns are similar to those for symptoms experienced on the day of the survey, generally with slightly higher prevalences.

The third column shows the percentage of employees who reported experiencing the respective symptom once a week or more often while at work during the 4 weeks preceding the survey and also reported that the symptom tended to get better when they were away from work. This latter criterion has, in some studies of indoor air

quality, been used to define a "building related" symptom, but it is possible that a symptom which does not usually improve when away from the building could also be due to conditions at work.

The reported "building-related" frequent symptom prevalences shown in column three, are consistently lower than the corresponding symptom prevalences over the last 4 weeks shown in the second column, and are highest for unusual fatigue and headache. Overall, 24 of 38 (63%) respondents reported having one or more symptoms that had occurred at work one or more days a week during the preceding 4 weeks and tended to get better when away from work.

Table II shows results of employee reports regarding environmental conditions at their work stations on the day of the survey and during the four weeks preceding the survey. Column one shows the results for the day of the survey. It shows that 50% of the respondents perceived that the ventilation system was not providing sufficient air movement and that 55% thought the air was too humid during at least part of their work day. Almost equal percentages of individuals thought it was too hot (29%) and too cold (21%) during at least part of their work day.

The second column shows the responses to the questions about environmental comfort conditions experienced in the facility during the 4 weeks preceding the survey. Adverse environmental conditions (too hot, too cold, odors, etc.) were considered "frequent" if they were reported to occur at work once a week or more often. The results are generally the same or somewhat higher than those shown in the first column for work station environmental conditions experienced during the day of the survey. Seventy-four percent of respondents perceived insufficient air movement and 79% reported that the building was frequently too humid. More than half (53%) were frequently too hot, 16% perceived frequent chemical odors in the workplace, and 34% frequently sensed other unpleasant odors.

Interviews were conducted with 19 teachers. Four of the teachers interviewed taught special classes or programs such as art, speech, or multimedia, and either did not have a full class or did not have a unique class assigned to them for the entire day. As these teachers did not have primary responsibility for attendance records, they were not asked to respond to questions relating to students being sent home during the course of the school day.

The 19 teachers who were interviewed had a mean of 15.1 years of teaching experience. Six taught sixth grade, seven taught seventh grade, and two taught eighth grade. One respondent taught each of the following: band, gifted students, art, and developmentally delayed students. Mean class size was 24.7 students. Teachers reported that students leaving school during the day because of illness averaged 7.7 days in the last month and 59.2 days in the entire school year. Seven teachers had more than one child leave in a given day because of illness, with a maximum of six

children from one class having left early. Fourteen teachers reported that classroom attendance was lower this year than in previous years that they had taught the same grade. Eighteen (95%) felt that student behavior this year was worse than in previous years that they had taught the same grade.

ENVIRONMENTAL RESULTS

HVAC Systems

Heating, ventilating, and air conditioning systems for typical classrooms (identified as 3/1 - 3/41 on blueprint specifications) are designed to provide 1,100 cubic feet per minute (cfm) total air flow, of which 75 cfm is outside air. Some larger classrooms (i.e., science labs, choral, art, and home economics) have larger capacity units. The design for the typical classroom system provides for approximately 8% outside air. For a class size of 25, this would correspond to 3 cfm per person, far below the 15 cfm of outside air per person currently recommended by ASHRAE.

Airflow from the HVACs to the classrooms was observed to be either "all" or "nothing." When the room thermostat reaches a preset temperature, the HVAC deactivates allowing no airflow to the room. On the other extreme, when the thermostat calls for cooling (or heat), the HVAC activates allowing maximum airflow into the room. We observed that the HVACs were in a deactive, more than an active mode. When the HVAC system is inactive, no outside air is supplied to the occupied space. The ASHRAE criteria are based on a continuous air supply per unit volume (cfm); not an intermittent air supply only when the system is activated.

During our investigation, several HVAC systems were inspected. The new filters were in relatively good condition, but the filter frames did not fit well which allowed for a significant amount of bypass. The internal components of the HVAC systems were relatively clean with no visible microbial contamination. The fiberglass liner inside the duct showed some evidence of dirt accumulation, which is expected, but not sufficient to warrant cleaning. Supply and return air diffusers in a number of classrooms showed evidence of dirt accumulation. This is common, and is typically a function of filter efficiency and activities within the occupied space.

Carbon Dioxide, Temperature, and Relative Humidity

Summary data CO_2, temperature, and RH measurements are presented in Table III. It is important to stress that measurements were made to determine the effectiveness of the ventilation systems for providing outside air and not to determine whether exposure concentrations in individual classrooms were hazardous or not. Carbon dioxide is used as a surrogate measure in determining the effectiveness of the ventilation system.

Measurements were made during both the morning and afternoon in randomly selected classrooms within the school. During the morning measurement period, CO_2 concentrations ranged from 700 - 2,850 ppm, and averaged 1,639 ppm. Afternoon concentrations ranged from 825 - 3,300 ppm, and averaged 1,948 ppm.

The highest morning CO_2 concentrations were measured in the 600 numbered classrooms. CO_2 concentrations in those rooms ranged from 1,300 - 2,850 ppm, with the highest level measured in room 615. Afternoon measurements in those same classrooms ranged from 825 - 1,400 ppm. The highest afternoon CO_2 concentrations were measured in the 700 numbered classrooms. CO_2 concentrations in those rooms ranged from 2,250 - 3,300 ppm, with the highest level measured in room 703. The outside CO_2 was measured at 575 ppm during the morning and 500 ppm during the afternoon.

Temperature measurements within the school recorded during the morning ranged from 73.1 - 79.2^{o}F, and averaged 75.6^{o}F. Afternoon measurements ranged from 73.6 - 76.5^{o}F, and averaged 74.9^{o}F. Outside temperatures were 68.8^{o}F during the morning, and 77^{o}F during the afternoon. Relative humidity levels recorded within the school during the morning ranged from 52.8 - 71.6%, and averaged 62.3%. Afternoon measurements ranged from 58.1 - 74.4%, and averaged 65.8%. Outside RH levels were 86.8% in the morning, and 71% in the afternoon.

Overall, most of the CO_2 measurements exceeded the 1,000 ppm level recommended by ASHRAE. Relative humidity levels also exceeded the 60% upper limit recommended by ASHRAE. ***Carbon dioxide concentrations in this range do not represent a health hazard.*** However, they do suggest that the air concentrations of other contaminants normally present in environments may also be elevated, and in combination, may be contributing to health complaints such as headaches, fatigue, and eye and throat irritation. This data also suggests that the HVAC systems at H.E. McCracken Middle School are not adequately providing sufficient outside air to the occupied spaces.

Mold and Mildew Problems

Mold and mildew problems identified in the HHE request at H.E. McCracken Middle School may be the result of high ambient RH levels, with little RH control within the school. Typically the air conditioning system assists in controlling RH levels. Since the HVACs at this school are temperature controlled, once the room conditions satisfy the temperature sensor, the HVAC shuts off and no conditioned air is introduced into the room. Also, during night setback the HVACs would only be activated if room temperatures reach 85° F.

Previous air and swab bioaerosol sampling documented the presence of various microorganisms within the school. Based on those results and a number of complaints from parents and staff, a mold and mildew remediation program was instituted at this school (and others in Beaufort County). This remediation program may have resulted in additional indoor air quality problems at these schools by introducing cleaning chemicals into the indoor environment. Anytime a chemical product is introduced into the indoor environment, either during occupied or unoccupied hours, residuals may remain in the facility. This can be a problem when an inadequate HVAC system fails to dilute or remove the chemical from the environment. Some individuals may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or hypersensitivity (allergy). A chemical product may be used to solve one problem, but may unintentionally create another.

Other Observations

Overall, the school appeared in relatively good physical condition, and the evaluated areas were generally clean and sufficiently well lit. Carpeting throughout the school appeared stained (possibly from previous steam cleaning or antimicrobial treatments). During this evaluation, a number of classrooms were observed with open windows, small room dehumidifiers operating, air cleaners operating, HVAC and heat pump systems working. When questioned, a few individuals responded that it was necessary to operate these systems because of the CO_2 and mold contamination within the school.

During our investigation, a strong sewer odor was noticed in some of the science labs. We observed that many of the P-traps for the lab sinks were dry. The purpose of the P-trap is to hold water which prevents sewer gas from backing up into the occupied space.

The HVAC condensation drain and the sink drain in the teachers' working room are connected together for discharge. These drains are vented through a single 4" pipe extending to the roof. These vent pipes are located adjacent to, and in most cases, are lower than the outside air intakes for the HVAC systems.

DISCUSSION AND RECOMMENDATIONS

As we have already stated during our closing meeting, we feel that the mold and mildew problems are a symptom of the poor HVAC systems, and not the sole cause of the IEQ problems at H.E. McCracken Middle School.

Documentation of the remediation efforts which was provided to us revealed broad application of biocides to the carpeting and furniture at this and other schools. One biocide, Sporicidin®, has been liberally used on carpeting to control mold growth (although we were told it has not been used at H.E. McCracken Middle School). The ingredients in the Sporicidin® Brand Disinfectant Solution used, according to manufacturers' information, are 1.56% phenol, 0.06% sodium phenate, and 98.38% inert ingredients.

Phenolics were among the first disinfectants used in hospitals. Certain detergent disinfectants belong to the phenol group, including phenol, para-tertiary butyl-phenol (ptBP), and para-tertiary amylphenol (ptAP). They are generally used for a wide range of bacteria, but they are not effective against spores. Phenolics are widely used on floors, walls, furnishings, glassware, and instruments. Phenol's odor may be detected at a concentration of about 0.05 ppm.[26]

Phenol is an irritant of the eyes, mucous membranes, and skin; systemic effects from overexposure can include convulsions as well as liver and kidney damage. Phenol does not frequently constitute a serious respiratory hazard in industry, in large part because of its low volatility. The skin is a primary route of entry for the vapor, liquid, and solid. The vapor readily penetrates the skin with an absorption efficiency equal to that for inhalation. Skin absorption can occur at low vapor concentrations, apparently without discomfort.[27]

The product label for the Sporicidin® Brand Disinfectant Solution states it is to be used only on "hard non-porous equipment and surfaces." Carpeting is considered a porous surface, and therefore the product would not be recommended for use in that manner to control mold and mildew. A distributor's flyer states that the Sporicidin® Brand Disinfectant Solution is an "excellent disinfectant for HVAC & DUCTED AIR (fibrous or metal) SYSTEMS."

In December 1993, the U.S. Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide, and Rodenticide Act, accepted Sporicidin® International's claim and amended product label to include duct cleaning. The part of that label which addresses duct cleaning states, "Manually apply to hard non-porous pre-cleaned duct surfaces. Rinse surfaces after cleaning." This EPA registered claim does not include porous surfaces, including fibrous duct linings.

The distributor's information for Sporicidin® Brand Disinfectant Solution states that the product has an "effective continuous bacteriostatic and fungistatic residual activity for over 6 months." According to the manufacturer's claim to EPA, the product is an active deodorizer providing residual bacteriostatic activity against odor-causing organisms. At present, EPA accepts claims and therefore registers antimicrobials for use only as sanitizers, not disinfectants or sterilizers in HVAC systems. Materials such as deodorizers that temporarily eliminate odors caused by microorganisms provide only a fresh smell, and are not intended to provide control of microbiological contaminants.

We have reviewed the results of all the bioaerosol sampling others have conducted at this and other Beaufort County schools. It is our opinion that the levels measured in the schools should not have warranted such extreme remediation efforts. Currently, there are no accepted scientific guidelines for interpreting results of bioaerosol sampling. In addition, the various problems associated with sampling make the results unreliable for establishing remediation efforts. Microorganisms (including fungi and bacteria) are normal inhabitants of the environment. In the outdoor environment, the levels of microbial aerosols will vary according to the geographic location, climatic conditions, and surrounding activity. In a "normal" indoor environment, the level of microorganisms may vary somewhat as a function of the cleanliness of the HVAC system and the numbers and activity level of the occupants. Generally, the indoor levels are expected to be below the outdoor levels (depending on HVAC system filter efficiency) with consistently similar ranking among the microbial species. The levels measured at these school are very low compared to other facilities in which NIOSH and others have conducted controlled, long-term sampling efforts. Without medical or epidemiological data indicating of a plausible relationship between adverse health effects and air concentrations of microbiological agents, the interpretation of air sampling and analytical data becomes very difficult.

Reports of building related health complaints have become increasingly common in recent years; unfortunately the causes of these symptoms have not been clearly identified. As discussed in the criteria section of this report, many factors are suspected (e.g., volatile organic compounds, formaldehyde, microbial proliferation within buildings, inadequate amounts of outside air, etc.). While it has been difficult to identify concentrations of specific contaminants that are associated with the occurrence of symptoms, it is felt by many researchers in the field that the occurrence of symptoms among building occupants can be lessened by providing a properly maintained interior environment. Adequate control of the temperature is a particularly important aspect of employee comfort.

Although there were no clear environmental causes for the symptoms reported by employees, the NIOSH evaluation identified some deficiencies at the H.E. McCracken Middle School. Based on the results and observations of this evaluation, the following recommendations are offered to correct those deficiencies and optimize employee comfort.

1. The HVAC systems should be inspected by a mechanical engineering firm to determine the amount of outside air currently being provided as well as assessing the capabilities and limitations of the existing system to provide additional outside air on a continuous, not intermittent, basis. Each individual heat pump should be adjusted to provide a minimum of 15 cfm of outside air per person. At no time should the systems be deactivated during occupied hours.

2. The practice of allowing windows to be opened and fans used to draw conditioned air to the outside should be discontinued, and should not be necessary once the HVAC systems are operated as outlined above. Open windows can increase the RH within the room and increases the likelihood of condensation. This may increase mold and mildew problems. It is doubtful that the small room dehumidifiers will be necessary once the HVAC systems are operating properly. These dehumidifiers are very difficult to clean and are a potential source of microbiological contamination.

3. Air bypass around the heat pump filters needs to be corrected. The use of the pleated medium efficiency filters is acceptable, however, it is not necessary to use filters treated with activated charcoal or a biocide.

4. We have been informed that plans are in the process to install a central dehumidification system for the school. Until that time, windows should remain closed and the HVAC mechanical systems operated during non-occupied time periods to control the RH levels within the facility. One other alternative to running the system continually during non-occupied periods would be to install a control system that monitors both RH and T, and activates the system when either one of those levels reach a pre-defined set-point. It is generally preferable to keep RHs above 20-30% during heating season and below 60% during the cooling season.

5. The sewer vent pipes adjacent to HVAC air intakes should be raised in order to reduce the possibility that offensive odors may be introduced into the school. This could be simply accomplished by adding a 4' PCV pipe to the vent stacks.

6. The carpeting within this facility has been subjected to repeated moisture infusion from steam cleaning and chemical treatments intended to control mold and mildew growth. As a result, the carpeting acts like a sponge to absorb and hold these fluids and odors. Therefore, the carpeting should be removed from the facility. Hard-surface flooring which can be cleaned and dried more easily may be considered as an alternative to carpeting.

7. Discontinue the use of Sporicidin® and other biocides on carpeting and all other porous surfaces. Biocides, by definition, kill living cells. They are considered poisons by the EPA. Biocides should be used with extreme caution only for labelled

purposes, and only when other measures are not sufficient to control microbial contamination.

8. We do not concur with recommendations that the HVAC ducts be cleaned and sealed with a biocide to control mold and mildew problems. No application techniques have been demonstrated to provide a complete and long-term barrier to microbiological growth, nor have such materials been evaluated for their potential health effects on occupants when used in this way.

9. The P-traps in the sinks through the school should be checked periodically to ensure proper operation. If the sinks are not used, the water in the P-traps may dry out allowing sewer odors to enter the occupied space.

REFERENCES

1. Kreiss KK, Hodgson MJ [1984]. Building associated epidemics. In: Walsh PJ, Dudney CS, Copenhaver ED, eds. Indoor air quality. Boca Raton, FL: CRC Press, pp 87-108.

2. Gammage RR, Kaye SV, eds. [1985]. Indoor air and human health: Proceedings of the Seventh Life Sciences Symposium. Chelsea, MI: Lewis Publishers, Inc.

3. Woods JE, Drewry GM, Morey PR [1987]. Office worker perceptions of indoor air quality effects on discomfort and performance. In: Seifert B, Esdorn H, Fischer M, et al, eds. Indoor air '87, Proceedings of the 4th International Conference on Indoor Air Quality and Climate. Berlin Institute for Water, Soil and Air Hygiene.

4. Skov P, Valbjorn O [1987]. Danish indoor climate study group. The "sick" building syndrome in the office environment: the Danish town hall study. Environ Int 13:399-349.

5. Burge S, Hedge A, Wilson S, Bass JH, Robertson A [1987]. Sick building syndrome: a study of 4373 office workers. Ann Occup Hyg 31:493-504.

6. Kreiss K [1989]. The epidemiology of building-related complaints and illness. Occupational Medicine: State of the Art Reviews 4(4):575-592.

7. Norbäck D, Michel I, Widstrom J [1990]. Indoor air quality and personal factors related to the sick building syndrome. Scan J Work Environ Health 16:121-128.

8. Morey PR, Shattuck DE [1989]. Role of ventilation in the causation of building-associated illnesses. Occupational Medicine: State of the Art Reviews 4(4):625-642.

9. Mendell MJ, Smith AH [1990]. Consistent pattern of elevated symptoms in air-conditioned office buildings: a reanalysis of epidemiologic studies. Am J Public Health 80(10):1193-1199.

10. Molhave L, Bach B, Pedersen OF [1986]. Human reactions during controlled exposures to low concentrations of organic gases and vapours known as normal indoor air pollutants. Environ Int 12:167-175.

11. Fanger PO [1989]. The new comfort equation for indoor air quality. ASHRAE J 31(10):33-38.

12. Burge HA [1989]. Indoor air and infectious disease. Occupational Medicine: State of the Art Reviews 4(4):713-722.

13. Robertson AS, McInnes M, Glass D, Dalton G, Burge PS [1989]. Building sickness, are symptoms related to the office lighting? Ann Occup Hyg 33(1):47-59.

14. Wallace LA, Nelson CJ, Dunteman G [1991]. Workplace characteristics associated with health and comfort concerns in three office buildings in Washington, D.C. In: Geshwiler M, Montgomery L, and Moran M, eds. Healthy buildings. Proceedings of the ASHRAE/ICBRSD conference IAQ'91. Atlanta, GA. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

15. Haghighat F, Donnini G, D'Addario R [1992]. Relationship between occupant discomfort as perceived and as measured objectively. Indoor Environ 1:112-118.

16. NIOSH [1991]. Hazard evaluation and technical assistance report: Library of Congress Madison Building, Washington, D.C. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HETA 88-364-2104 - Vol. III.

17. Skov P, Valbjørn O, Pedersen BV [1989]. Influence of personal characteristics, job-related factors, and psychosocial factors on the sick building syndrome. Scand J Work Environ Health 15:286-295.

18. Boxer PA [1990]. Indoor air quality: a psychosocial perspective. J Occup Med 32(5):425-428.

19. Baker DB [1989]. Social and organizational factors in office building-associated illness. Occupational Medicine: State of the Art Reviews 4(4):607-624.

20. CDC [1992]. NIOSH recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

21. Code of Federal Regulations [1989]. OSHA Table Z-1-A. 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

22. ACGIH [1991]. 1991-1992 Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

23. ASHRAE [1990]. Ventilation for acceptable indoor air quality. Atlanta, GA: American Society of Heating, Refrigerating, and Air-conditioning Engineers. ANSI/ASHRAE Standard 62-1989.

24. ASHRAE [1981]. Thermal environmental conditions for human occupancy. Atlanta, GA: American Society for Heating, Refrigerating, and Air-conditioning Engineers. ANSI/ASHRAE Standard 55-1981.

25. ACGIH [1989]. Guidelines for the assessment of bioaerosols in the indoor environment. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

26. NIOSH [1988]. Guidelines for protecting the safety and health of health care workers. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 88-119.

27. Proctor NH, Hughes JP, ed. [1991]. Chemical hazards of the workplace. 3rd ed. New York, NY: Van Nostrand Reinhold, p 468.

INVESTIGATORS AND ACKNOWLEDGEMENTS

NIOSH Investigators:

Joseph E. Burkhart, MS, CIH
Industrial Hygienist

Elizabeth A. Jennison, MD, MPH
Medical Officer

Originating Office:

Respiratory Disease Hazard Evaluation
and Technical Assistance Program
Division of Respiratory Disease Studies
Clinical Investigations Branch
1095 Willowdale Road
Morgantown, WV 26505

DISTRIBUTION AND AVAILABILITY

Copies of this report may be freely reproduced and are not copyrighted. Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications Office, 4676 Columbia Parkway, Cincinnati, Ohio 45226. To expedite your request, include a self-addressed mailing label or envelope along with your written request. After this time, copies may be purchased from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office in Cincinnati.

Copies of this report have been sent to:

Assistant Superintendent for Operations, Beaufort County Schools
Principal, H.E. McCracken Middle School
Vice Chair, School Improvement Council
Chair, IEQ Task Force
Teacher Representative, H.E. McCracken Middle School
Student Representative, H.E. McCracken Middle School
District Health Director, Low Country Health Department
Occupational Safety and Health Administration (OSHA), Region 4

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
H.E. McCRACKEN MIDDLE SCHOOL,
HILTON HEAD ISLAND, SOUTH CAROLINA
HETA 94-0237

Symptoms Experienced At Work

Symptoms of 38 Workers	Experienced on Days of Survey While at Work	Frequently Experienced Last 4 Weeks While at Work	Have Frequent Symptoms that Improve When Away from Work
Dry, itching, or irritated eyes	29%	45%	26%
Tired or strained eyes	26%	37%	21%
Stuffy nose, or sinus congestion	47%	50%	24%
Sneezing	11%	21%	5%
Sore or dry throat	32%	39%	21%
Dry or itchy skin	32%	24%	11%
Unusual fatigue or drowsiness	50%	66%	42%
Headache	42%	50%	34%
Tension, irritability or nervousness	45%	42%	24%
Difficulty with memory or concentration	21%	18%	13%
Nausea or upset stomach	11%	8%	5%
Feeling depressed	16%	24%	11%
Pain or stiffness in back, shoulders, or neck	45%	45%	21%
Dizziness or lightheadedness	26%	16%	8%
Cough	21%	34%	16%
Chest tightness	8%	21%	5%
Wheezing	11%	11%	5%
Shortness of breath	3%	11%	3%

Table II
H.E. McCRACKEN MIDDLE SCHOOL
HILTON HEAD ISLAND, SOUTH CAROLINA
HETA 94-0237

Description of Workplace Conditions

Conditions	Experienced at Work During Days of the Survey 38 Workers	Frequently Experienced While at Work During Previous 4 Weeks 38 Workers
Too much air movement	8%	5%
Too little air movement	50%	74%
Temperature too hot	29%	53%
Temperature too cold	21%	18%
Air too humid	55%	79%
Air too dry	5%	5%
Tobacco smoke odors	3%	3%
Chemical odors (e.g., paint, cleaning fluids, etc.)	13%	16%
Other unpleasant odors (e.g., body odor, food odor, perfume)	29%	34%

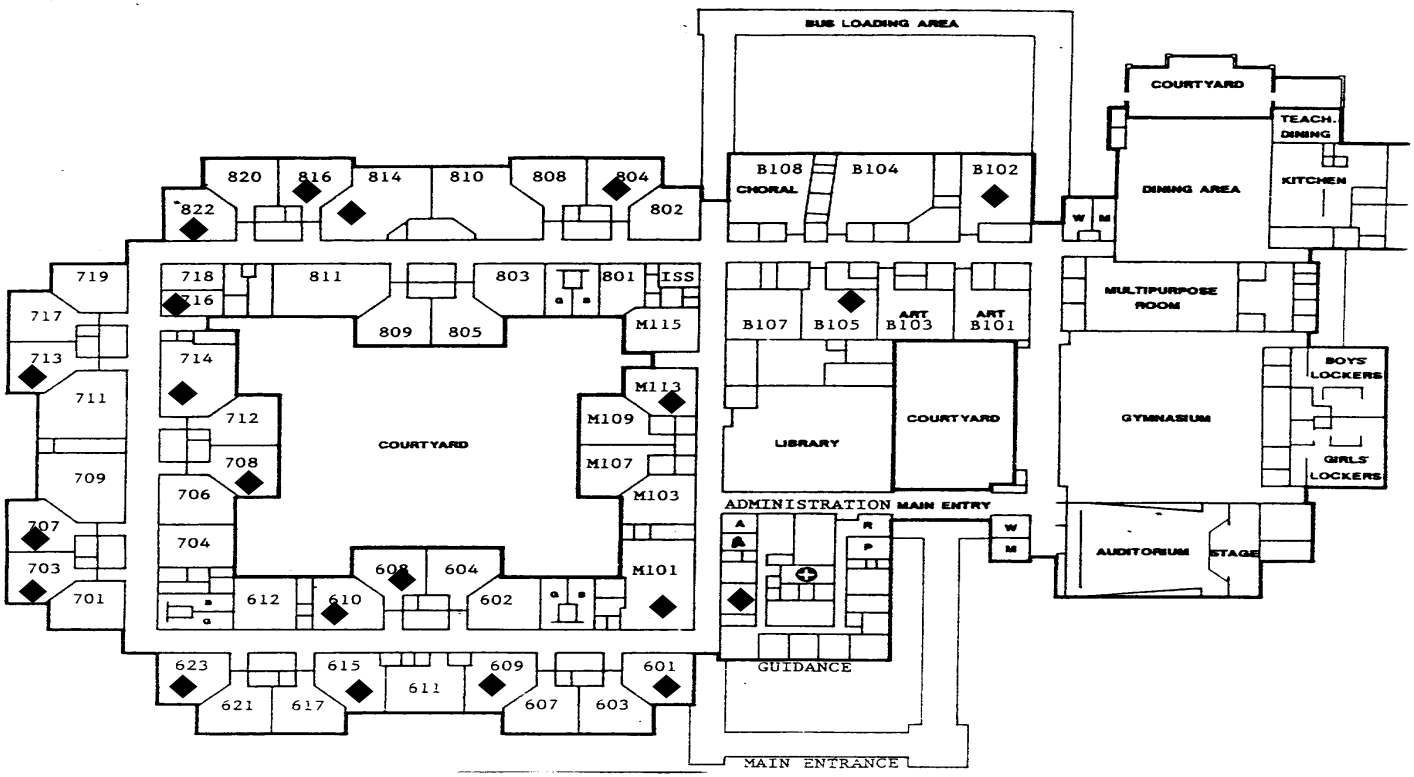
Table III
H.E. McCRACKEN MIDDLE SCHOOL
HILTON HEAD ISLAND, SOUTH CAROLINA
HETA 94-0237

Results of Carbon Dioxide, Temperature, and Relative Humidity Measurements

MORNING MEASUREMENTS (0730 - 1000 HRS.)					AFTERNOON MEASUREMENTS (1300 - 1420 HRS.)			
Room	**CO_2 (ppm)**	**Temp (°F)**	**%RH**	**No. People**	**CO_2 (ppm)**	**Temp (°F)**	**%RH**	**No. People**
M-101	1825	74.3	52.8	25	2300	74.8	61.8	5
M-102	1100	79.2	52.8	14	2000	75.2	60.1	40
B-102	1100	73.6	62.9	15	1950	75.1	59.5	19
B-105	1975	74.9	62.2	23	2800	76.5	58.1	22
M-113	1200	77	57.0	7	1325	74.4	64.3	2
601	1300	73.8	65.0	15	825	74.4	67.9	1
608	2500	75	65.1	19	1125	74.1	66.9	2
609	2400	76.1	66.4	18	1200	74.4	68.1	3
610	2700	77.6	62.6	26	825	76.1	61.4	4
615	2850	78.8	60.6	23	1325	74.2	70.9	1
623	2200	74.1	66.6	19	1400	73.9	69	0
703	900	73.1	64.7	30	3300	75.9	66.4	21
707	1500	76.1	60.2	14	2975	75.2	74.4	29
708	1500	75.7	66.5	25	2250	75.9	66.4	21
713	2300	75.6	56.6	25	2950	74.7	65.2	24
714	1750	76.2	61.5	20	2275	74.7	63.3	27
716	1250	76.6	60.1	4	1800	73.6	61.8	5
804	1750	78.3	63.0	16	2500	75.7	69.5	10
805	1050	73.9	66.0	2	2200	75.7	68.7	16
814	700	73.6	71.6	1	1475	75.2	67.1	22
816	725	74.2	65.8	2	1575	74.1	66.7	20
822	1475	78.1	59.9	14	2475	73.6	69.5	25
MEAN	**1639**	**75.6**	**62.3**	**15.7**	**1947.7**	**74.9**	**65.8**	**14.5**

Figure 1
H.E. McCRACKEN MIDDLE SCHOOL
HILTON HEAD ISLAND, SOUTH CAROLINA
HETA 94-0237

Floor Plan and Sampling Locations



◆ = SAMPLING LOCATIONS