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SOUTH JUNIOR HIGH SCHOOL
MORGANTOWN, WEST VIRGINIA

NIOSH INVESTIGATOR:
Steve Berardinelli, Jr.

I. SUMMARY

On May 27 and June 3, 1992, an indoor air quality evaluation was performed at South Junior High School, in Morgantown, West Virginia. The evaluation was requested by the Superintendent of Monongalia County Schools as a result of employee and parental concerns of indoor air quality. No health complaints were reported in the request. Environmental measurements for temperature, relative humidity, and carbon dioxide (CO_2) were collected. An indoor air quality questionnaire was distributed to all employees to characterize any building comfort and health complaints. An inspection and assessment of building conditions and the heating, ventilating, and air-conditioning (HVAC) system were also conducted.

Results from the self-administered questionnaire distributed during the survey indicated that the majority of the building's occupants had numerous complaints with the indoor air quality at South Junior High School. Occupant complaints appear to be related to thermal discomfort, unbalanced air flow, and a temperature control system which is not adequately responsive to the conditions within the classrooms.

Temperature and relative humidity were measured to evaluate thermal comfort. Some of the temperatures measured during the survey were not in accordance with the thermal comfort guidelines for summer, as published by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). All measurements of relative humidities were within the recommended range.

Carbon dioxide measurements were used as a surrogate measure of the dilution capabilities of the building's ventilation system. Measurements of CO_2 at the school ranged from 400 parts per million (ppm) to 1500 ppm and were indicative of a ventilation system that did not adequately supply the building with fresh air.

Although no health hazards were specifically identified, the questionnaire revealed that the majority of employees have experienced symptoms consistent with those commonly referred to as "sick building syndrome." An evaluation of the HVAC system identified a number of concerns. Increasing the outside air ventilation rates, relocating the outside boiler stack from the proximity of the fresh air intake, and balancing the ventilation system are among the recommendations provided in Section VIII of this report for relieving occupant complaints.

Keywords: SIC 8211 (Educational Facilities, Elementary and Secondary), indoor air quality, schools, carbon dioxide, relative humidity, ventilation

II. INTRODUCTION

In February 1992, the Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health (NIOSH) received a technical assistance request to investigate employee and parental concerns regarding the indoor air quality at South Junior High School in Morgantown, West Virginia. The request was submitted by the Superintendent of Monongalia County Schools. No health complaints were reported. The request was made to "determine the possible presence of airborne agents which may illicit allergic symptoms among students and faculty and to determine the overall quality of air in the facility."

A site visit was conducted by NIOSH representatives on May 6, 1992. An opening conference was held with the school principal and assistant principals, the chairperson of the faculty senate, the supervisor of environmental maintenance, and the HVAC manager. An overview of the NIOSH health hazard evaluation (HHE) program and a review of the issues which prompted the HHE request were discussed. After the meeting, a walk-through survey of the school was conducted.

On May 27 and June 3, 1992, area air samples were collected with direct-reading carbon dioxide meters and short-term detector tubes. Temperature and relative humidity measurements were also obtained. The HVAC system was inspected and an indoor air quality questionnaire was distributed to all employees.

III. BACKGROUND

South Junior High School is a public educational facility located in a suburban, residential area of Morgantown, West Virginia. There are approximately 900 students ranging from 7th to 9th grade, and 86 full-time employees at the facility. The majority of the full-time employees are teachers who work five 8-hour days per week, 9 months per year.

The school was completed and first occupied in the fall of 1980. A schematic diagram of the school is included in this report (see Figure 1a and 1b). South Junior High consists of 4 educational areas (A, B, C, and D) laid out in a rectangular configuration. Section A consists of the auditorium and stage; music classrooms, practice rooms and rehearsal area; and 2 other classrooms. Section B is an instructional area covering 2 floors and consists of 20 general classrooms, 4 science classrooms, and 4 teacher planning rooms. Section C consists of 3 art rooms, 2 classrooms, an industrial arts area, and a home economics area. Section D includes the school gymnasium and locker rooms.

South Junior High School is a smoke free building (as required by West Virginia State law). However, students have been caught by the staff smoking in the bathrooms on several occasions and teachers have complained of smoking odors in their classrooms.

IV. METHODS

Carbon dioxide, temperature, and relative humidity were measured in occupied classrooms during two different time periods on May 27, 1992, and June 3, 1992. The time periods were approximately: 9:00 to 11:00 am (before lunch period) and 1:30 to 2:30 pm (before the end of classes). Since these measurements were taken to evaluate the adequacy of the ventilation system, they were obtained when concentrations were expected to be maximum. Classrooms selected for the measurements were dispersed throughout the building. Attempts were made to make measurements in all of the selected classrooms at least once during the day.

A. Temperature and Relative Humidity Measurements.

Temperature and relative humidity measurements were collected using a Bacharach (model 12-7012) sling psychrometer. Dry and wet bulb temperature readings were monitored and the corresponding relative humidity was determined using the manufacturer-supplied curve.

B. Carbon Dioxide Measurements.

Carbon dioxide concentrations were measured using Dräger detector tubes (CH 30801) and two direct reading CO_2 instruments. Detector tubes were used to determine morning and afternoon carbon dioxide concentrations in occupied classrooms. These tubes have a relative standard deviation of ±10 to 15%.

A portable infrared CO_2 gas analyzer (Fuji Electric model ZFP5) equipped with a (Metrosonics dl-714) data logger and a portable CO_2 detection monitor (Gastech model 3252) equipped with an identical data logger were utilized to collect instantaneous data over the day in two classrooms (A2 and B23). These classrooms were selected since they were occupied during each class period. Instrument zeroing and calibration were performed prior to use with zero CO_2 concentration air and known CO_2 concentration span gases (495 and 1000 ppm).

A questionnaire was distributed to all school employees which included questions concerning length of employment at South Junior High School, smoking status, and symptoms associated with indoor environmental quality. A copy of the self-administered questionnaire distributed during the survey is included in this report.

A ventilation evaluation was conducted which included a visual inspection of the air handling unit (filters, coils, condensate pans, fans, and plenum interiors), supply ductwork, ceiling diffusers, thermostats, and return plenum areas. The percentage of outdoor air was estimated from the thermal mass balance equation using temperature readings obtained from the HVAC control panel.

Thermal Mass Balance Equation:

$$\text{Outdoor air (percent)} = \frac{T_{\text{return air}} - T_{\text{mixed air}}}{T_{\text{return air}} - T_{\text{outdoor air}}} \times 100$$

Where: T = air temperature (degrees Fahrenheit)

In addition, the building and HVAC system were visually inspected for indications of water leakage or mold growth.

V. EVALUATION CRITERIA

A high prevalence of adverse health symptoms have been reported among occupants working in buildings with poor indoor air quality.[1-5] Symptoms and health complaints reported by building occupants have been diverse and are not usually suggestive of a 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. Typically, the workplace environment has been implicated because workers report that their symptoms lessen or resolve when they leave the building.

Scientists investigating indoor air quality problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are: HVAC system deficiencies; 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] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts ($\geq$15 cubic feet per minute per person) are beneficial.[14-15] However, rates lower than these amounts appear to increase the rates of complaints and symptoms reported in some studies.[16,17] Design, maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutants can arise from either outdoor sources or indoor sources.[18]

Other reports describe results which suggest that occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than the measurement of any indoor contaminant or condition.[19-21] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[22-24]

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 reactions 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 the 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.

NIOSH investigators have completed over 600 investigations of the indoor air environment in a variety of settings since 1971.[25] Problems found by NIOSH investigators in non-industrial indoor environments have included: (1) poor air quality associated with ventilation system deficiencies; overcrowding; volatile organic chemicals from office furnishings, machines, structural components of the building and contents; tobacco smoke; microbiological contamination; and pollutants from outdoor air; (2) comfort problems due to improper temperature and relative humidity; (3) poor lighting; (4) unacceptable noise levels; (5) adverse ergonomic conditions; and (6) job-related psychosocial stressors. However, in most cases a causative agent for reported symptoms could not be determined.

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.[26-28] However, standards have not been specifically established for non-industrial indoor air environments. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[29,30] The ACGIH has also developed guidelines for approaching investigations of building-related complaints that might involve bioaerosols.[31]

In general, measurements of indoor contaminants have rarely proved to be helpful in determining the cause of symptoms and complaints except where there are strong or unusual sources, or an established causal relationship exists between a contaminant and a building-related illness. However, indirect evaluation of the ventilation in a building by measuring carbon dioxide concentrations and the measurement of comfort indicators such as temperature and relative humidity are useful in providing information relative to the proper functioning and control of HVAC systems. The basis for monitoring individual environmental parameters is presented below.

A. Temperature and Relative Humidity.

Temperature and relative humidity affect the perception of comfort in an indoor environment. The perception of thermal comfort is related to one's metabolic heat production, the transfer of heat in the environment, physiological adaptation, and body temperatures. Heat transfer between the body to the environment is influenced by factors such as air temperature, humidity, movement, the temperature and heat radiating properties of the body and surrounding surfaces, and the insulative properties of clothing. The American National Standards Institute (ANSI)/ASHRAE Standard 55-1981, Thermal Environmental Conditions for Human Occupancy, specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally acceptable.

The conditions for thermal comfort are found in the standard (Figure 2, ASHRAE Thermal Comfort Chart) and adapted into the table below.

Acceptable Ranges of Temperature and Relative Humidity During Winter and Summer

Relative Humidity (%)	Winter Temperature (°F)	Summer Temperature (°F)
30	68.5 - 76.0	74.0 - 80.0
40	68.5 - 75.5	73.5 - 79.5
50	68.5 - 74.5	73.0 - 79.0
60	68.0 - 74.0	72.5 - 78.0

Temperatures range from 68.0°F to 76.0°F in the winter and from 72.5°F to 80.0°F in the summer dependent on the relative humidity. The difference between winter and summer is largely due to seasonal clothing selection. In a separate document (ASHRAE Standard 62-1989), ASHRAE also recommends that relative humidity be maintained between 30% and 60%. Excessive humidity can support the growth of pathogenic and allergenic microorganisms.

B. Carbon Dioxide.

Carbon dioxide (CO_2) is a normal constituent of exhaled breath and can be used as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space. Carbon dioxide concentrations are normally higher indoors than the generally constant ambient (outdoor) carbon dioxide concentration which ranges from 300 to 350 parts per million (ppm). When carbon dioxide concentrations measured indoors exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected and widespread complaints can be anticipated. Carbon dioxide concentrations at this level do not represent a health hazard. However, elevated carbon dioxide levels suggest that other indoor contaminants may also be elevated and in combination may contribute to health complaints, such as, headaches, fatigue, and eye and throat irritation. Assuming that there are no significant uncontrolled point emission sources in the building, that the outside air being brought in via the HVAC system is of good quality, and that temperature and relative humidity are at comfortable levels, then indoor air quality type complaints should be minimal if interior carbon dioxide concentrations are maintained below 600 ppm (please refer to the table below).

Relationship of Carbon Dioxide Levels to Occupant Complaints[32,33]

Carbon Dioxide (ppm)	Comments
< 600	Adequate outdoor air intake; complaints rare
600 - 800	Occasional complaints, particularly if the air temperature rises
800 - 1000	Complaints more prevalent
> 1000	Insufficient fresh air; widespread complaints

The ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, specifies that indoor carbon dioxide levels be less than 1000 ppm. This criterion is based on a correlation with odor perception and comfort that is far below the established industrial criteria and the levels at which adverse health effects would be expected. For educational institutions ASHRAE recommends outdoor air supply rates of 15 cubic feet per minute per person (cfm/person) in classrooms, music rooms, libraries, and auditoriums based on a specific number of occupants per 1000 ft^2 of occupied area. Laboratories and training shops should be supplied with 20 cfm/person. Locker rooms and corridors should be provided with 0.50 and 0.10 cfm per square foot of area, respectively. By ventilating the building with the proper amount of outdoor air, ASHRAE believes that CO_2 levels can be kept less than 1000 ppm and that other contaminants, except for unusual sources, will be kept at acceptable levels. This standard further specifies that the outdoor air meet applicable Environmental Protection Agency (EPA) standards for outdoor air. Applicable EPA standards for outdoor air and applicable standards by other organizations for indoor air for certain contaminants are listed in the ASHRAE 62-1989 Standard.

C. Bioaerosol Monitoring.

Issues regarding airborne biological contamination are difficult to address. Biological contamination is typically characterized as colony forming units (CFU) per cubic meter of air, or square inch of surface area. Unfortunately, this type of data is extremely difficult to interpret because of the large variety of methods used to collect, incubate, and cultivate the samples. One of the major problems is that there is not an established scientific data base concerning the "normal" range of microbial concentrations and species in indoor environments. A dose-response relationship in humans has not been established, and criteria for acceptable exposure levels is not available. Furthermore, microbes are ubiquitous in nature; samples collected outdoors may reveal substantial bioaerosol concentrations. Hence, NIOSH generally does not routinely recommend this type of sampling. However, visible microbial growth on interior building surfaces, for example, should serve as clear evidence that there is a potential biological problem and steps should be taken to correct conditions supporting such growth. It is not typically necessary, or helpful, to then try to quantify this contamination.

The guidelines published by the American Conference of Governmental

Industrial Hygienists' Committee on Bioaerosols share this interpretation. "One should use air sampling as a last resort...Air sampling rarely provides proof of inappropriate exposure to bioaerosols."

VI. RESULTS AND DISCUSSION

A. Building Evaluation.

South Junior High School is a large dual story structure with a flat roof. In 1991 the roof was replaced with rubberized membrane roofing to repair leaks. Stained ceiling tiles were observed and have not been replaced since the leaks were corrected. Some ceiling tiles were broken or missing in several locations. No visible microbial growth was observed in the building.

Floor coverings are tile at entrance locations and in the commons area with carpeting throughout the rest of the structure. In the past, the maintenance personnel used a turpentine solution to shampoo the carpets during routine cleaning since it effectively removed chewing gum. This cleaning solution also attacked the underlining carpet padding. The result is that the carpeting will not lie flat, is torn in numerous locations, and is held together with duct tape.

The walls are either painted cement block or metal partitions. The school was originally built with open instructional areas, having removable walls and partitions. Some doorways have been constructed altering the open plan design.

Several specialized-use areas are present at the school. The art classroom has a pottery kiln which is used several times a semester. A ceiling exhaust vent, similar to a household bathroom vent, is located in the room and is used when the kiln is fired. However, the vent is not located above the kiln, thus greatly reducing its effectiveness. Students in industrial arts complete several woodworking projects each semester. Wood dust is generated by table saws, drills, and sanders.

Fire protection equipment was inspected as part of the building evaluation. Several fire extinguishers were missing from their wall mounted cabinets. In the event of a fire, a building occupant might determine too late that the extinguisher was missing since the cabinets have an opaque door which must be opened to reach the extinguisher. Several fire exit signs and emergency lighting units were either not working or broken. A fire exit located in the gymnasium was observed to be chained and locked.

B. Heating, Ventilating, and Air-Conditioning System Evaluation.

The central HVAC system consisted of a single air handling unit (AHU) and was a variable air volume (VAV) system. The fresh air intake, located on the roof above the interior AHU, had louvered openings which were adjustable according to ambient temperature and relative humidity. The fresh air intake was located adjacent (within 3-4 feet) to the exhaust stack for the natural gas fired boiler. The school was heated with hot water (finned radiation) baseboards, hot water unit heaters, or hot water tubing within the VAV boxes, and cooled with central air-conditioning. Airflow was controlled by individual room thermostats which adjust dampeners within the VAV boxes. The HVAC system operates continuously for 23 hours a day, shutting down for one hour at midnight. Conditioned air was ducted via the VAV control boxes to supply diffusers (slot type satellite terminal units) located in the ceiling tiles. Return air slots are located in the light fixtures, with the area above the ceiling tiles serving as the return air plenum. Since the area above the ceiling tiles functions as the return air plenum, missing tiles degrades the HVAC system's efficiency.

The return air access area of the HVAC system was being utilized for storage. Large quantities of paper, boxes, and janitorial cleaning products are stored in this location.

The HVAC unit's condensate pan was in poor condition with a thick mineral precipitate covering the bottom. The plenum interiors and coils were free from debris and appeared in good condition.

Thermostats were last calibrated in June 1991 and are set to 65-70°F for heating and cooling. Several broken and vandalized thermostats were observed, specifically in the hallways of sections A and B.
Air filters are fiberglass with backup bag filters and presently are being replaced monthly. Prior to the NIOSH survey, air filters were replaced as needed (when dirty or full of material). During the spring and summer months filters are replaced more frequently due to dirt and dust from adjacent baseball fields.

C. Temperature and Relative Humidity.

The results of temperature and relative humidity measurements are presented in Table 1. The average classroom temperature remained constant throughout the day on May 27, 1992, at 78°F. Individual room temperatures ranged from 75°F to 88°F with an average relative humidity of 40%. Each room's temperature and relative humidity were plotted on the ASHRAE Comfort Chart. At 40% relative humidity ASHRAE recommends temperatures of 73.5°F to 79.5°F. Six measurements were outside the comfort zone due to high temperature levels.

On June 3, 1992 the average morning temperature was 75°F with 59% relative humidity and ranged from 73-79°F. All morning measurements were within the ASHRAE comfort zone. In the afternoon the average temperature was 78°F with 54% relative humidity and ranged from 76-81°F. The average afternoon temperature increased slightly from the morning. Two afternoon measurements fell slightly outside the ASHRAE comfort zone due to high temperatures.

D. Carbon Dioxide.

Carbon dioxide measurements taken by detector tubes in occupied classrooms were observed to range from 400-1500 ppm on May 27, 1992 (see Table 1). This was a cool spring day, the early morning temperature outside was 61°F and rose only 3 degrees throughout the day. It was estimated by thermal mass balance that the HVAC system brought in 0% fresh air at the start of the day but increased to nearly 100% by the end of school. This explains that fact the average carbon dioxide concentrations decreased from a morning level of 873 ppm to an afternoon level of 638 ppm.

June 3, 1992, was a warmer day and the HVAC system was in the air-conditioning mode, the early morning temperature outside was 56°F and the afternoon temperature rose to 77°F. On this day the HVAC system brought in a minimum of fresh air over the course of the day with an estimated range of 0 to 20% fresh air. Since a minimum of fresh air was introduced into the school this day and most of the conditioned air was recirculated, the carbon dioxide levels rose slightly over the course of the school day. The carbon dioxide levels (determined with detector tubes) ranged from 600-1500 ppm with average levels at 871 ppm in the morning and 964 ppm in the afternoon (see Table 1).

Direct reading CO_2 instruments recorded data over the school day in two classrooms (see Figures 2 and 3). Figure 2 displays the carbon dioxide levels in classroom A2, this is an interior room on the ground floor with no windows. The classroom door was shut during each class period. CO_2 levels rose sharply at the start of the day and peaked at about 1600 ppm during the largest class of the day.

After this class period, the number of occupants and CO_2 levels decreased to a minimum level at lunch when the room was unoccupied. As classes resumed after lunch, the CO_2 level rose sharply to above 1000 ppm until the end of school.

Figure 3 displays the carbon dioxide levels in classroom B23. This is an open space design room with no door and is located on the second floor. A large but brief homeroom period explains the first CO_2 peak of the day and the resultant decrease with the following small class period. Levels increased sharply to over 900 ppm with the next large class period and fell with the teachers planning period when the room was unoccupied. This trend was observed again with the next class period and the following lunch period, levels peaked to over 1100 ppm toward the end of the school and fell dramatically at the end of the day.

E. Indoor Air Quality Questionnaire.

Fifty-one of the 86 employees completed and returned questionnaires for a response rate of 59%. Respondents have worked at the school for periods ranging from 6 months to 12 years. Ninety percent of the respondents (46/51) have worked at the facility for 2 years or longer. Seven respondents (14%) were smokers and did not report smoking at school.

Ninety-eight percent of the respondents reported significant complaints related to their current work environment. The most frequently reported complaints included: lack of air circulation or stuffy feeling (86%), air too dry (63%), dust in the air (57%), temperature too cold (49%), and temperature too hot (41%). Only one employee who had worked at the school for over 5 years reported no complaints with the work environment.

All respondents indicated experiencing health complaints related to the work environment. The most frequently reported symptoms that employees believed to be associated with their work environment were sinus problems (75%), headache (65%), dry throat (61%), nasal congestion (57%), dry skin (55%), scratchy throat (51%), and burning/itching eyes (51%).

VII. CONCLUSIONS

The carbon dioxide measurements were used as an indication of the dilution capabilities of the school's ventilation system. Measurements for CO_2 exceeded ASHRAE recommendations for acceptable indoor air quality and were indicative of a ventilation system that did not adequately supply the building with fresh air.

Results from the questionnaire distributed during the survey indicated that many of the building's occupants have numerous complaints with the indoor air quality at South Junior High School. The majority have experienced symptoms consistent with those commonly associated with "sick building syndrome." Many of the occupant complaints appear to be related to an insufficient outside air supply rate, temperature extremes in some rooms (especially during the heating season), and a temperature control system which is not adequately responsive to the conditions within the classrooms.

Two potential causes of poor indoor air quality at the school include: (1) a boiler exhaust stack located in close proximity to the fresh air intake and (2) janitorial cleaning supplies stored in a HVAC return air access area. In both cases, it would be possible for contaminants to be drawn through the HVAC system and circulated throughout the building.

Temperatures and relative humidities were measured to determine if classroom occupants were thermally comfortable. Some of the temperatures measured during the survey were not in accordance with the thermal comfort guidelines for summer, as published by ASHRAE. All relative humidities were in the recommended range.

VIII. RECOMMENDATIONS

The following recommendations should be implemented to improve the indoor air quality in the school:

1. Raise the boiler exhaust stack further from the fresh air intake. The stack is too low in relation to the fresh air intake and combustion gas entrainment into the HVAC system could occur during the heating season.

2. Improve the storage practices for janitorial supplies. Currently, large quantities of housekeeping and maintenance products are stored in the return air access area of the HVAC. These products can emit chemicals or odors which will be distributed building wide in the event of a spill or leak in this location. Access to this area should be restricted to authorized individuals and should not be used for storage.

3. Rebalance and adjust the HVAC system to ensure that it is operating according to the ASHRAE recommended standards for outdoor air supply, indoor temperature, and relative humidity. All damaged and broken thermostats should be replaced. The designed air flows and temperatures should be verified by a mechanical firm. Changes in the system which affect the current design should be recorded as an addendum to the original HVAC documents. Personnel performing the testing and balancing should be certified by the National Environmental Balancing Bureau (NEBB) or other equivalent certifying organization. Once completed the mechanical firm should submit a certified report that the system has been tested, adjusted and balanced in accordance with the latest building industry standards.

4. Investigate relocating the thermostats that are not in representative locations of the spaces that they control. For example, thermostats for the classrooms on the second floor of B section are located too close to the hallway, since these are open space rooms with no doors the thermostats do not adequately gauge actual room conditions.

5. Missing or damaged ceiling tiles should be replaced. Stained ceiling tiles should also be replaced so that if future roof or boiler leaks develop, they can be located and corrected in a timely manner. Inspecting for leaks should become a routine maintenance procedure.

6. Local exhaust ventilation should be provided for the pottery kiln in the art classroom and for the wood working machinery in the industrial arts classroom. These specialized-use areas should be keep under negative pressure relative to the surrounding spaces and the air from these areas should not be recirculated to the rest of the structure.

7. The National Fire Protection Association (NFPA) Code 101, the Life Safety Code, should be followed to ensure the safety of building occupants. Fire exit signs should be illuminated at all times, broken emergency lighting should be replaced, missing fire extinguishers should be restored to their marked locations, and fire exits should never be chained and locked from the interior of the building.

8. One full-time person should be responsible for the mechanical systems in the school to ensure that the systems are adequately maintained. This person should be formally trained in the operation, hardware, and controls of the HVAC system. Access to system's control panel and individual thermostats should be restricted to authorized individuals.

9. Set up and maintain an information file on the building's HVAC system. This file should include, as a minimum, up-to-date mechanical and control system drawings, manufacturer's product literature on each component of the system, system operation parameters, written operating methods for the system, maintenance schedules and records, and records of changes to the system. Complaints and their disposition should also be kept in this file.

10. School personnel should continue to enforce the policy of no smoking on school grounds. Signs should be posted at the buildings entrances and in the bathrooms to help enforce this policy.

11. The carpeting on the second floor of B section has reached its end of service life and should be discarded. In the future, carpeting should not be cleaned with organic based solvents.

IX. REFERENCES

1. Kreiss KK, Hodgson MJ [1984]. Building associated epidemics. In: Walsh PJ, Dudney CS, Copenhaver ED, eds. Indoor air quality. Boca Ratan, 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 [1984]. Danish indoor climate study group. The "sick" building syndrome in the office environment: The Danish town hall study. Environ Int 13:349-399.

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(4A):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(2):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. Mendall 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, Bachn B, Pedersen OF [1986]. Human reactions to low concentrations of volatile organic compounds. Environ Int 12:167-176.

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. Nagda NI, Koontz MD, Albrecht RJ [1991]. Effects of ventilation rate in a health building. 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. Menzies R, et. al. [1991]. The effect of varying levels of outdoor

ventilation on symptoms of sick building syndrome. 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.

16. Jaakkola JJK, Heinonen OP, Seppänen O [1991]. Mechanical ventilation in office buildings and the sick building syndrome. An experimental and epidemiological study. Indoor Air 1(2):111-121.

17. Sundell J, Lindvall T, and Stenberg B [1991]. Influence of type of ventilation and outdoor airflow rate on the prevalence of SBS symptoms. 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.

18. Levin H [1989]. Building materials and indoor air quality. Occupational Medicine: State of the Art Reviews. 4(4):667-694.

19. 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.

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

21. 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.

22. 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(4):286-295.

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

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

25. EPA/CDC [1991]. Building Air Quality: A guide for building owners and facility managers. Washington DC: U.S. Environmental Protection Agency and U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

26. CDC [1988]. NIOSH recommendations for occupational safety and health standards 1988. Atlanta GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. MMWR 37 (suppl S-7).

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

28. 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.

29. ASHRAE [1989]. Ventilation for acceptable indoor air quality. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers. ASHRAE Standard 62-1989.

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

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

32. Bell SJ, Khati B [1983]. Indoor Air Quality in Office Buildings. Occup Health in Ontario 4:160-167.

33. Rajhans GS [1983]. Indoor Air Quality and CO_2 Levels. Occup Health in Ontario 4:160-167.

X. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared by: Steve Berardinelli, Jr.

Industrial Hygiene Assistance: Ella Rice, IH
Joseph E. Burkhart, CIH

Originating Office: Respiratory Disease Hazard Evaluations and Technical Assistance Program

Clinical Investigations Branch
Division of Respiratory Disease Studies
Morgantown, West Virginia

XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45526. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publication Office at the Cincinnati address. Copies of this report have been sent to:

1. Superintendent, Monongalia County Schools
2. South Junior High School

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

Table 1. Carbon Dioxide, Temperature, Relative Humidity, and Occupant Summary Data
South Junior High School
Morgantown, West Virginia
May 27, 1992 and June 3, 1992
HETA 92-138

May 27,1992 Summary Data	Carbon Dioxide (ppm)		Temperature (°F)		Relative Humidity (%)		Number of Occupants	
Time	A.M.	P.M	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Mean	873	638	78	78	NA	40	20	18
S.D.	303.6	281.5	1.8	3.3	NA	6.4	7.5	6.0
Range	600-1500	400-1500	75-81	75-88	NA	23-46	4-30	7-26
N	11	13	13	13	NA	13	11	11

Outdoor conditions on May 27,1992 were as follows:
Carbon Dioxide (ppm): A.M. 200 ppm; P.M. 200 ppm
Temperature (°F):A.M. 61°F; P.M. 64°F
Relative Humidity (%): A.M. 52%; P.M. 52%

June 3,1992 Summary Data	Carbon Dioxide (ppm)		Temperature (°F)		Relative Humidity (%)		Number of Occupants	
Time	A.M.	P.M	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Mean	871	964	75	78	59	54	22	21
S.D.	189.9	229.2	1.7	1.4	2.8	4.2	7.2	5.7
Range	600-1200	700-1500	73-79	76-81	54-63	44-60	9-28	9-27
N	13	11	15	12	15	12	14	11

Outdoor conditions on June 3, 1992 were as follows:
Carbon Dioxide (ppm): A.M. 200 ppm; P.M. 300 ppm
Temperature (°F): A.M. 56°F; P.M. 77°F
Relative Humidity (%): A.M. 100%; P.M. 52%

Note: A.M. Measurements were taken before lunch period
P.M. Measurements were taken before the end of school
NA= Not Available
S.D.= Standard Deviation
N= Number of Measurements