HAZARD EVALUATION AND TECHNICAL ASSISTANCE REPORT
HETA 92-309
RANDOLPH COUNTY SCHOOLS ADMINISTRATION BUILDING
ELKINS, WEST VIRGINIA
APRIL 1993

Respiratory Disease Hazard Evaluation and Technical Assistance Program
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CENTERS FOR DISEASE CONTROL AND PREVENTION

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Randolph County Schools
Administration Building
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I. SUMMARY

On August 3, 1992, industrial hygienists from the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation (HHE) at the Randolph County Schools Administration Building, in Elkins, West Virginia. The evaluation was requested by the Superintendent of Randolph County Schools as a result of employee complaints regarding indoor air quality (IAQ) and exposure to chemical odors emitted from a printing area. Health complaints included: respiratory complaints, fatigue, irritant symptoms, stress, and short-term memory loss.

Environmental measurements for temperature, relative humidity, and carbon dioxide (CO_2), were collected. An IAQ questionnaire was distributed to all employees to characterize building comfort and health complaints. A building walk-through inspection identified an offset printing operation which did not have local exhaust ventilation. Odors from this process permeated adjacent work areas. The Hazard Communication Standard was not being implemented and no occupation safety and health committee existed.

Results from the self-administered questionnaire distributed during the survey indicated that 41% of the respondents had health concerns and a number of these suspected building-related illness. Several employees had seen their physicians regarding potential occupational illness and provided medical records for review.

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 humidity and CO_2 were within the recommended ranges. Recommendations are made to improve the IAQ and safeguard the occupational safety and health of the employees within the building.

Based on employee medical records, a potential health hazard existed for one worker employed to operate an offset copying machine. Assessment of the printing operation identified several industrial hygiene concerns. The employee was not provided with the appropriate chemical protective equipment, the operation was not provided with local exhaust ventilation, and the process and its effluents were not isolated from adjacent offices. Employees located in the surrounding offices had complaints consistent with those commonly referred to as "sick building syndrome." Specific recommendations for addressing these complaints are provided in Section VII of this report.

Keywords: SIC 9411 (Administration of Educational Programs), indoor air quality, carbon dioxide, relative humidity, ventilation.

II. INTRODUCTION

On July 17, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Superintendent of Randolph County Schools to conduct a health hazard evaluation (HHE) at the Randolph County Schools Administration Building in Elkins, West Virginia. Several complaints had been filed by the staff related to the IAQ in the building.

On August 3, 1992, a site visit was conducted by NIOSH investigators. An opening conference was held with school administrators which included an overview of the NIOSH HHE program and a review of the issues which prompted the HHE request. After the meeting, a walk-through survey of the building was conducted to identify potential sources of air contamination. Area air samples were collected for carbon dioxide, temperature, and relative humidity. A self-administered indoor air quality questionnaire was distributed to all building occupants. The results from the questionnaire indicated a number of concerns regarding building-related illness.

Results of the environmental survey were distributed to all concerned parties in the form of an interim report on November 30, 1992. Several employees had seen physicians regarding potential occupational illnesses. The medical records which the employees made available were reviewed.

III. BACKGROUND

The Randolph County Schools Administration Building is located in Elkins, West Virginia. Thirty-six employees work in the building, four of these are part-time employees. The majority of employees (22/36 or 61%) are school administrators or program directors who work over 40 hours per week. The remaining employees are either secretaries or computer operators who work 37.5 hours per week.

The building houses the administrative offices for Randolph County Schools. The building is approximately 35 years old and was originally designed as a school. The facility is a single story structure (approximately 9100 square feet) and has a flat roof. A specialized offset copying machine is located in the facility. Approximately 25,000 pieces of printed material are produced on a weekly basis. Copying operations involve type setting, xeroxing, and electronic stenciling. The Administration Building is a smoke free building.

A previous indoor air quality assessment was performed at the facility by the Office of Environmental Health and Safety from West Virginia University (WVU) on May 15, 1992. The assessment request was made by the Associate Superintendent of Randolph County Schools and was based on several employee complaints. The study found that xerox machines and the offset copying machine had been the focus of complaints. The report indicated, with regard to the copying room: (1) volatile organic chemicals were not stored correctly, (2) the exhaust fan was observed to be inefficient, (3) hazard communication training should have been performed for the building staff, and (4) the chemicals used should have been inventoried. The report stated that the copying operation should be relocated to another room or building and isolated with an effective local exhaust ventilation system. The report also indicated that administrative controls should be implemented in order to reduce employee complaints. However, the primary recommendation of the WVU study was that NIOSH perform an IAQ evaluation. None of the recommendations pertaining to engineering or administrative controls outlined in the WVU report were implemented at the time of the NIOSH survey.

IV. METHODS

A. ENVIRONMENTAL.

Carbon dioxide (CO_2) concentrations, temperature, and relative humidity were measured in all rooms and offices on the afternoon of August 3, 1992. Since these measurements were taken to evaluate the adequacy of the ventilation system, they were taken in the afternoon before the end of work when concentrations were expected to peak.

1. Carbon Dioxide Measurements.

Real-time CO_2 concentrations were measured using a Gastech Model RI-411A portable CO_2 meter. This portable, battery-operated instrument monitors CO_2 (range: 0 to 4975 ppm) by nondispersive infrared absorption with a sensitivity of 25 ppm. Instrument calibration and zeroing were performed prior to use.

2. Temperature and Relative Humidity Measurements.

Temperature and relative humidity were measured using a Vaisala HM #34 humidity

and temperature meter. Measurements were taken to evaluate thermal comfort parameters at various locations within the building.

B. MEDICAL.

Indoor air quality questionnaires were administered to 36 employees in the administration building. These questionnaires contained sections regarding work-related health concerns and suspected work-related medical illnesses, as well as a section on physical aspects of the work setting. Nine employees indicated they had sought medical attention for illnesses thought possibly related to IAQ problems. Medical histories and records were provided by six employees. Questionnaires and medical data were assessed for work-related concerns and illnesses.

V. EVALUATION CRITERIA

A high prevalence of adverse health symptoms have been reported among occupants working in buildings with poor IAQ.[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 IAQ problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are: heating, ventilation, and air-conditioning (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 IAQ 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, and structural components of the building; tobacco smoke; microbiological contamination; and outside air pollutants; (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.

The Occupational Safety and Health Administration (OSHA) has published regulatory standards for occupational exposures.[26] NIOSH and the American Conference of Governmental Industrial Hygienists (ACGIH) have published recommended limits for occupational exposures.[27,28] Specific standards have not yet been 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 CO_2 concentrations and the measurement of comfort indicators such as temperature and relative humidity are useful for providing information relative to the proper functioning and control of the HVAC system. The basis for monitoring individual environmental parameters is presented below.

A. Temperature and Relative Humidity.

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 Figure 1, the 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

Acceptable temperatures range from 68°F to 76°F in the winter and from 73°F to 80°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 undesirable growth of pathogenic and allergenic microorganisms.

B. Carbon Dioxide.

Carbon dioxide 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) CO_2 concentration which typically ranges from 300 to 350 ppm. When indoor CO_2 concentrations 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, but suggest that other indoor contaminants may also be elevated. In combination, these may contribute to health complaints such as headache, fatigue, and eye and throat irritation. Assuming that there are no significant uncontrolled 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 complaints related to IAQ should be minimal if interior CO_2 concentrations are maintained below 600 ppm.

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 CO_2 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. The ASHRAE Standard 62-1989 regarding office buildings recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) in office space and conference rooms based on a specific number of occupants per 1000 ft^2 of occupied area. Corridors should be provided with 0.10 cfm per square foot of area. 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.

The OSHA Permissible Exposure Limit (PEL) for CO_2 is 10,000 ppm for a 8-hour Time-weighted Average (TWA) exposure. The NIOSH Recommended Exposure Limit (REL) and the ACGIH Threshold Limit Value (TLV) is 5,000 ppm for an 8-hour TWA exposure. It would be extremely unusual to encounter CO_2 concentrations near these criteria in a non-industrial, office environment.

VI. RESULTS AND DISCUSSION

A. ENVIRONMENTAL.

1. Building Evaluation.

During the survey, water leakage was observed in the hallway. The water that was generated from the rooftop air-conditioning unit, spilled over the condensate pan, and was leaking into the interior of the building. In addition, numerous water stained ceiling tiles were observed. The exterior finish of the building was red brick and interior walls were painted cement block. Floor coverings were carpet; the hallway carpet was water soaked in the area of the roof leak. The exterior walls had windows that could be opened.

2. Heating, Ventilation and Air-Conditioning System Evaluation.

The HVAC system at the Randolph County Board of Education Building is composed of six separate air handling units (AHU). The ventilation supply and return are both ducted to diffusers. Each rooftop AHU supplies a given area with conditioned air for 11.5 hours each day beginning at 6:00 a.m. and ending at 5:30 p.m. The thermostats are set for 72°F for heating and 75°F for cooling; when an occupant is in the building past business hours, the offset must be engaged on the thermostat to supply the area with conditioned air. The thermostats and louvers on the supply air diffusers are adjustable by the employees. Air filters are replaced on an average of every 90 days.

The copying room is provided with a dedicated HVAC system and exhaust fan. This room is not separated from the surrounding office above the ceiling tiles. Although the area above the ceiling tiles does not serve as the return air plenum, this architectural feature allows vapors and odors which result from the printing process a pathway to migrate to the surrounding offices when the HVAC is off overnight. Several employees indicated the surrounding offices were subject to intermittent episodes of odors from the copying room.

Housekeeping and maintenance products are stored, dispensed, and mixed in a janitorial closet which is supplied with general ventilation. The air from this area is recirculated within the AHU zone which includes office areas. Bulk quantities of volatile organic cleaning supplies are stored in this location.

3. Industrial Hygiene Evaluation.

Summary data for CO_2, temperature, and relative humidity are presented in Table 1. On the day measurements were taken, Monday, August 3, 1992, the weather was warm and sunny and the HVAC system was operating in the air-conditioning mode.

1. Temperature and Relative Humidity.

Temperature ranged from 75.0°F to 83.0°F and the average temperature in the building was 77.3°F. Relative humidity ranged from 28.0% to 53.8% and the average relative humidity was 42.8%. Some temperatures measured (3/30 or 10%) were above the ASHRAE recommendations for summer thermal comfort. These temperatures were measured in the hallway and rooms of the trailer annex. At 40% relative humidity ASHRAE recommends temperatures of 73.5°F to 79.5°F. All relative humidity measurements were close to the recommended range.

2. Carbon Dioxide.

Carbon dioxide measurements were observed to range from 350 to 625 ppm and the average CO_2 level was 487 ppm. These CO_2 levels were within the ASHRAE recommendations for adequate fresh air supply. Although this data would indicate that the building was adequately supplied with conditioned fresh air, the building occupancy was slightly less than 4 people per 1000 ft^2 during the survey. Therefore, CO_2 measurements may not be a good indicator of adequate ventilation of the workspace data. The ambient (outdoor) CO_2 concentration was 325 ppm.

B. MEDICAL.

Thirty-six questionnaires were distributed to building occupants. Twenty-seven were returned for a response rate of 75%. Work-related health concerns are presented in Figure 2, Graph A. The most common complaints were irritant eye symptoms, nasal symptoms (sinus congestion and runny nose), aches and pains (headache), and stress (depression, fatigue, and irritability). Irritant complaints were clustered among those employees working in the vicinity of the printing operation and may reflect improper ventilation of the printing operation. Poor ventilation was identified as the primary environmental concern (Figure 2, Graph C).

Several employees expressed concern regarding possible work-related medical illness (Figure 2, Graph B). Seven employees submitted medical records for evaluation. The histories for the medical illnesses of six of these individuals could not be correlated with a work-related cause of illness. In the case of one print shop employee, however, occupationally-related illness could not be ruled out.

VII. CONCLUSION and RECOMMENDATIONS

The major difference noted between the Randolph County School Administration Building and most non-industrial environments is the presence of an industrial-type print shop operating in the facility. Employee complaints appeared related to the presence of odors generated from this printing operation.

Questionnaire data regarding work-related health concerns indicates employee complaints consistent with poor IAQ were clustered in the vicinity of the printing shop. Physician's records and medical histories reviewed for suspected work-related medical illnesses noted on questionnaires and in accompanying statements, were not consistent with work-related causes of illness, with the noted exception of the print shop employee. It is possible that prolonged exposure, including skin contact with printing compounds, has resulted in adverse effects to this individual. This employee should be protected from detrimental exposures through improved engineering controls and personal protective equipment. Consideration should, additionally, be given to transfer of this individual to a position where exposure to print shop chemicals does not constitute a potential hazard and continued health concerns.

The following recommendations should be implemented to improve indoor air quality and safeguard the occupational safety and health of the employees in the building:

1. Local exhaust ventilation should be provided for the offset copying machine. The purpose of this ventilation is to reduce operator exposure and to lessen the opportunity for chemical odors to migrate to other areas of the building. An engineering firm familiar with industrial ventilation guidelines should be retained to design this system. This specialized-use area should also be kept under negative pressure at all times relative to the surrounding spaces and the air from this area should not be recirculated. The chemical inventory in the printing room should be stored in accordance with the manufacturer's specifications. This is for fire safety purposes as well as preventing the spread of odors. In addition, the print shop operator should be provided and trained in the use of the appropriate chemical protective gloves.

2. Extend the wall to eliminate openings above the ceiling tiles in the copying room to ensure that odors from the offset copying machine do not reach the adjacent office spaces. Not only will this prevent the spread of odors, but it will improve the fire safety of the structure by providing a smoke barrier.

3. Improve the storage practices for janitorial supplies. Housekeeping and maintenance products are stored, dispensed, and mixed in the janitorial closet which is supplied with general ventilation. These products can emit vapors and odors which will be distributed to the entire AHU zone. The storage space for chemicals should be kept under negative pressure in relation to the rest of the surrounding areas and air from the closet should not be recirculated to the rest of the structure.

4. Operate the HVAC system in accordance with the recommendations of the current ASHRAE standards particularly with reference to the supply and distribution of fresh outdoor air to occupied spaces. The louvers of the supply air diffusers should be readjusted and secured, in order to prevent tampering.

5. The HVAC system's thermostats should be adjusted to ensure that the system is operating in accordance with the ASHRAE recommended standard for indoor temperature. Thermostats should be inspected on a regular basis to ensure that they are calibrated and functioning properly, and secured so that the temperature setting cannot be altered by individual occupants.

6. Permanently repair the leaking roof of the building in order to prevent damage to interior furnishings as well as to protect the health of building occupants. Once leaks are repaired, water damaged porous furnishings, including carpets and ceiling tiles should be discarded rather than disinfected to effectively prevent the potential of microbial contamination. When carpet is replaced, disinfect the floor surface with household bleach before resurfacing with new carpet. Microbial contamination can result in a potentially severe health condition known as hypersensitivity pneumonitis, as well as, other disorders including allergic rhinitis and conjunctivitis.

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

8. Implement a Hazard Communication (Worker and Employer Right-to Know) Program. The Hazard Communication Standard is delineated in The Code of Federal Regulations 29, Part 1910.1200.[36] This standard describes practices which ensure both employers and employees are appraised of information essential to establishing and maintaining a safe and healthful work environment. It also describes the OSHA requirement for determination of a worksite health hazards inventory. Although Randolph County Schools do not fall under jurisdiction of OSHA, information from OSHA standards provide guidelines which may benefit the management and employees of the Board of Education.

9. An occupational safety and health committee should be established to provide a means to identify and surveil occupational safety and health matters. The committee should be composed of employer and employee representatives, enabling problems to be identified, addressed effectively, and dealt with cooperatively.

10. Future IAQ complaints should be handled in the manner outlined in the EPA/NIOSH "Building Air Quality" guide book that was provided to the superintendent, director of facilities, and concerned staff members. This document was designed to assist with the prevention and resolution of indoor air quality problems. Since this document is in the public domain it may be reproduced without permission.

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2. Vice President, Randolph County Schools
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4. Director of Facilities and Vocational Education
5. West Virginia Department of Health and Human Resources
6. Randolph County Health Department
7. West Virginia University

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 1. Carbon Dioxide, Temperature, and Relative Humidity Summary Data
Randolph County Board of Education Building
Elkins, West Virginia
August 3, 1992
HETA 92-309

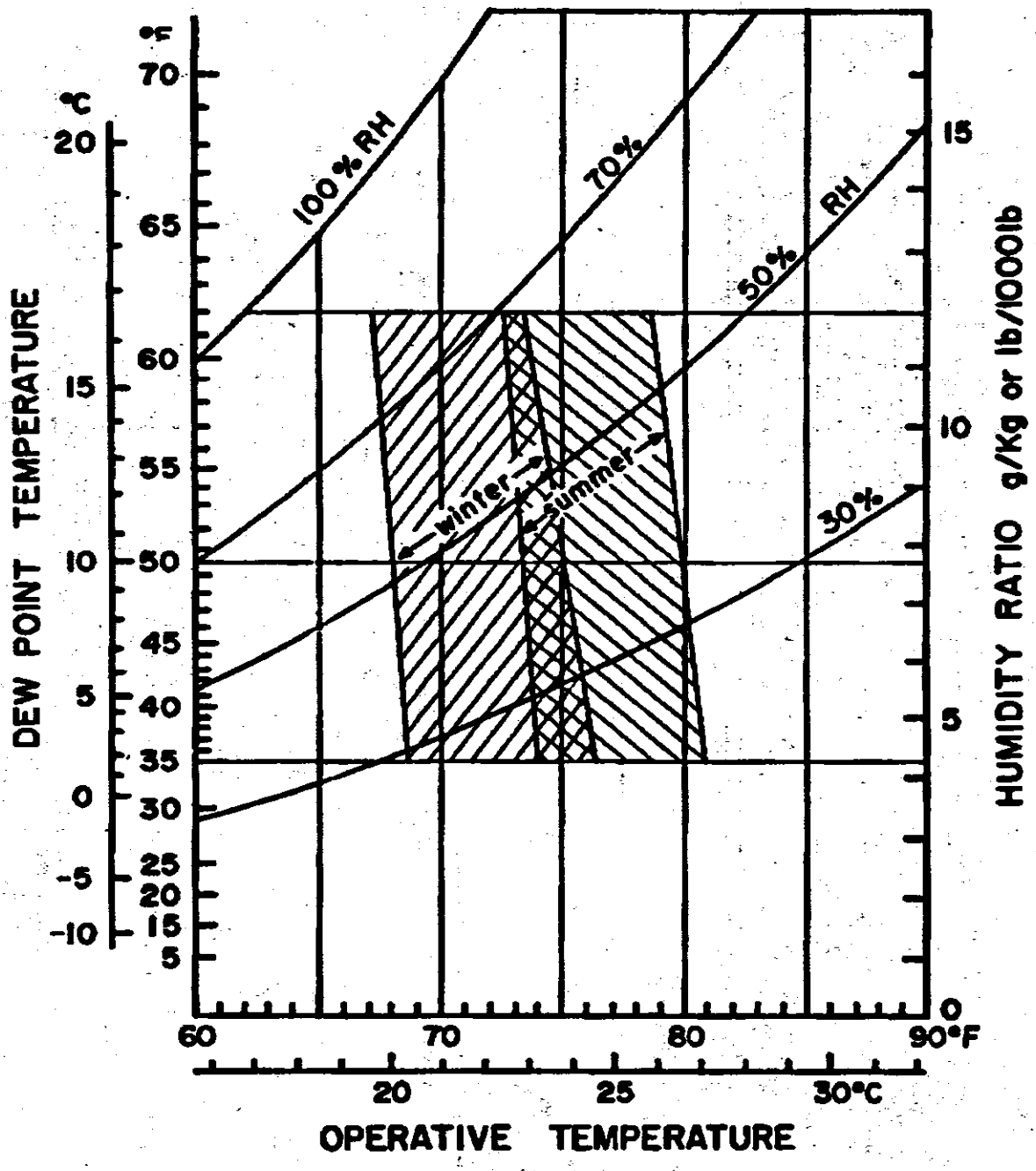
	Carbon Dioxide (ppm)	Temperature (°F)	Relative Humidity (%)
Average	487	77.3	42.8
Standard Deviation	66.5	1.9	6.3
Range	350 - 625	75.0 - 83.0	28.0 - 53.8
Number of Measurements	30	30	30

Outdoor conditions on the afternoon of August 3, 1992, were as follows:

Carbon Dioxide: 325 ppm
Temperature: 78°F
Relative Humidity: 48%

Note: Measurements were taken in the afternoon.

Figure 1. Thermal-comfort criteria, from ANSI/ASHRAE Standard 55–1981.
Randolph County Schools Administration Building
Elkins, West Virginia
HETA 92-309



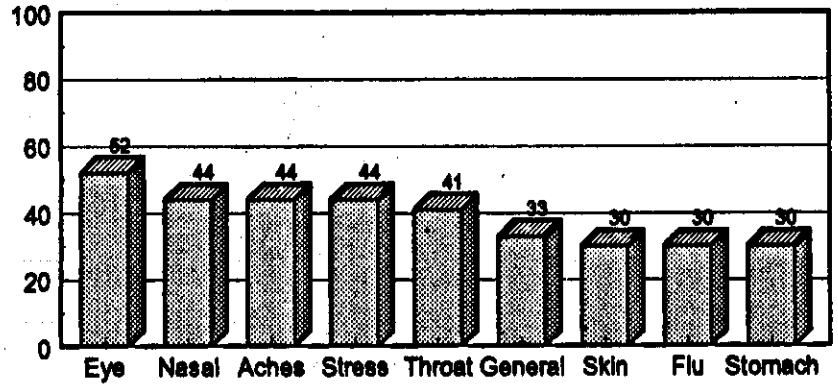
Acceptable ranges for persons, at light activity levels, wearing typical summer and winter clothing.

Figure 2

Indoor Air Quality Questionnaire Data
Randolph County Schools Administration Building
HETA 92-309

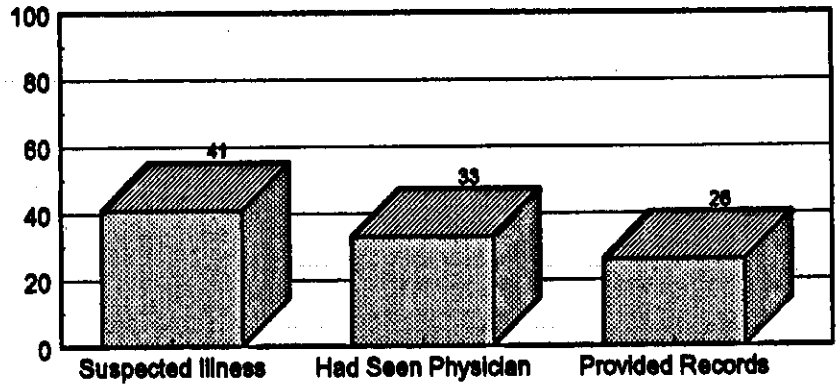
Graph A

Work-Related Health Concerns
(Percent of Respondents)



Graph B

Suspected Work-Related Illness
(Percent of Respondents)



Graph C

Environmental Concerns
(Percent of Respondents)