TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

HETA 92-269-2330
JULY 1993
CELEBREZZE FEDERAL BUILDING
CLEVELAND, OHIO

NIOSH INVESTIGATORS:
Anthony T. Zimmer, CIH
Robert Malkin, DDS, Dr.P.H.

SUMMARY

On May 14, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a written request for a Health Hazard Evaluation from an authorized representative of the National Treasury Employees Union (NTEU). Specifically, an indoor environmental quality study was requested for Internal Revenue Service (IRS) employees working on floors 2 through 6 in the Anthony J. Celebrezze Federal Building in Cleveland, Ohio. A number of employees had reported stuffed nose, dry throat, headaches, eye irritation, and general discomfort with the indoor environment. These individuals believed that their health problems were due to environmental exposures at the building. Based on discussions with the union representative and the IRS safety officer prior to the visit, the investigation focused on floors 2, 5, and 6.

A site visit was conducted on September 16-17, 1992. The investigation included: a walk-through of floors 2, 5, and 6 to survey the work activities and office layout; an examination of heating, ventilating, and air conditioning (HVAC) systems servicing floors 2 through 6; an environmental survey which included measurements for carbon dioxide (CO_2), temperature, and relative humidity (RH) throughout the workday; and a medical evaluation which consisted of questionnaires and interviews with IRS employees.

The walkthrough and HVAC inspections included the following findings: (1) several perimeter ventilators appeared to have excess particulate buildup including one ventilator (adjacent to room 629) which had a water leak; (2) the doors to all smoking areas were left open to the adjoining hallway , and smoke odors were clearly evident in the surrounding hallways; (3) no visible evidence of biological growth was noted in the four HVAC systems that serve floors 2-15, although standing water was noted in the southwest quadrant HVAC system condensate collection area.

On September 17, 1992, environmental sampling was conducted at 35 different sample locations throughout floors 2, 5, and 6 during the morning, mid-day, and late afternoon. The results of temperature and relative humidity measurements were within the American Society of Heating, Refrigerating, and Air-Conditioning Engineers thermal comfort guidelines. These guidelines correspond to those conditions in which 80% or more of the building occupants would be expected to find the environment thermally comfortable. Additionally, the

carbon dioxide (CO_2) concentrations measured on that day were all below 1,000 parts per million (ppm), suggesting that floors 2, 5, and 6 were being adequately ventilated with outside air.

The medical evaluation consisted of interviews with employees and administration of a questionnaire. Eleven individual interviews were conducted among employees who had notified the union that they wished to talk to the NIOSH investigators. Reported symptoms included headache, nausea, eye irritation, sinus and head congestion, cough, losing one's voice, lightheadedness and chest tightness. The questionnaire was administered on floors 2 and 6. One hundred fifty two questionnaires were distributed, and 127 (84%) were returned (90 female and 37 male); all job categories were represented. The results of the medical questionnaire surveys revealed symptom prevalence rates typical to those reported in problem buildings. Fatigue, strained eyes, stuffed nose, irritated eyes, dry throat, and headache were reported frequently by 57, 50, 43, 41, 37 and 34%, respectively, of participants.

The NIOSH investigators found no exposures or environmental conditions that would help explain the symptoms reported by employees. However, several ventilation system deficiencies were noted during the walkthrough survey. Recommendations to improve the indoor environmental quality of the building included: (1) eliminating smoking in the building or modifying the existing smoking areas to improve the ventilation system; (2) increasing the slope of the condensate collection drains for the HVAC systems which serve floors 2-15; (3) conducting routine maintenance on perimeter ventilators located on each floor to check for water leaks and the condition of the filters and; (4) establishing an indoor environmental quality committee to address employee concerns.

Keywords: SIC 9311 (Public Finance, Taxation, and Monetary Policy), indoor air quality, indoor environmental quality, ventilation.

INTRODUCTION

On May 14, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a written request for a Health Hazard Evaluation from an authorized representative of the National Treasury Employees Union (NTEU). Specifically, an indoor environmental quality study was requested for Internal Revenue Service (IRS) employees working on floors 2 through 6 in the Anthony J. Celebrezze Federal Building. A number of employees had reported stuffed nose, dry throat, headaches, eye irritation, and general discomfort with the indoor environment. These individuals believed that their health problems were due to environmental exposures at the building. Based on discussions with the union representative and the IRS safety officer prior to the visit, the investigation focused upon floors 2, 5, and 6.

A site visit was conducted on September 16-17, 1992. An opening conference was held with management, union representatives, and several concerned employees. The investigation included the following actions: a walk-through of floors 2, 5, and 6 to survey the work activities and office layout; an examination of heating, ventilating, and air- conditioning (HVAC) systems servicing floors 2 through 6; an environmental survey which included measurements for carbon dioxide (CO_2), temperature, and relative humidity (RH) throughout the workday; and a medical evaluation which consisted of questionnaires and interviews with IRS employees. A closing conference was held prior to departure to discuss our findings and preliminary recommendations.

BACKGROUND

The Anthony J. Celebrezze Federal Building, constructed in 1967, is a 31 floor, rectangular office building located in downtown Cleveland, Ohio. No parking garages are located within the building, although a loading dock is located on the south side in the sub-basement level. Several government agencies occupy the building which is maintained by the General Service Administration. IRS employees occupy floors 2 through 6. The approximate number of personnel occupying the floors focused upon during the survey were as follows; second floor, 141; fifth floor, 142; sixth floor, 161. The main activities accomplished by IRS employees include tax examination, tax collection and taxpayer servicing. Each floor had one room designated as the smoking area. The approximate area of each floor was 26,000 square feet (ft^2).

The heating, ventilating, and air-conditioning (HVAC) systems which supply floors 2-15 are located in the basement of this building. The ventilation systems are constant air volume systems. According to the operations and maintenance supervisor of the building, the

volumetric flowrate of air supplied to each floor is approximately 21,500 cubic feet per minute (cfm). Separate HVAC systems are dedicated to each quadrant of the building (i.e., northeast, northwest, southeast and southwest).

Each system operates in the following manner: 1) outside air is drawn into grills located on the second floor; 2) the outside air is mixed with the return air from the 2nd-15th floors; 3) the mixed air (of which 20% by volume is the minimum required outside air) is filtered and is divided into separate hot and colds decks for heating and cooling of the air; 4) the air from these decks is ducted separately to floors 2 through 15. Based on the temperature requirements of each quadrant of each floor, the air from the hot and cold decks is mixed proportionally to lower or raise the temperature.

In addition, ventilators are used along the perimeter of each floor to provide additional HVAC capabilities to compensate for uneven environmental heat or cold loads (the sun providing a heat load to a building face is a good example of this). These ventilators recondition the air supplied by the main HVAC systems located in the basement. The computer room located on the second floor has a dedicated HVAC system to accommodate its strict temperature and humidity requirements.

EVALUATION CRITERIA

NIOSH investigators have completed over 1100 investigations of the occupational indoor environment in a wide variety of non-industrial settings. The majority of these investigations have been conducted since 1979.

The symptoms and health complaints reported to NIOSH by 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. Typically, 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 prevalences of symptoms among occupants of office buildings.[1,2,3,4,5] 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 heating, ventilating, and air-conditioning (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.[8,9,10,11,12,13] Indoor environmental pollutants can arise from either outdoor sources or indoor sources.[14]

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.[15,16,17] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[17,18,19,20]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potentially 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-engine exhaust emissions 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 mirror those discussed in the preceding three paragraphs, and have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals (from building materials and office furnishings, machines, and other contents), tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and relative humidity 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 for exposures to chemical substances and other agents 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.[21,22,23] With few exceptions, airborne pollutant concentrations observed in the office work environment 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.[24,25] 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.[26]

NIOSH and the Environmental Protection Agency (EPA) jointly published a manual on building air quality, written to help prevent environmental problems in buildings and solve problems when they occur.[27] This manual suggests that indoor environmental quality (IEQ) is a constantly changing interaction of a complex set of factors. Four of the most important elements involved in the development of IEQ problems are: 1) a source of odors or contaminants; 2) a problem with the design or operation of the HVAC system; 3) a pathway between the contaminant source and the location of the complaint and; 4) building occupants. A basic understanding of these factors is critical to preventing, investigating, and resolving IEQ problems.

Measurement of indoor environmental contaminants has rarely proved to be 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 variable 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 has 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 (CO_2) 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. The ANSI/ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces and conference rooms, 15 cfm/person for reception areas, and 60 cfm/person for smoking lounges, and provides estimated maximum occupancy figures for each area.[24]

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 parts per million). 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 the concentration of other indoor contaminants may also be increased.[24]

Temperature and Relative Humidity

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. ANSI/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[25]

METHODS

The NIOSH investigation included the following actions: (1) a walk-through of floors 2, 5, and 6 to survey the work activities and office layout; (2) an examination the HVAC systems serving the affected building floors; (3) an environmental survey which included measurements for carbon dioxide, temperature, and relative humidity throughout the workday and; (4) a medical evaluation which consisted of interviews with employees and administration of a questionnaire.

Environmental measurements were taken with the following equipment. Real-time carbon dioxide (CO_2) levels were measured using a Gastech Model RI-411A, portable CO_2 indicator. This portable, battery-operated instrument monitors CO_2 via non-dispersive infrared absorption with a range of 0-4975 ppm, and 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 (800 ppm). Confirmation of calibration was conducted periodically throughout the instrument use period. Real-time temperature and relative humidity (RH) 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 140ºF, and 0 to 100% RH, respectively.

The medical evaluation involved a walk through tour of the facility to observe work practices, medical interviews, and a questionnaire survey. Medical interviews were conducted with individuals who had notified the union that they wished to talk to the NIOSH investigators. Questionnaires were administered on floors 2 and 6 because of the higher number of symptoms reported to the union from these floors. Each employee present at work on September 16, 1992, was given a questionnaire at his or her work area and asked to complete it during the day. The questionnaire was placed in sealed envelopes and collected at the end of the day. Questionnaires were labelled to correspond to the different sides of the building.

For determination of prevalence data from the questionnaire, responses of "1-3 days per week in the last 4 weeks" and "every or almost every workday" were considered "yes" responses and "1-3 days in the last 4 weeks," and "not in the last 4 weeks" were considered to be "no" responses. A lack of response to a given question concerning a symptom was considered a "no" response. For computation of correlations, the data were left in the original categories.

INDUSTRIAL HYGIENE RESULTS AND DISCUSSION

Walkthrough and HVAC System

A general walkthrough of floors 2, 5, and 6 was accomplished on the afternoon of September 16. Areas surveyed included the general administrative areas, individual offices, hallways, elevators, bathrooms, and smoking areas. Figure 1 illustrates the general floor layout. The perimeter ventilators on each floor were randomly inspected for excess particulate buildup on the filters and evidence of leakage or damage. In several instances, the filters appeared to have excess particulate buildup. Also, one ventilator (adjacent to room 629) had a water leak. Smoke tubes were used to visually assess air flow patterns and pressure differentials among several areas. In general, the individual floors were pressurized such that air flowed from the exterior office and administrative areas to the interior hallways.

The smoking areas, located on each floor, were also examined. In the smoking areas, the door to the room was left open to the adjoining hallway. There was no pressure differential in the smoking areas relative to the hallway and smoke odors were clearly evident in the surrounding hallways. Although smoke filtration devices were located in the smoking areas, the HVAC system that serves the smoke room is the same HVAC system serving floors 2-15. Therefore, the environmental tobacco smoke generated from these areas is mixed with the air supplying the rest of the building.

The four HVAC systems that serve floors 2-15 were also inspected. As stated earlier, outside air enters through intakes located on the second floor and is mixed with return air in the basement. The mixed air is filtered through the use of a roll-type filter bank. As particulate matter builds up, new filter media is periodically rolled-up. The decision to roll-up new filter materials is based on

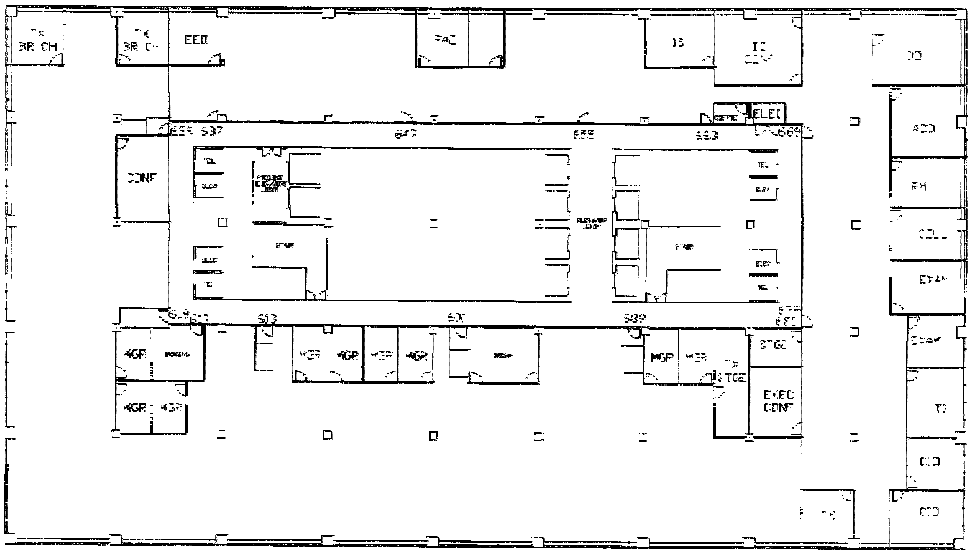

Figure 1

General Floor Layout
Anthony J. Celebrezze Bui. ding
Cleveland, Ohio
HETA 92-269

the pressure drop (as measured by a manometer) across the filter. No problems were noted either with excess particulate buildup or air bypassing the filter banks. In addition, the cooling coils of all the HVACs were inspected for visible signs of biological growth in condensate collection basins and past the cooling coils prior to being ducted to floors 2-15. No evidence of biological growth was noted, and the water generated from the cooling coils was freely draining to the sanitary sewer system in three of the HVAC systems. However, standing water was noted in the southwest HVAC condensate collection area. According to the operations and maintenance supervisor, there are plans (construction materials for this contract were in the basement area) to increase the steepness of the slope to the drains thus insuring that there will be no standing water in the condensate pans.

Environmental Survey

The environmental survey included selecting appropriate sample sites and conducting environmental sampling. The survey locations were selected on floors 2, 5, and 6 to represent: (1) a particular work environment such as a hallway, an administrative area cubicle or an individual office, and (2) locations previously identified as complaint areas to determine whether or not these areas were measurably different from non-complaint areas. The environmental sampling consisted of measurements for carbon dioxide concentrations, temperature and relative humidity. These measurements were used as aids in assessing indoor environmental quality.

Carbon Dioxide

Thirty-five different sample locations were selected throughout floors 2, 5, and 6. Measurements were taken at each location in the morning, early afternoon and late afternoon to determine variations throughout the day. A summary of the CO_2 measurements taken during the day is presented in Table 1.

Table 1

Environmental Monitoring Results,
Carbon Dioxide (CO_2)*

Floor	Mean Concentration	Range	
		High	Low
Second	480	625	400
Fifth	480	600	425
Sixth	460	525	425

* results are given in parts per million (ppm)

For comparison, the outside CO_2 levels averaged 300 ppm during the monitoring period. In all locations, the CO_2 levels measured were well below 1,000 ppm suggesting that these office areas were being adequately ventilated with outside air on September 17, 1992.[24]

Temperature and Relative Humidity

As with the CO_2 measurements, 35 different sample locations were selected throughout floors 2, 5, and 6. Measurements were taken at each location in the morning, early afternoon and late afternoon to determine daily variations in temperature and relative humidity. The summary results are presented in Tables 2 and 3.

Table 2

Environmental Monitoring Results, Relative Humidity*

Floor	Mean % RH	Range	
		High	Low
Second	50	57	45
Fifth	50	57	45
Sixth	50	57	43

* results are given in percent (%)

Table 3

Environmental Monitoring Results, Temperature*

Floor	Mean Temperature	Range	
		High	Low
Second	74	78	71
Fifth	75	77	71
Sixth	74	77	71

* results are given in degrees fahrenheit (^oF)

For comparison, the average outside temperature and relative humidity measurements were 77°F and 57%, respectively. When compared to the ASHRAE thermal comfort chart (see Figure 2), these building results fall within the comfort zones for summer and winter periods, which could be expected considering the survey date (September 18, 1992). Of the 105 measurements taken at various locations and time periods, no areas could be specifically identified as consistently cool or warm. The results obtained throughout floors 2, 5, and 6 fall within the summer and winter "comfort" parameters as defined by ASHRAE. In other words, those conditions in which 80% or more of the building occupants would be expected to find the environment thermally comfortable.[25]

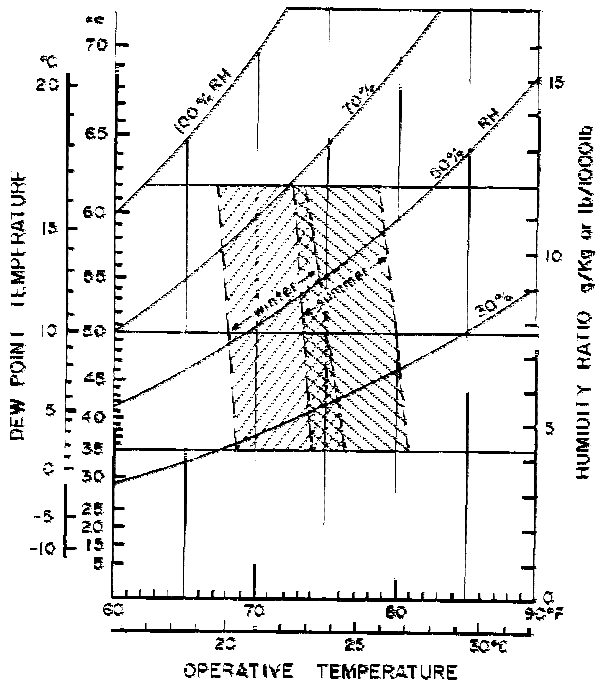

Figure 2: ASHRAE 55-1981

MEDICAL RESULTS AND DISCUSSION

Medical Interviews

Eleven individual interviews were conducted among employees who had notified the union that they wished to talk to the NIOSH investigators. In addition, five group interviews were conducted. Reported environmental deficiencies in the building included a lack of fresh air, odors in the building, cigarette smoke, dryness and dust. Reported symptoms included headache, nausea, eye irritation, sinus and head congestion, cough, losing one's voice, lightheadedness and chest tightness. Employees reported that exhaust odors from cars and trucks on the street were detectable in the building as well as cigarette smoke from the smoking rooms. Employees who were required to work on Saturdays and during the evening also reported that the air quality was markedly worse at those times. Other reported environmental problems included excessive dust throughout the building, poor lighting, noise from computer printers and ineffective vacuuming of the floors that, according to employees, made more dust while it was being done than had previously been present.

Employees reported having to use heavy reference books containing IRS regulations in order to service clients calling with tax questions on the phone. During the walkthrough tour, it was observed that the IRS does not provide any area for the employees to place these books during work, which requires them to improvise by balancing the books on their lap, rearranging furniture to fit them on the desk or propping them up on the desk drawer. Without a system for keeping the books close at hand, the employees would have to repeatedly reach for the books off a shelf, which they reported was stressful to the arms and back.

Questionnaire Results

One hundred fifty-two questionnaires were distributed and 127 were returned (90 female and 37 male) for a response rate of 84% and represented all job categories. The distribution of employees by job category is given in Table 4.

Table 4

Distribution of Questionnaire Respondents by Job Category

Job category	Frequency	Percent
Managerial	13	11
Professional	24	20
Technical	62	51
Secretarial/clerical	16	13
Other	7	6

The questionnaire responses were consistent with the problems reported during the employee interviews. The symptoms prevalences are given in Table 5. There was no difference in the prevalence of reported symptoms by floor the employee worked on. For further statistical analysis of the questionnaire data, only the six most prevalent symptoms (tired or strained eyes, stuffed nose/sinus congestion, dry/itching eyes, tiredness/fatigue, headache and dry throat) were considered because of the markedly lower prevalence of other symptoms.

Table 5

Symptom Prevalence

Symptom	% reporting symptom "frequently" over the last 4 weeks	% reporting symptom on day questionnaire was administered	% reporting symptom who improved from work
unusual tiredness, fatigue, or drowsiness	57	38	76
tired or strained eyes	51	41	84
stuffed nose/sinus congestion	43	38	61
dry, itching or irritated eyes	41	39	74
dry throat	37	35	76
headache	34	28	74
cough	19	21	58
concentration problems	14	13	75
dizziness or lightheadedness	12	10	74
shortness of breath	12	12	58
sore throat	11	11	51
chest tightness	9	9	51
wheezing	9	6	67

Employees were asked about their perception of environmental conditions in the building. On the day of the NIOSH investigation, 59% of the respondents reported that the building had too little air movement, 46% felt it was too dry and 42% felt it was too hot. Only 7% thought that the building had too much air movement. Perceived environmental conditions are listed in Table 6. A sizable number of people reported exactly the opposite environmental condition to that which was most commonly reported. For example, 28% of respondents thought the building was frequently too hot, and 15% thought it was frequently too cold and 18 % thought it was frequently both too hot and too cold.

Table 6

Perceived Environmental Conditions

Environmental parameter	% Reporting Condition	% Reporting condition on day questionnaire was administered
Too much air	7	13
Too little air	63	59
Too hot	28	24
Too cold	15	15
Both too hot and too cold	18	24
Too humid	23	24
Too dry	44	46
Tobacco smoke odors	17	13
Other odors	24	17

The number of symptoms reported by an individual employee was calculated (see Table 7). Two or more symptoms were reported by 68% of the respondents and 56% reported three or more symptoms.

Table 7

Number of Symptoms Reported by Employees

Number of Symptoms	Frequency	Percent
0	26	21
1	15	12
2	15	12
3	17	13
4	13	10
5	13	10
6	8	6
7	6	5
8	2	2
9	3	2

Kendall tau b correlation coefficients were obtained to determine if any of the perceived environmental conditions were associated with symptoms reporting. The correlations were done for both the symptoms and environmental conditions over the last 4 weeks (see Table 8), as well as the symptoms and environmental conditions reported on the day of our site visit (see Table 9). Symptoms reported "frequently over the last 4 weeks" were associated with the perception of different environmental conditions; the associations appeared to be greatest between symptoms and

perceiving the building as being too dry or having too little air. Similarly, employees reporting symptoms "today" perceived the building as having too little air and as being too dry. These perceptions, however, were not consistent with the environmental conditions measured by NIOSH investigators that day.

Table 8

Kendall Tau b Correlation Coefficients
Environmental Parameters and Symptoms Reported Frequently Over The Last 4 Weeks

	Dry throat	Dry eyes	Stuffed nose	Tired/ fatigue	Strained eyes	Headache
Too much air	r=0.157 p=0.042	0.049 0.524	0.244 0.0015	0.139 0.070	0.058 0.450	0.158 0.040
Too little air	0.272 0.0002	0.289 0.0001	0.261 0.0004	0.292 0.0001	0.210 0.004	0.370 0.001
Too hot	0.217 0.003	0.191 0.0087	0.258 0.0004	0.244 0.0008	0.137 0.059	0.404 0.0001
Too cold	0.179 0.0135	0.087 0.233	0.223 0.0020	0.208 0.004	0.209 0.004	0.236 0.0012
Too dry	0.308 0.0001	0.274 0.0002	0.154 0.034	0.333 0.0001	0.202 0.005	0.280 0.0001
Too humid	0.176 0.016	0.181 0.013	0.265 0.0003	0.306 0.0001	0.066 0.365	0.336 0.0001

Table 9

Kendall Tau b Correlation Coefficients
Environmental Parameters and Symptoms on the Day of the NIOSH Investigation

	Dry throat today	Dry eyes today	Stuffed nose today	Tired/ fatigue today	Strained eyes today	Headache today
Too much air today	r=-0.008 p=0.932	-0.093 0.298	-0.025 0.775	-0.089 0.320	-0.168 0.060	-0.102 0.254
Too little air today	0.269 0.003	0.232 0.009	0.253 0.005	0.319 0.0003	0.205 0.022	0.227 0.011
Too hot today	0.223 0.012	0.116 0.191	0.065 0.467	0.197 0.027	0.140 0.117	0.230 0.0008
Too cold today	0.254 0.004	0.124 0.163	0.206 0.021	0.066 0.460	0.159 0.074	0.037 0.678
Too dry today	0.362 0.0001	0.377 0.0001	0.231 0.010	0.263 0.003	0.201 0.024	0.425 0.0001
Too humid today	0.140 0.115	0.054 0.542	0.025 0.777	0.255 0.0043	0.065 0.468	0.155 0.082

Perceived lighting was evaluated to determine its effects on reporting of symptoms. The effects of perceived deficiencies in lighting were analyzed in two manners. In the first analysis, the questionnaire responses "much too bright" and "a little too bright" were combined to create a new variable, "too bright," and the variables "much too dim and "a little too dim" were combined to create a variable, "too dim," to assess the role that perceived dimness or brightness played on symptom reporting. In this analysis an employee finding his work station "too bright was more likely to report the symptom dry/irritated eyes (p=0.01) or strained eyes (p=0.02) and headache (p=0.056). "Too dim" lighting was not associated with any studied symptom.

The second analysis combined the questionnaire responses "much too dim," and "much too bright" to form a new variable "very bad lighting," and combined the responses "a little too dim" and "a little too bright" to create the variable, "not too bad lighting," in order to determine whether or not symptom reporting was related to the magnitude of perceived lighting deficiencies. Using the Mantel-Haenzel Chi-square statistic, linear relationships were found between increased perceived lighting deficiencies (not too bad and very bad) and the following symptoms: headache (p=0.048), dry/irritated eyes (p=0.026), strained eyes (p=0.016) (see Table 10). The role played by glare on computer workstations and reporting of lighting deficiency is not known, but glare was reported by employees during the interviews.

Table 10

Percent of Employees Reporting Symptoms
Under Different Perceived Lighting Conditions

	Nose/Sinus problems	Strained eyes	Dry/itching/ irritated eyes	tiredness/ fatigue	Headache	Dry throat
just right	40	38	28	52	24	34
not too bad	44	56	50	56	39	36
very bad	50	75	50	75	50	50
p value	0.553	0.016	0.026	0.307	0.048	0.483

The questions concerning job satisfaction, job category, education, coffee consumption, number of hours working on a computer, and conversational privacy were analyzed using Kendall Tau b correlation coefficients, to evaluate whether correlations existed with symptoms. No associations were found. Increased reporting of restless/disturbed sleep was associated with increased reporting of dry throat (p=0.02) and tiredness/fatigue (p=0.021).

Questionnaire Discussion

These questionnaire results illustrate the relationship of perceived environmental conditions and symptoms reporting. Symptoms appear to be related to the individual perception of improper humidity and temperature levels in the work environment regardless of measured parameters, as different people may report similar symptoms with completely different perceptions of their environment. A building may be too hot for some employees and may be too cold for others. In addition, it is conceivable that an area of a floor might be, at times, hotter than another and that might result in these seemingly contradictory responses. However, at the time NIOSH investigators were in the building, there was little difference in measured temperature or humidity between areas on a given floor.

Many employees (46%) felt that the building was too dry although the environmental results were within the ASHRAE comfort guidelines for temperature and humidity. This occurrence has been reported by other researchers. A controlled study of subjects exposed to different humidity levels have found that they were not able to judge air humidity levels. However, a relationship was found between temperature and humidity. As humidity decreased, subjects were more likely to perceive the temperature as decreased and vice versa.[28] In a previous NIOSH investigation, *perceived* low humidity in indoor environments was associated with dryness of the eyes, nose, and throat.[29]

Although many of the responses to variables asked on the questionnaire correlated with symptoms, most variables are not known medically to be risk factors for the particular symptom. The etiology of the symptoms is presently unknown. The results, however, do give insight into how different employees perceive that they are affected by their work environment.

CONCLUSIONS

The environmental sampling revealed temperature, relative humidity and CO_2 conditions that are commonly found in indoor environments. The temperature and relative humidity measurements taken on September 17, 1992, were well within ASHRAE comfort guidelines, corresponding to those conditions in which 80% or more of the building occupants would be expected to find the environment thermally comfortable.[25] Additionally, the CO_2 concentrations measured on that day were below 1,000 ppm suggesting that floors 2, 5, and 6 were being adequately ventilated with outside air.[24]

None of the environmental measurements documented any conditions that would help explain the symptoms reported by the IRS employees. The results of the questionnaire surveys revealed prevalence rates typical to what has been reported in problem buildings.[5,9] Symptoms were associated with employee perceptions of low humidity and too little air.

It must be emphasized that the measurements taken reflect one day's conditions. Indoor environmental conditions may vary depending on local outdoor environmental conditions or with fluctuations involving the operation of HVAC systems.

RECOMMENDATIONS

Vehicle Exhaust Emissions: Several employees complained about intermittent vehicle exhaust odors in their work areas. The downtown location of the office building, along with the location of

the outside air intakes (second floor), creates a situation where transient vehicle exhaust odors would be nearly impossible to prevent. However, one source of emissions may be reduced, that being the loading dock located in the sub-basement of the building. Facility managers should insure that vehicles in this area are not allowed to idle. This action would reduce a potential source of vehicle emissions that could reach the outside air intakes which services floors 2-15.

Smoking Areas: The designated smoking areas on each floor are inadequate in preventing non-smoker exposure to environmental tobacco smoke. Environmental tobacco smoke contributes to particulate and gaseous contaminants and is suspected to increase the risk of developing lung cancer and respiratory illnesses.[30,31] For these reasons, exposures should be reduced to the lowest feasible concentration by: 1) eliminating smoking in the building, or 2) modifying the existing smoking areas. Specifically, the smoking areas should be under negative pressure with respect to adjacent areas and have a dedicated exhaust system (room air directly exhausting to the outside) providing 60 cubic feet per minute per person of outside air.[24]

HVAC System: Standing water in the condensate collection basins could act as a reservoir for microbial growth. To prevent this situation, the slope to the collection drain (for the HVAC systems located in basement) should be increased in accordance with the planned contract modifications. Additionally, the perimeter ventilators located on each floor should have documented routine maintenance to check for water leaks and the condition of the filters. These filters should be changed out as needed, or according to a routine maintenance schedule.

Indoor Environmental Quality Committee: Effective communication between management and employees should be facilitated through the establishment of an indoor environmental quality committee as a separate entity or as a sub-component to the health and safety committee. Employees should have a means of voicing concerns over indoor environmental quality issues and be made aware of problems with the building and decisions that facility and building management make to address those problems.

Ergonomic Issues: Although NIOSH investigators did not conduct a formal ergonomic evaluation, the IRS should address the problems associated with use of the heavy reference books that were needed to respond to telephone requests for information.

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

15. 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.

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

17. 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. HHE 88–364–2104 — Vol. III.

18. 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.

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

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

21. NIOSH [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.

22. Code of Federal Regulations [1989]. Air contaminants — permissible exposure limits. 29 CFR 1910.1000. U.S. Department of Labor, Occupational Safety and Health Administration (OSHA).

23. ACGIH [1991]. 1991–92 Threshold limit values for chemical substances and physical agents, and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

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

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

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

27. NIOSH [1991]. Building air quality: a guide for building owners and facility managers. 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. 91-114.

28. Andersen I, Lundqvist GR, Proctor DF [1973]. Human perception of humidity under four controlled conditions. Arch Environ Health 26:22-27.

29. NIOSH [1991]. Hazard evaluation and technical assistance report: Library of Congress, Washington D.C. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 88-364-2104.

30. Taylor A, Johnson D, Homayoun K [1992]. Environmental tobacco smoke and cardiovascular disease; a position paper from the council on cardiopulmonary and critical care, American Heart Association. Circulation 86(2):1-4.

31. NIOSH [1991]. Current intelligence bulletin 54: environmental tobacco smoke in the workplace: lung cancer and other health effects. 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. 91-108.

AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:
Anthony Zimmer, C.I.H.
Industrial Hygiene Engineer
Industrial Hygiene Section

Robert Malkin, DDS, DrPH
Medical Officer
Medical Section

Report Formatted by:
Donna M. Pfirman
Office Automation Assistant
Industrial Hygiene Section

Originating Office:
Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations and Field Studies

DISTRIBUTION AND AVAILABILITY OF REPORT

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 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 at the Cincinnati address.

Copies of this report have been sent to:
1) Employee Representative
2) Safety Representative
3) OSHA, Region Five

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 days.