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I. SUMMARY

On March 28, 1991, the National Institute for Occupational Safety and Health (NIOSH) conducted an indoor air quality investigation at an office building occupied by the Oakland County Department of Social Services. The request for a health hazard evaluation was received from an authorized union representative and stated that a number employees had been experiencing symptoms such as headaches, respiratory problems, eye irritation, and allergic-like reactions.

Average environmental carbon dioxide (CO_2) concentrations ranged from a low in the morning (between 6:25 and 7:04 a.m.) of 350 parts per million (ppm) to a high of 875 ppm in the afternoon (between 3:11 and 3:50 p.m.), with a gradual rise between these time periods. Indoor CO_2 concentrations under 1000 ppm are thought to be an indication that building ventilation is adequate. Temperatures measured over four sampling times ranged from 73.4 to 77.7 °F (generally within comfort guidelines). Average relative humidities ranged from a high of 32.2% (between 6:25 a.m. and 7:04 a.m.) to a low of 20.4% (between 3:11 p.m. and 3:50 p.m.). Relative humidity below 30% is sometimes associated with increased discomfort and drying of mucous membranes. Respirable particulate concentrations were typical for office building environments, except for the smoking room, where levels increased to nearly 12 times the Environmental Protection Agency (EPA) ambient air quality standard for airborne particulates (PM_{10} standard).
Personal breathing zone (PBZ) ozone (O_3) concentrations measured at two photocopy machines ranged from 0.02 to 0.18 ppm. PBZ concentrations of O_3 measured at a laser printer ranged from 0.03 to 0.05, just slightly above ambient background concentrations. O_3 concentrations up to 0.94 ppm, however, were measured at the exhaust port of the laser printer. The NIOSH Recommended Exposure Limit (REL) for O_3 is a ceiling concentration of 0.1 ppm.

Eighty-five questionnaires (79% of employees) were completed by the staff to determine the nature and extent of symptoms that might be related to the workplace environment. A vast majority reported thermocomfort complaints, in addition to a number of non-specific symptoms that can result from a variety of causes.

Based on the results of this investigation, several recommendations are offered to improve air quality and comfort parameters in the building. Two photocopy machines were found to generate ozone in concentrations above the NIOSH recommended exposure limit (REL). A potential health hazard exists from exposure to ozone generated by these photocopy machines. A complete discussion of recommendations may be found in section VII of this report.

KEYWORDS: SIC 8322 (social service centers), indoor air quality, carbon dioxide, temperature, relative humidity, sick-building syndrome, ozone.

II. INTRODUCTION

On December 12, 1990, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from a representative of the United Auto Workers (UAW) local 6000 to conduct an indoor air quality investigation at the Oakland County Department of Social Services. A number of employees had reported allergic-like reactions, headaches, respiratory problems, eye irritation, and frequent illness. A site visit of the facility was conducted on March 28, 1991.

III. BACKGROUND

The Oakland County Department of Social Services leases a single-story brick-building, which was constructed in 1988 (see Figure 1 for floor plan). About 108 employees work in the 21,000 square foot structure. Including visitors, as many as 130 to 150 people may occupy the building. The southern and eastern sides of the building have narrow windows, which can be opened along the top edges. There are a number individual offices along the periphery of the building, but most employees work in individual 8 by 8 foot cubicals. Throughout the building, the floor is covered by replaceable carpet tiles.

Some of the work performed in the building (word processing, typing, filing, photocopying) is typical of most office environments. In addition to office work, interviewing and counseling activities are conducted throughout the typical day. There are two photocopy machines and one laser printer in the building. Employees are present in the building between approximately 7:00 a.m. and 5:30 p.m.

The heating, ventilating, and air conditioning (HVAC) system is divided into five heating and cooling zones. Constant volume air handlers, one for each zone, are located on the roof. Each air handler is controlled by a single thermostat. Above the false ceiling, there are supply and return ventilation ductwork systems that serve all zones throughout the building. Each single-occupant office has at least one supply and return air duct. Steam humidification is controlled by duct-mounted humidistats set to maintain a minimum 30% indoor relative humidity. All five HVAC systems are Carrier® combined heating (natural gas) and air conditioning units, each equipped with separate humidifiers. There are no additives (corrosion inhibitors, etc.) reportedly used in the humidifiers. Three HVAC systems serve the perimeter areas of the building, one system serves the interior of the building, and one system serves both peripheral and interior areas (see shaded areas in Figure 1).

Each roof-top air handling unit (AHU) is equipped with an economizer system, which is designed to provide a minimum of 20% fresh air under normal operating

conditions. The entire HVAC system is designed to provide 16,500 cubic feet per minute (cfm) of total supply air, and therefore, the system will provide a minimum of 3300 cfm of outside air and 2150 cfm minimum exhaust. Assuming that there are 150 people present in the building and the HVAC units are operating properly and providing good distribution, the system will provide an average of 22 cfm/person. The system is equipped with night shutoff timers on all exhaust fans.

During the day cycle, the AHU fans run continuously, providing heating or cooling as needed. During the night cycle, the fans run intermittently, depending on heating or cooling demands.

The current smoking policy permits smoking in private offices. Employees working in other areas are required to use the smoking lounge. The smoking room is equipped with two exhausts (designed for a total exhaust of 400 cfm) and one supply duct.

IV. EVALUATION DESIGN AND METHODS

The purpose of the evaluation was to evaluate if reported symptoms may be related to indoor air quality and to measure ventilation and comfort parameters. Carbon dioxide concentrations, temperature, humidity, and respirable particulate levels were measured throughout the office areas. A series of four measurements was made at each location (denoted by letters in Figure 1), beginning in the morning and ending in mid-afternoon. The measurement strategy allowed trends in environmental parameters to be observed throughout the day. A health symptom and comfort questionnaire was distributed to all employees present on the evaluation day. Eighty-five questionnaires (79% of employees) were completed by the staff.

The ventilation system was qualitatively evaluated within the building. However, the rooftop HVAC systems were not inspected because of accessibility and weather conditions.

A. *Environmental*

1. Carbon Dioxide Real-time carbon dioxide (CO_2) concentrations were measured using a Gastech Model RI-411A, portable CO_2 meter. This portable, battery-operated instrument monitors CO_2 by non-dispersive infrared absorption with a sensitivity of 25 parts per million (ppm). Instrument zeroing and calibration were performed before use with zero air and 800 ppm CO_2 span gas.

2. Temperature and Relative Humidity (RH) Real-time temperature and RH measurements were taken with a Vaisala HM #34 humidity and temperature meter. Outside measurements were obtained with a Environmental Tectonics Corporation Psychro-dyne® battery-operated psychrometer. Dry and wet bulb temperature readings were monitoring and the corresponding relative humidity determined via the manufacturer-supplied curve.

3. Respirable Suspended Particulates (RSP) Real-time RSP concentrations were measured using a GCA Environmental Instruments Model RAM-1 monitor. This portable, battery-operated instrument measures changes in airborne particle concentration via an infrared detector, centered on a wavelength of 940 nanometers.

4. Ventilation System A visual inspection of the ductwork, interior rooms, and exterior structure the building was conducted. The return and supply diffusers were qualitatively checked using chemical smoke. The locations of the thermostats in the building were identified.

5. Ozone Real-time ozone (O_3) concentrations were measured with a Mast Model 727-3 Ozone Monitor. During operation, sample air is continuously supplied to the sample and reference cells within the instrument. UV (ultraviolet) light, produced by a mercury vapor lamp at a wavelength centered on 254 nm, is emitted through the cells within the instrument. When O_3 is present, the intensity of the UV light is reduced in proportion to the O_3 concentration in the air. Self-zeroing and interference removal is performed by comparison of the sample and reference cells. The instrument range is 0 - 9.99 parts per million (ppm) ozone, with a lower detectable limit of 0.02 ppm and an incremental sensitivity of 0.01 ppm. The instrument was factory calibrated on June 25, 1990.

   The sample probe was positioned in the breathing zone of a standing person operating the copy machine. This was done by placing the O_3 meter on a cart and attaching the sample probe to a vertical yardstick.

B. *Questionnaires*

Eighty-five out of 106 questionnaires (79 percent of employees) were completed by the staff to determine the nature and extent of symptoms that might be related to the workplace environment. The questionnaires were returned with the respondent's telephone number extension. The extension numbers could be keyed to building locations. The questionnaire was directed toward health symptoms and comfort parameters.

V. EVALUATION CRITERIA

NIOSH investigators have completed over 700 investigations of indoor air quality problems in a wide variety of settings. The majority of these investigations have been conducted since 1979, paralleling the "energy efficiency" concerns of building operators and architects.

Commonly, the symptoms and health complaints reported by building occupants have been diverse and not suggestive of any particular medical diagnosis or readily associated with a causative agent. A typical spectrum of symptoms has include headaches, varying degrees of itching or burning eyes, irritation of the skin, sinus problems, dry and irritated throats and other respiratory irritations. The workplace environment has been implicated because workers' symptoms reportedly disappear when they are away from the office or work environment.

Very few episodes of comfort and health problems have been found to result from a single factor acting alone. Most problems investigated are multifactorial and can include contributors from the following categories: inadequate ventilation, contamination from inside the building, contamination from outside the building, microbiological contamination, contamination from building materials, and "unknown." The predominant problems identified in the NIOSH indoor environment investigations can be placed into the following three general categories listed in order of decreasing frequency: inadequate ventilation, chemical contamination, and microbiological contamination. Inadequate ventilation, a category which includes shortages of outside air, poor distribution, and short circuiting of supply air, is found most often in the NIOSH building investigations (greater than 50% of cases). These ventilation problems make it difficult to control heating and cooling and allow the accumulation of contaminants in the occupied space. The resulting conditions may cause occupants to become uncomfortable or experience adverse health effects.

Standards specifically for the 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 and recommended limits for a number of occupational exposures.[1,2,3] With few exceptions, pollutant concentrations observed in the office work environment fall well below these published occupational standards or recommended exposure limits. Scientists suspect that work- related health complaints in indoor environments may not be attributable to individual airborne contaminants, but to the cumulative effects resulting from exposures to low concentrations of multiple pollutants and uncomfortable work environments. The American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria, and thermal comfort guidelines.[4,5]

The basis for monitoring carbon dioxide, temperature, relative humidity, respirable suspended particulates, and ozone are presented below. A discussion of microorganisms is also included.

A. *Carbon Dioxide*

CO_2 is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. The ASHRAE standard 62-1989, "Ventilation for Acceptable Indoor Air Quality,"[4] 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. The standard provides estimated maximum occupancy figures for each area.

Indoor CO_2 concentrations are normally higher than the generally constant ambient $C0_2$ concentration (range 300-350 ppm). When indoor $C0_2$ concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected and health complaints may be more frequent.[4] Elevated $C0_2$ concentrations suggest that other indoor contaminants may also be increased.

B. *Temperature and Relative Humidity*

The perception of comfort is related to an individual'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.[5] The ASHRAE "comfort chart" is presented in Figure 2. The acceptable ASHRAE humidity range for sedentary people is a dew point temperature between 35 and 62°F. This is generally equivalent to a relative humidity between 30 and 50%.

Relative humidities below 30% may be associated with increased discomfort and drying of the mucous membranes. High relative humidities (above 70%) may promote the amplification of fungal populations.[6]

C. *Respirable Suspended Particles (RSP)*

In contrast to fibrogenic dusts which cause scar tissue to be formed in lungs when inhaled in excessive amounts, the so-called "nuisance" dusts are believed

to cause few adverse effects on the lungs and are not expected to produce significant organic disease or toxic effects when exposures are kept under reasonable control.

The greatest contributor to indoor RSP is environmental tobacco smoke (ETS).[7] NIOSH has recently determined that environmental tobacco smoke is potentially carcinogenic to occupationally exposed workers.[8] In buildings where smoking is not allowed, RSP levels are influenced by outdoor particle concentrations with minor contributions from other indoor sources. In buildings with oil, gas, or kerosene heating systems, increased RSP concentrations associated with the heating source may dominate.

The Environmental Protection Agency (EPA) has an ambient air quality standard for respirable particulate matter (PM_{10} standard, 150 ug/m^3, a 24 hour maximum concentration limit).[9] PM_{10} concentrations (particles smaller than 10 microns in diameter) combine combustion, soil, dust, and mechanical source particulate contributions. The larger particles are associated with outdoor particle concentrations, mechanical processes, and human activity. When indoor combustion sources are not present, indoor particle concentrations generally fall well below the EPA ambient PM_{10} standard.

D. *Microorganisms*

Most building-related antigens are thought to be of fungal or bacterial origin. Endotoxins, mycotoxins, and other microbial products can affect indoor air quality and cause immunologic (allergic) reactions in some individuals. For example, most fungi produce spores that can be transported through the air and within ventilation systems.

In previous NIOSH investigations, microbiological contamination has commonly resulted from water damage to carpets or furnishings, or standing water in or near ventilation system components. Stagnant water, and soil or vegetation near HVAC units or air intakes can permit the growth of bacteria or fungi, which can be taken up by the HVAC unit and enter occupied areas of the building. Air filters containing organic dusts may become moist depending on environmental conditions, allowing growth of bacteria or fungi on the filter itself.

If possible sources are found where biological contaminants may be growing, or if visible growth is identified, the sources should be removed as a preventative measure. After removal, further field investigation is not required unless there is positive medical evidence of disease related to bioaerosols, such as humidifier fever, hypersensitivity pneumonitis, or Legionnaire's Disease.

E. *Ozone*

Ozone (O_3) is a colorless gas consisting of three atoms of oxygen rather than two, as in normal atmospheric oxygen. O_3 is unstable and highly reactive, and consequently high concentrations are usually only found in the immediate vicinity of where it was formed.[10] O_3 is less stable at high relative humidities. Natural sources may produce ambient air levels of 0.04 to 0.05 ppm, caused predominantly by the down draft of stratospheric O_3. Ambient ozone is also produced by a photochemical interaction of hydrocarbons, nitrogen oxides, and light. Common indoor sources of O_3 include photocopy machines, laser printers, and electrostatic air cleaners. O_3 is often produced by equipment utilizing high electrical charges.[11]

In electrostatic process photocopiers, O_3 is produced by the interaction of oxygen, nitrogen oxides, and electrical charge created by the corona discharge wire.[11] Most photocopiers and laser printers have some type of ozone filter. The filters are commonly made of hopcalite, paper, activated charcoal, or a honeycomb paper filter impregnated with activated charcoal.[12,13]

The primary health effects of O_3 are related to its irritation of the mucous membranes and the lungs. Symptoms include nose and throat irritation, cough, difficulty breathing, and chest pain.[14] Concentrations of O_3 in indoor environments have been reported to range between 0.04 and 0.40 ppm.[11]

Animals exposed to high concentrations of O_3 over long durations have resulted in inflammatory responses and development of scar tissue in the lungs.[11] The long-term effects of lower O_3 exposures in humans are not as clearly defined, but some studies have found changes in lung function and vital capacity.[15] O_3 is also reported to cause increased susceptibility or exacerbation of respiratory disease of bacterial or viral origin.[16,17]

The World Health Organization's (WHO) Working Group Consensus of Concern about Indoor Air Pollutants reports that O_3 concentrations of "limited or no concern" are in the range of <0.05 ppm O_3. Concentrations of "concern," which may result in symptoms, are in the range of 0.08 ppm and greater. These indicated ranges are for short term exposures.[18]

The Food and Drug Administration prohibits devices that generate concentrations of O_3 of more than 0.05 ppm in enclosed areas occupied by the ill or infirm.[19]

The NIOSH Recommended Exposure Limit (REL)[1], the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Value®

(TLV)[2], and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for ozone is 0.10 parts per million (ppm) as a ceiling concentration. The OSHA PEL is 0.10 ppm as an eight-hour time-weighted average (TWA) and 0.30 ppm as a short-term exposure limit (STEL). There is no OSHA PEL ceiling standard.[3] These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 8-10 hours per day, 40 hours/week for a working lifetime without experiencing adverse heath effects. It is important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance over the course of a normal 8- to 10-hour workday. Some substances have a short-term exposure limit (STEL) or ceiling (C) values where there are recognized toxic effects from high short-term exposures. A STEL is the employee's 15-minute TWA exposure which may not be exceeded. Ceiling limits are concentrations which shall at no time be exceeded.

In evaluating the exposure concentrations, it should be noted that employers are legally required to meet those limits specified by an OSHA PEL.

VI. RESULTS and DISCUSSION

A. *Environmental*

Carbon Dioxide and Fresh Air Intake Carbon dioxide (CO_2) concentrations ranged from 350 to 875 ppm (see Table 1). Outdoor CO_2 concentrations ranged from 275 to 350 ppm. Building levels were lowest at the beginning of the day (averaging 392 ppm) and peaked in the afternoon (averaging 709 ppm) (see Figure 3). A slight drop was observed after some of the employees left the building for lunch. These levels are below the ASHRAE recommendation of 1000 ppm, which did not suggest that fresh air intake was inadequate.

Particulates Measurement results of respirable suspended particulates (RSP) can be found in Table 2. Except for the smoking room, all RSP levels were below the EPA PM_{10} standard of 150 ug/m^3. When a single employee was smoking in one of the individual offices within the HVAC #2 air distribution area, other offices served by the same HVAC showed a parallel increase in RSP levels as the result of recirculation of the smoke. RSP levels in the smoking room

increased steadily throughout the day, reaching an afternoon high of 1180 ug/m_3 in the afternoon (3:11 - 3:50 p.m.).

According to ASHRAE recommendations, smoking rooms should supply 60 cfm/person of "clean" air intake (may be transfer air from other areas). The exhaust in the smoking room, according to the design specifications, is 400 cfm. This air is mechanically exhausted to the outside. Assuming the exhaust flow is actually 400 cfm, no more than six smokers should be using the lounge. However, the highest RSP level (1180 ug/m_3) was measured when only three smokers were present. This indicates that the exhaust may be below the design specifications or that supplemental smoke removal equipment is necessary.

The smoking lounge was under negative pressure with respect to the adjacent hallway, preventing the migration of tobacco smoke to other work areas.

Temperature and Humidity Indoor temperatures (Table 3) ranged from 73.4 to 77.7 °F. This is generally within the comfort range specified by ASHRAE. The highest temperature (77.7 °F) was measured in the mail room and smoking room. The mail room had a disconnected supply duct; the smoking room was used extensively later in the day. Within the zone supplied by HVAC #1, significant temperature variability was measured on the day of the survey. HVAC #1 supplies both interior and perimeter areas of the building. Such designs sometimes result in greater temperature variability due to heat load differences, especially when the entire area is controlled by a single thermostat.

Relative humidities (Table 3) fell throughout the day (Figure 4). The mean relative humidity at the start of the day was 32.2%. By mid-afternoon, the mean relative humidity fell to 20.4%. As previously discussed, relative humidities below 30% can sometimes cause drying of mucous membranes and irritation. Low relative humidities are commonly present in buildings and homes in northern climates. The humidification system, which is designed to provide at least 30% relative humidity during the winter, did not appear to be functioning properly.

The placement and use of a single thermostat for each HVAC system may not adequately control comfort in all locations. The degree of control is probably related to outdoor environmental conditions and the demands placed on the HVAC system. During extremely cold or hot weather, the temperature variability within the building is probably more pronounced.

Visual Inspection A visual, qualitative inspection of the building and ventilation system did not reveal any serious functional problems. A duct supplying air to the mail room was found disconnected. In the accounting room, the supply duct

appeared to be unbalanced, since little air appeared to be supplied from the diffuser. HVAC system #5 was found to be running in the "auto" mode, rather than the "on" mode. This allowed the HVAC system to cycle on and off, depending on the heating demand. These problems may result in comfort related concerns for employees in the affected areas. No evidence of significant water damage or microbiological growth was found.

Ozone Breathing zone concentrations of O_3 for a person operating a laser printer ranged from 0.03 to 0.05 ppm, just slightly above the background concentration (0.02 - 0.03 ppm) in the area (see Table 4). These levels are within the range of "limited or no concern," according to WHO. The concentrations are also well below the OSHA standard (STEL 3.0 ppm) and the NIOSH REL and ACGIH TLV® (Ceiling of 0.1 ppm). At the exhaust exit of the printer, levels of 0.19 and 0.94 ppm O_3 were measured during printing. Unless a person is working very close to the exhaust on the printer, over-exposure to O_3 appears unlikely. The small quantity, albeit high concentration, of O_3 released from the printer exhaust quickly reacts and decomposes, apparently before reaching the breathing zone of the person operating the printer.

Ozone concentrations from photocopy machines ranged from 0.04 to 0.11 ppm for the Monroe® photocopier, and 0.02 to 0.18 ppm for the Konica® photocopier (see Tables 5 and 6). Several of the measurements were within the range of "concern" according to WHO (0.08 ppm and greater). Two measurements were above the NIOSH REL and ACGIH TLV® ceiling concentration of 0.1 ppm. These measurements were collected in the breathing zone of a person operating the copier. Measured concentrations of O_3 did not always appear consistent from one measurement to the next. Variability may be the result of nearby air currents (caused by people walking nearby). Both photocopy machines had the potential to create high concentrations of O_3 while in operation. After photocopying ceases, the concentrations of O_3 immediately decreased to background level. A potential hazard exists only when the photocopier is in operation. In addition, the hazard is apparently limited to the person operating the photocopier.

Air samples of other potential indoor air pollutants, such as volatile organic compounds and microorganisms, were not collected in this investigation. It was thought in this instance that these were not probable contributors to the reported employee symptoms. The ventilation system appeared to provide adequate outside air intake to control the buildup of contaminants such as volatile organic compounds. Microbiological growth was not visibly present anywhere in the building, nor was there a potential for growth of these organisms (no abnormal roof leaks, high humidity, etc.).

B. *Questionnaires*

Table 7 shows the percentage of respondents who reported their personal impressions regarding the comfort level of their work stations during the "last week" and the "last six weeks." The most common symptoms were those that have been reported in many other studies of building-related complaints (symptoms associated with mucous membrane irritation, fatigue or sleepiness, and headache).[20,21,22,23] The percentage of persons reporting symptoms is similar to that in other buildings using the same questionnaire and the same definition of a positive symptom.[21,22]

A majority of the respondents felt that there was insufficient air movement in their work station. A majority of the employees also felt that the temperature was too hot or too cold both during the "last week" and "last six weeks." A vast majority (81% during the "last six weeks," 78% during the "last week") felt that the humidity was too low. Most of the employees were uncomfortable enough to desire an adjustment in one or more of the above environmental conditions.

Table 8 shows the percentage of workers who noted the presence of specific odors at their work station on the day of the survey. The most significant odor reported were food smells (72%), cosmetics (56%), body odor (43%), and tobacco smoke (42%). Some odors may be common when many people are working in close proximity.

Table 9 indicates the percentage of respondents who experienced symptoms during the "last six weeks." Some of the symptoms may be attributable to low relative humidities in the building during the winter months. Ozone exposure from photocopy machines might also have contributed to these symptoms. These include dry, itching, or tearing eyes (73%), burning eyes (61%), dry throat (63%), and dry or itching skin (74%).

Eighty-six percent of the respondents indicated that they "sometimes, often, or always" had a headache during the "last six weeks." This apparently high prevalence may not be abnormal, since in the United States, an estimated 70 to 80% of the entire population experiences at least one headache per month. Headaches can be due to a wide variety of non-specific causes.[24]

Several of the reported symptoms (nausea, stuffy nose or congestion, sneezing, cough, chills, and aching muscles or joints) can result from colds or influenza, which are common during the winter months. Other symptoms, such as sore or strained eyes, headache, back pain or stiffness, unusual fatigue or sleepiness, headache, and pain or numbness in the hands or wrists are non-specific and can

be due to a variety of causes, including ergonomic factors at the work station. Ergonomics involves designing the job and workplace to fit the worker.

VII. RECOMMENDATIONS

Based upon the findings of this evaluation, the following recommendations are offered as prudent measures to improve air quality and comfort in the building.

1. Measurements on the day of the survey revealed some variability in temperature at different locations in the building. During extreme weather, these difference may be pronounced, resulting in complaints regarding thermal comfort. Relative humidity was poorly controlled on the day of the survey, even though the building is equipped with relative humidity controls. In addition, the level of complaints regarding thermal comfort indicates that the building may have poor thermal control at times.

   The HVAC contractor should check the ventilation system air flow to determine that the system is operating according to the design specifications. Optimally, offices and conference room areas should be provided with a minimum of 20 cfm/person. In place of the current thermostats with a single sensor, thermostats with multiple sensors that integrate temperatures within a zone might better control overall temperature. Thermostats in different zones should be set onthe same temperature so that the different HVAC systems operate in a uniform manner. It should be noted that providing uniform heating and cooling is sometimes difficult with constant volume systems, although they generally have the advantage of reliably delivering fresh air throughout the system. Accurate maintenance and preventative maintenance logs should be kept.

2. The HVAC contractor should inspect the steam humidifiers to determine if they are functional. The set-points on the humidistats, which control the humidifiers, should also be checked. The humidifiers should be visually inspected for microbiological or mold growth. These should be checked on a regular schedule.

   Additionally, the following should be included in regularly scheduled and recorded inspections. The HVAC systems on the roof should be inspected for proper drainage, biological growth, or other debris that could interfere with the system. The air intakes should be free of dead leaves, soil, or any visible microbiological or mold growth.

3. The smoking policy should prohibit smoking in all areas except the smoking room, since most of the air within the respective heating and cooling zones is recirculated. This will reduce complaints of cigarette smoke odors and reduce the possibility of health effects from the smoke. In the smoking room, the steady increase in RSP levels, along with concentrations nearly 12 times in excess of the EPA PM_{10} standard, indicates that the exhaust ventilation may be under the ASHRAE recommendation of 60 cfm/person rate. Supplementary smoke-removal equipment, such as an additional exhaust, may be required in the smoking room.

   In addition, management and labor should work together to develop appropriate nonsmoking policies that might include smoking-cessation classes, incentives to encourage workers to stop smoking, and distribution of literature on the harmful effects of smoking.

4. The ozone filters in the photocopy machines need to be replaced on a regular schedule. Some photocopier manufacturers recommend that the filters be changed every 60,000 copies (i.e. Konica®). For instance, if 100 copies per day are produced, the filters will need changing about every two and one-half years.

   To reduce personal contact with ozone, employees should avoid standing over the copier while it is operating. Photocopy machines should not be placed in the immediate vicinity of work stations. Since ozone dissipates quickly, exposures are probably not significant 4 or 5 feet from the copier. If a great deal of photocopying is performed, consideration should be given to placing the machines in a separate, well-ventilated, room. Also, a local exhaust ventilation system might be considered to remove ozone. This would reduce employee exposure to ozone, as well as noise and heat generated by the machines.

   The laser printer does not appear to be a significant source of ozone exposure. As a preventative measure, a service representative should be contacted to determine if there are any recommendations regarding replacement of the ozone filter.

5. An evaluation of potential workplace factors that could induce physical stress should be evaluated by a qualified consultant. This might involve ergonomic and anthropometric evaluations of the relationships of the employees to the equipment that they use.

If further evaluation or technical expertise is needed to resolve any indoor air problems, on-site assistance is available from the following sources. The expertise, availability, and cost of these consultants vary with locality and state.

1. A list of engineering firms certified by the National Environmental Balancing Bureau (NEBB) can be obtained from the following address:

   National Environmental Balancing Bureau
   8224 Old Courthouse Road
   Vienna, Virginia 22180

2. A list of industrial hygiene ventilation consultants who are members of the American Industrial Hygiene Association (AIHA) is available from the following address:

   American Industrial Hygiene Association
   345 White Pond Drive
   Akron, Ohio 44311-1087

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2. UAW Local 6000
3. OSHA, Region V

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 Concentrations
Oakland County Department of Social Services
Pontiac, Michigan
HETA 91-056

March 28, 1991

	Carbon Dioxide Concentrations (ppm)			
Location Phone#/Code	Time 0625-0704	Time 1011-1043	Time 1300-1359	Time 1511-1550
8742 A	450	675	550	675
8738 B	425	725	575	675
8731 C	425	675	575	625
8583 D	425	700	525	700
8577 E	425	675	525	700
8564 F	375	700	575	675
8547 G	375	675	550	675
8287 H	375	700	550	800
8293 I	375	650	550	675
8280 J	400	650	550	675
8285 K	425	725	575	725
8709 L	425	750	600	725
8707 M	400	775	725	850
8283 N	400	750	650	725
8504 O	375	725	625	725
8279 P	350	675	600	675
8704 Q	350	675	675	675
8749 R	350	625	525	675
8725 S	350	525	500	625
Mail Room T	--	675	625	775
CIS Room U	375	600	575	675
Smoking Room V	375	825	575	875
Outside W	300	--	275	350

TABLE 2

Respirable Particulates
Oakland County Department of Social Services
Pontiac, Michigan
HETA 91-056

March 28, 1991

Location Phone#/Code	Respirable Particulates ($\mu g/m^3$) Time 0625-0704	Time 1011-1043	Time 1300-1359	Time 1511-1550
8742 A	3	7	20	6
8738 B	3	9	17	2
8731 C	2	7	24	3
8583 D	3	10	12	5
8577 E	3	9	10	4
8564 F	6	8	9	4
8547 G	4	8	12	4
8287 H	3	8	10	7
8293 I	6	8	10	7
8580 J	0	7	9	7
8285 K	3	10	10	5
8709 L	3	48	9	7
8707 M	2	48	24	6
8283 N	4	46	10	6
8540 O	2	5	10	4
8279 P	4	40	8	4
8704 Q	4	8	7	7
8749 R	4	7	6	7
8725 S	4	6	5	7
Mail room T	--	15	7	5
CIS room U	4	13	5	7
Smoking room V	3	180	225	1180
Outside W	10	--	5	8

TABLE 3

Temperature and Relative Humidity
Oakland County Department of Social Services
Pontiac, Michigan
HETA 91-056

March 28, 1991

Location Phone#/Code	Temperature (°F) & Relative Humidity (%) Time 0625-0704	Time 1011-1043	Time 1300-1043	Time 1511-1550
8742 A	74.5/33.4	74.8/24.3	74.5/21.4	75.7/19.2
8738 B	75.0/32.6	74.8/24.5	76.4/22.4	75.5/19.4
8731 C	74.7/31.3	74.7/24.1	74.7/22.5	75.3/19.3
8583 D	74.7/36.9	74.7/24.9	74.9/21.7	75.3/20.6
8577 E	75.6/31.5	74.7/24.7	75.0/21.9	75.5/20.4
8564 F	75.7/34.0	74.8/24.4	75.3/21.8	75.6/20.1
8547 G	75.8/34.9	74.7/24.5	75.1/21.5	75.5/19.4
8287 H	75.9/32.1	75.0/24.1	75.1/21.7	75.6/20.9
8293 I	76.2/28.8	75.0/23.2	73.7/21.0	74.6/20.0
8280 J	75.9/32.3	74.3/23.7	73.8/22.3	74.2/20.0
8285 K	75.5/30.0	74.1/25.2	73.9/22.1	74.0/20.6
8709 L	74.5/31.6	73.9/26.6	73.8/23.4	74.2/22.5
8707 M	73.4/34.8	73.8/27.7	74.3/26.5	74.0/23.8
8283 N	73.4/33.9	75.6/25.0	74.7/23.4	74.4/21.6
8540 O	73.6/34.5	74.1/24.7	75.1/22.0	74.5/21.1
8279 P	74.9/31.1	76.1/24.0	77.7/20.5	77.6/19.5
8704 Q	74.5/29.7	75.2/23.2	75.3/21.2	76.1/19.0
8749 R	74.6/30.3	75.2/23.7	75.5/20.3	76.0/19.0
8725 S	74.5/30.9	74.9/24.1	75.4/21.7	75.2/21.3
Mail room T	--/--	76.4/24.9	76.5/22.0	77.7/20.7
CIS room U	74.9/30.0	75.3/23.2	75.5/19.6	76.6/18.4
Smoking room V	74.1/32.0	75.3/28.0	77.4/21.9	77.7/21.9
Outside W	39/67	43/--	51/37	51/40
Mean	74.9/32.2	74.9/25.1	75.2/21.9	75.5/20.4

TABLE 4

Ozone Concentrations, Unisys Laser Printer
Personal Breathing Zone
Oakland County Department of Social Services
Pontiac, Michigan
HETA 91-056

March 28, 1991

		Ozone Concentration (ppm)		
Number of Pages	Time	Start	Stop	
2	1419-1419	0.03	0.05 (PBZ) 0.19 (exhaust exit	of printer)
10	1425-1427	0.03	0.03 (PBZ) 0.94 (exhaust exit	of printer)
10	1450-1452	0.02		

TABLE 5

Ozone Concentrations, Monroe RL-932 Copier
Personal Breathing Zone
Oakland Department of Social Services
Pontiac, Michigan
HETA 91-056

March 28, 1991

		Ozone Concentration (ppm)	
Number of Copies	Time	Start	Stop
0	0820-0825	0.04	0.04 (no copies)
4	0825-0827	0.04	0.08
30	0830-0833	0.05	0.09
8	0835-0836	0.03	0.09
6	0838-0839	0.04	0.07
3	0839-0840	0.07	0.11
30	0842-0845	0.03	0.06 (9 copies) 0.09 (21 copies) 0.09 (30 copies)
4	0848-0848	0.02	0.07

TABLE 6

Ozone Concentrations, Konica Copier 2590
Personal Breathing Zone
Oakland County Department of Social Services
Pontiac, Michigan
HETA 91-056

March 28, 1991

		Ozone Concentration (ppm)	
Number of Copies	Time	Start	Stop
6	0850-0851	0.0	0.0
1	0854-0855	0.0	0.18
1	0858-0858	0.02	0.08
1	0902-0902	0.04	0.04
30	0913-0915	0.02	0.02

TABLE 7

Environmental Comfort Parameters
Oakland County Department of Social Services
Pontiac, Michigan
HETA 91-056

March 28, 1991

	Occurrence of Parameter* (percentage)	
Comfort Parameter	Last 6 weeks	Last Week
Too much air movement	25	18
Too little air movement	75	80
Want to adjust air movement	84	84
Temperature too hot	67	64
Temperature too cold	79	73
Want to adjust temperature	94	91
Too humid	20	17
Too dry	81	78
Want to adjust humidity	79	76
Air too stuffy	84	84
Too noisy	74	72
Too quiet	7	7
Work area too dusty	75	74

* Prevalence of parameter that occurred "sometimes, often, or always."

TABLE 8

Odor Occurrence
Oakland County Department of Social Services
Pontiac, Michigan
HETA 91-056

March 28, 1991

Type of Odor	Occurrence of Odor* (Percentage) (Last 6 weeks)
Body odor	43
Cosmetics (perfume, after-shave)	56
Tobacco smoke	42
Fishy smells	21
Other food smells	72
Moist or damp basement smells	21
Odors from new carpet	7
Odors from new drapes or curtains	10
Odors from engine exhaust	6
Odors from photocopy machines	24
Odors from printing processing	6
Odors from other chemicals (glues, cleansers, etc.)	29
Odors from pesticides	27
Odors from cleaning carpets, drapes, furnishings	5
Odors from paint	1
Other unpleasant odors	27

* Odor during the last six weeks that occurred "sometimes, often, or always."

TABLE 9

Frequency of Symptoms
Oakland County Department of Social Services
Pontiac, Michigan
HETA 91-056

March 28, 1991

Symptom	% Experiencing Symptom in last 6 weeks: Sometimes, Often or Always	% Experiencing Symptom in last 6 weeks: Often or Always	% Who report symptom improves when not at work
Headache	86	54	73
Nausea	32	1	43
Runny Nose	75	41	59
Stuffy Nose/Congestion	83	61	57
Sneezing	63	37	52
Cough	41	26	38
Wheezing	25	14	42
Shortness of Breath	23	7	49
Chest Tightness	25	6	45
Dry, Itching, Tearing Eyes	73	51	73
Sore/Strained Eyes	77	51	77
Blurry/Double Vision	33	11	68
Burning Eyes	63	36	75
Sore Throat	51	17	52
Hoarseness	40	11	58
Dry Throat	63	31	66
Unusual Fatigue or Tiredness	88	56	74
Sleepiness or Drowsiness	83	40	76
Chills	44	19	72
Fever	15	3	41
Aching Muscles or Joints	42	21	37
Problems with Contact Lenses	28	26	77
Difficulty Remembering Things	50	21	32
Dizziness/Lightheadedness	43	11	61
Feeling Depressed	29	20	49
Tension or Nervousness	69	30	74
Difficulty Concentrating	66	24	74
Dry or Itching Skin	74	48	33
Upper Back Pain or Stiffness	53	34	58
Lower Back Pain or Stiffness	59	30	44
Shoulder/Neck Pain or Numbness	54	31	60
Hands/Wrists Pain or Numbness	39	15	54