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ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION JUNEAU, ALASKA

NIOSH INVESTIGATOR:

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I. SUMMARY

On April 22, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Safety Officer of the Alaska Department of Environmental Conservation in Juneau, Alaska to conduct a health hazard evaluation (HHE) at the new Department of Environmental Conservation (DEC) office building in Juneau. The requestor was seeking assistance with indoor air quality concerns in the building.

On August 25-26, 1992, an evaluation of the 3-story office building was conducted. The NIOSH evaluation consisted of: (1) an assessment of questionnaire results from building employees, (2) an examination of the building's heating, ventilating and air conditioning (HVAC) systems, (3) an examination of the building for identifiable contaminant sources, (4) interviews with representatives from the building management and building employees; (5) and an environmental survey designed to assess key parameters related to the building's air quality including carbon dioxide (CO_2), temperature, humidity, carbon monoxide, and air samples for volatile organic compound (VOCs).

Prior to the site visit, questionnaires were circulated by the requestor and summarized by the investigator. There was a 65% response rate (129 of 200 occupants) to the questionnaire. The major complaints were centered on comfort-related issues; the building was too hot, too stuffy (lack of air circulation), and there were noticeable odors. The major health problems reported were headache (19%), stuffy or runny nose (16%), burning or itchy eyes (13%), and a host of miscellaneous symptoms (18%). Occupants on the first and third floors uniformly complained that the building was too hot on hot days and too cool on cool days. The predominant complaint on the second floor was that the air in the building was too dry.

The ventilation system consisted of a central HVAC system which provided heated and cooled air to 78 zones. Each zone contained variable air volume boxes to control the heating/cooling for that zone. The central HVAC system was on an economizer cycle which had a minimum setting for outside air of 20%. Since employees began experiencing symptoms (December, 1991), the building HVAC system was set to operate with 100% outside air. Estimates of outside air volumes were made by an engineering firm, during normal operation, and were calculated to be at 85% or about 36 cubic feet per minute (cfm) of outside air per occupant.

Carbon dioxide (CO_2) levels ranged from 325 up to 880 ppm throughout the building during August 25 and 26. Outside levels stayed fairly constant at 300 ppm of CO_2. No CO_2 levels were measured above 1000 ppm anywhere in the building. Relative humidity levels were fairly constant for both days, ranging between 33 and 45% RH. Temperature levels ranged from 70° to 77.2° throughout the two days. The outside air dampers were fully open during these measurement periods. Most of these values fall within the ASHRAE thermal comfort guidelines.

Based on the building inspection and the environmental monitoring results, the investigator was unable to identify any airborne contaminants which would constitute a health hazard. Minor deficiencies in the ventilation system were noted. Recommendations are made in Section VIII to help alleviate the employee complaints.

KEYWORDS: SIC 9511 (Air and Water Resource and Solid Waste Management), indoor air quality, indoor air pollution, IAQ, IEQ.

II. INTRODUCTION

On April 22, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Safety Officer of the Alaska Department of Environmental Conservation in Juneau, Alaska to conduct a health hazard evaluation (HHE) at the new Department of Environmental Conservation (DEC) office building in Juneau. The requestor was seeking assistance with indoor air quality concerns in the building.

On August 25-26, 1992, an evaluation of the 3-story office building was conducted. During the visit the investigator talked with state administrative personnel, affected employees, and supervisors of affected employees. Complaint questionnaires had been distributed to all employees in the building and the results had been tabulated prior to the site visit. Responses were received from 65% of the building occupants. The major complaints were centered on comfort-related issues; the building was too hot, too stuffy (lack of air circulation), and there were noticeable odors in the air. The major health problems reported were headache, stuffy or runny nose, burning or itchy eyes, and a host of miscellaneous symptoms. A thorough visual inspection of the heating, ventilating, and air-conditioning (HVAC) unit serving the building was conducted. Also, carbon dioxide (CO_2), temperature, relative humidity, and air samples for volatile organic compounds (VOCs) were collected to evaluate the efficiency of the HVAC system and the overall indoor air quality.

III. BACKGROUND

The State of Alaska DEC building is a three-story wood frame building with approximately 50,000 square feet of office space and 200 occupants. The Department moved from several different locations into the building in November of 1991. Shortly after moving in, employees began complaining of poor air quality and physical discomfort.

The building ventilation consists of a central HVAC system which provides heated and cooled air to 78 zones. Each zone contains variable air volume boxes to control the heating/cooling for that zone. The central HVAC system is on an economizer cycle which has a minimum setting for outside air of 20%. Since employees began experiencing symptoms, the building has been set for 100% outside air. Before occupancy, the HVAC system was operated for 90 days. Estimates of outside air volumes were made by the engineering firm who is in charge of maintaining the building HVAC systems. This was done in October, 1991 before occupancy and then again in December, 1991 after the tenants had moved in and were experiencing problems. On both occasions, they calculated the outside air to be at 85% or about 36 cubic feet per minute (cfm) of outside air per occupant, far in excess of the ASHRAE guidelines of 20 cfm per person.

The ventilation system is shut down overnight. When the building was first occupied, the ventilation system was on from 8:00 am to 4:30 pm. After occupants began having problems, the system was changed to start at 6:30 am and operate until 5:30 pm. Most occupants work 8:00 am to 4:30 pm but many arrive between 7:00 am and 8:00 am and may work occasionally on the weekend. The building has a no smoking policy in effect.

Once employees began experiencing problems, a number of corrective measures were tried, including: increasing the amount of outside air to 100%, operating the ventilation systems longer, changing the system design temperatures, having inspections conducted by the building system

engineering firm and the Alaska Department of Labor (OSHA), conducting air sampling, keeping employee logs of symptoms, and conducting employee surveys. None of these actions resolved the problems.

IV. MATERIALS AND METHODS

The NIOSH evaluation consisted of: (1) an assessment of questionnaire results from building employees, (2) an examination of the building's HVAC system, (3) an examination of the building for identifiable contaminant sources, (4) interviews with representatives from the building management and building employees; and (5) an environmental survey designed to assess key parameters related to the building's air quality. The specific measurements and types of samples collected in the environmental survey are detailed below.

A. Instantaneous measurements of carbon dioxide (CO_2) concentrations were made at several different times and locations throughout the building and outdoors. These measurements were made using a Metrosonic Model AQ-501 Indoor Air Quality Meter which included a portable direct-reading infrared analyzer capable of measuring CO_2 concentrations up to 5000 parts per million (ppm). The instrument was calibrated before use and checked against outdoor levels at various intervals throughout the workday. The same instrument was used to measure temperature and relative humidity. The instrument could be used for instantaneous determination of levels of CO_2, temperature, and relative humidity or to store the data for long periods on an internal data logger.

B. Concentrations of carbon monoxide (CO) were measured using a Draeger Model 190 Datalogger. This is a direct-reading electrochemical instrument which is specific for CO.

V. EVALUATION CRITERIA

A number of published studies have reported a high prevalence of symptoms among occupants of office buildings.[1-5] NIOSH investigators have completed over 700 investigations of the indoor environment in a wide variety of settings. The majority of these investigations have been conducted since 1979.

The symptoms and health complaints reported 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.

Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are imprecisely defined characteristics of HVAC systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[8-13] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts (>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 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]

There are also reports describing results which show 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.[21-24]

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 exhaust and inadequately ventilated kerosene heaters or other fuel-burning appliances. Exposure to boiler additives can occur if boiler steam is used for humidification or is released by accident.

Problems NIOSH investigators have found in the non-industrial indoor environment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from office furnishings, machines, structural components of the building and 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, no cause of the reported health effects could be determined.

Standards specifically for the non-industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[25-27] With few exceptions, 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.[28-29] 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.[30]

Measurement of indoor environmental contaminants has rarely proved to be helpful, in the general case, in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proved relationship between a contaminant and a building-related illness. However, measuring ventilation and comfort indicators such as carbon dioxide (CO_2), and temperature and relative humidity, is useful in the

early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems. The basis for the measurements made in this investigation are presented below.

A. Carbon Dioxide (CO_2)

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 fresh air are being introduced into an occupied space. The 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.[28]

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

B. 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.[29]

C. Carbon Monoxide

Carbon monoxide can occur as a waste product of the incomplete combustion of carbonaceous fuels. Sources of carbon monoxide in indoor environments include tobacco smoke, malfunctioning or improperly vented heating systems, and the introduction of contaminated air from outside sources such as loading docks. Carbon monoxide exposure in sufficient concentrations can result in headache dizziness, drowsiness, nausea, vomiting, collapse, coma, and death.[3]

D. Environmental Tobacco Smoke (ETS)

Environmental tobacco smoke is a well-recognized health hazard, associated with effects ranging from eye irritation to lung cancer[32-37]. NIOSH has recently published a Current Intelligence Bulletin (CIB #54) on Environmental Tobacco Smoke in the Workplace, Lung Cancer and Other Health Effects[38]. This document summarizes the literature on ETS and concludes that ETS meets the OSHA criteria as a potential occupational carcinogen and, therefore, exposures to ETS should be reduced to the lowest feasible concentration. The document further recommends that "Employers should minimize occupational exposure to ETS by using all available preventative measures."

The Federal Occupational Safety and Health Administration (OSHA) currently has no specific regulation regarding exposure to environmental tobacco smoke.

VI. RESULTS AND DISCUSSION

A. HVAC System Inspection

The central HVAC system was new and in good working order. There was standing water in the drip pans under the condensation coils which was indicative of poor drainage. Many of the workers that were complaining of temperature problems did not know the location of the thermostat that controlled the temperature in their zone. Several of these controls were located during the survey using mechanical drawings, and were pointed out to the employees. Some of the thermostats were located in adjacent spaces which were unoccupied.

The ventilation system consisted of a central HVAC system which provided heated and cooled air to 78 zones. Each zone contained variable air volume boxes to control the heating/cooling for that zone. The central HVAC system was on an economizer cycle which had a minimum setting for outside air of 20%. When employees began experiencing problems, the HVAC system was set to operate with 100% outside air. Before occupancy, the HVAC system was operated for 90 days while the building was empty. Estimates of outside air volumes were made by the engineering firm who is in charge of maintaining the building HVAC system. This was done in October, 1991 before occupancy and then again in December, 1991 after the tenants had moved in and were experiencing problems. On both occasions, the firm calculated the outside air to be at 85% or about 36 cfm of outside air per occupant.

The ventilation system is shut down overnight. When the building was first occupied, the ventilation system was on from 8:00 am to 4:30 pm. After occupants began having problems, the system was changed to start at 6:30 am and operate until 5:30 pm. Most occupants work 8:00 am to 4:30 pm but many arrive between 7:00 am and 8:00 am and may work occasionally on the weekend. Therefore, there are times when workers are in the building and no ventilation is on. According to one of the building owners, ventilation in any zone can be turned on at any time by pressing a button on the zone temperature control, thus alleviating this problem. No one in the building that NIOSH interviewed, including management representatives, were aware of that building feature.

B. Environmental Survey Results

Spot measurements of carbon dioxide (CO_2), temperature, and humidity measured throughout the building on August 25 and 26, 1992 are summarized in Table 1. Longer term measurements were collected on each floor and stored electronically in data loggers. These data are shown graphically and in a summary report in Figures 1-3. Carbon dioxide (CO_2) levels ranged from 325 up to 880 ppm throughout the building during August 25 (Table 1 and Figure 1) and about the same on August 26, 325 up to 807 ppm (Table 1, Figures 2 and 3). Outside levels stayed fairly constant at 300 ppm of CO_2. No CO_2 levels were measured above 1000 ppm anywhere in the building. Relative humidity levels were fairly constant for both days, ranging between 33 and 45% RH. Temperature and

humidity logs had been recorded in a first floor instrument room since these workers had moved into the building (their instruments required a minimum of 30% RH to operate properly). During the winter months, humidities as low as 10% were recorded. Temperature levels ranged from 70° to 77.2° throughout the two days. The outside air dampers werefully open during these measurement periods. Most of these values fall within the thermal comfort guidelines of 69° to 76°F temperature range and the 30 to 60 percent relative humidity range recommended by ASHRAE.[29]

The environmental air samples identified several organic compounds (see attached analytical report; Attachment 1) but none in any substantial quantity. The estimated concentration ranges for the various chemicals is 15-30 micrograms per cubic meter. These levels are at least a factor of 1000 less than the recommended occupational exposure limits for these chemicals.

Carbon monoxide (CO) levels were measured throughout the building and were found to be less than 1 ppm. The CO instrument was worn by the investigator during the entire investigation which took him to all areas of the building over a two-day period.

C. Results of Questionnaires

Prior to the site visit, questionnaires were circulated by the requestor and had been summarized by the investigator. The results of these questionnaires are summarized in Table 2. There was a response rate of 65% (129 of 200 occupants) to the questionnaire. The major complaints were centered on comfort-related issues; the building was too hot, too stuffy (lack of air circulation), and there were noticeable odors in the air. The major health problems reported were headache (19%), stuffy or runny nose (16%), burning or itchy eyes (13%), and a host of miscellaneous symptoms (18%). Occupants on the first and third floors uniformly complained that the building was too hot on hot days and too cool on cool days. The predominant complaint on the second floor was that the air in the building was too dry.

VII. CONCLUSIONS

In general, measurements of ventilation system parameters (i.e., CO_2, temperature, and relative humidity) did not reveal any particular problems with the system on the days examined. Conditions were such that the outside air dampers were fully open. The CO_2 and humidity levels were all within recommended limits. However, humidity levels as low as 10% had been recorded by building occupants during the cold weather months. The temperature, in general, was within the ASHRAE guidelines although it was cool in the morning and was hot by afternoon. It is possible that temperature variation could be greater on hotter and colder days. No organic chemicals were found in levels high enough to be of concern. In fact, the levels were lower than is normally found for many of the common organic chemicals identified in indoor air quality investigations around the country. The only real deficiencies noted were the standing water in the condensation drip pans and the fact that the ventilation system might be off while workers are inside the building.

The major worker complaints centered around comfort related issues, i.e., the temperature was too hot or too cold. Thirty-three percent of those workers responding to the symptom questionnaire reported that conditions had improved recently. The specific symptom complaints were around 20%, which is about what is estimated to be the background levels for complaints in buildings around the world.[4]

VIII. RECOMMENDATIONS

1) Drainage should be provided for the condensation collected in the drip pans under the cooling coils in the HVAC system.

2) The workers in the building should be educated about how the ventilation system works. This should include the location of the thermostat that controls the ventilation zone in which they work and how to turn the system on during off hours.

3) Continue running the ventilation system longer after occupants leave and start it up earlier in the morning to insure that the building is purged prior to occupancy.

4) The maximum person loading should be checked on the first floor. ASHRAE recommends a maximum loading of 7 people per 1000 square feet for general office areas.[28]

5) Insure that VAV boxes have minimum stops which allow the ASHRAE outside air criteria to be met.

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3. Mad/TIFF Development Co., Juneau, Alaska.
4. U.S. Department of Labor/OSHA - Region X.
5. NIOSH, Region VIII

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

TABLE 1
Indoor Air Quality Measurements Summary
ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
Juneau, Alaska
HETA 92-228
August 25-26, 1992

Area	Floor No.	Time	CO^2 (ppm)	Temp. (F)	%RH
August 25, 1992					
Outside	1	1:50p	300	65	45
Safety Office	3	2:00p	610	74	37.6
Personnel	3	2:25p	530	74.2	35.2
AdMin Services	3	2:37p	620	73.6	36.2
Computer Service	3	2:30p	630	73.6	36.5
Commissioner's Office	3	2:32p	570	74	36.4
Outside Commissioner's Office	3	2:38p	630	73.5	36.5
Environmental Quality	2	2:41p	560	73.6	36
Water Quality	2	2:44p	740	74	35.3
Solid & Hazardous Waste	2	2:50p	640	74	36.1
Wedge-shaped office area	2	2:54p	700	74.5	35.6
Solid & Hazardous Waste	2	3:04p	610	74.8	34.6
FC&O	1	3:08	660	74	36.4
Air Quality	1	3:12p	705	73	37.9
August 26, 1992					
Outside (light rain)	1	6:10a	300	55	>70
Safety Office	3	6:20a	425	70.0	40.2
Water Quality	2	6:50a	325	72.3	40.2
Hallway	2	6:55a	325	72.7	40.2
Hallway	1	7:00a	665	72.1	43.1
Mailroom	1	7:04a	505	72	42.6
North office area	1	7:08a	590	71.3	42.6
South office area	3	7:14a	330	71.8	40

CO_2 = carbon dioxide
RH = relative humidity
ppm = part per million

TABLE 2
Indoor Air Quality Questionnaire Summary
ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
Juneau, Alaska
HETA 92-228
August 25, 1992

COMPLAINTS	Floor No. 1st (%)	2nd (%)	3rd (%)	All N	All %
Number of Respondents (200 total)				129	65
Yes, I have a complaint	96	100	100	89	69
Temperature too cold	18	16	42	25	19
Temperature too hot	9	80	53	44	34
Lack of air circulation	50	92	78	67	52
Noticeable odors	32	32	19	24	19
Dust in the air	4	0	8	4	3
Disturbing noises	46	16	8	19	15
Other-	4	8	28	13	10
HEALTH PROBLEMS OR SYMPTOMS					
Watery, burning, itchy eyes	18	16	22	17	13
Stuffy, runny nose	36	16	19	21	16
Sneezing	4	8	11	7	5
Headache	27	16	28	25	19
Coughing	0	0	3	1	1
Sore throat	4	4	14	7	6
Other-sleepy, irritable dry skin, bloody nose	12	24	31	23	18
OCCURRENCE					
All day/daily	55	40	33	37	29
No trend	4	24	36	21	16
Morning	8	4	6	5	4
Afternoon	8	32	14	16	13
OTHER FACTORS					
Smokers	0	0	0	0	0
Allergies	8	16	8	9	7
Contact wearers	41	20	36	28	22
VDT users	68	72	81	68	53

COMMENTS

Response rate was 129/200 or 65%. Only 99 questionnaires, the positive responses, were received.

Predominant complaints were that it was stuffy, too dry, too hot, not enough windows, over-crowded, and odors.