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PENSACOLA CITY HALL
PENSACOLA, FLORIDA

NIOSH INVESTIGATORS:
Gregory A. Burr, CIH

I. SUMMARY

In response to a management request from the city of Pensacola, Florida, an environmental survey was performed on February 21 to 22, 1991, at the Pensacola City Hall. Industrial hygiene measurements for temperature, relative humidity (RH), carbon dioxide (CO_2), and airborne particulates were made on floors 4 through 7. Approximately 150 self-administered questionnaires were distributed to city employees in the building as part of this evaluation. A total of 102 completed questionnaires (68%) were returned for analysis.

On the days of this survey, the CO_2 concentrations on floors 4 through 7 were below 1000 parts per million (ppm), a guideline which NIOSH uses to determine the adequacy of the ventilation in an office work area. The ambient CO_2 concentration outside the office building ranged from 400 to 425 ppm.

All work areas surveyed were within the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) guidelines for both temperature and RH. The ASHRAE "comfort chart," which presents temperature and RH ranges considered to be both comfortable and healthful for a majority of employees, lies between 73 and 77°F and 20 to 60% RH.

The concentrations of respirable particulate matter, measured with a direct reading aerosol monitor, ranged from 2 to 70 micrograms per cubic meter (ug/m^3). Although there are no established criteria for exposure to airborne total particulate in office buildings, as a guideline, the Environmental Protection Agency's (EPA) Ambient Air Quality Standard for respirable particulate matter (PM_{10} standard, 150 ug/m3 for 24 hours) was used.

In general, employees on floors 3 through 7 were nearly equally divided on the temperature of their work space (either too hot, too cold, or just right). Most employees considered the RH levels acceptable throughout the building. Most of the employees felt the illumination levels in their work area were adequate, with the highest acceptance levels obtained from workers on floors 3 and 7. More than one-half of the respondents on floors 4 and 6 felt that their work area was "too dusty." The percentages of workers who considered their work environment "too noisy" ranged from 8% (7th floor) to 58% (5th floor). The majority of employees on the 3rd floor (63%) who responded to the questionnaire felt their work area was "too stuffy."

Based on the data collected during this survey, NIOSH investigators concluded that the indoor air quality parameters which were measured (carbon dioxide, temperature, relative humidity, and particulates), were within acceptable levels. An indoor air quality problem did exist, however, in that the existing smoking policy at the Pensacola City Hall did not restrict smoking to smoking areas/lounges which were provided with a dedicated air handling system to reduce the possibility of reentrainment and recirculation of any secondary cigarette smoke. Recommendations for several minor ventilation repairs are included in Section X. of this report.

Keywords: SIC 9199 (General Government), indoor air quality, carbon dioxide, ventilation, temperature, relative humidity, particulates.

II. INTRODUCTION

NIOSH received a request from the city of Pensacola for technical assistance in investigating a history of numerous health complaints among employees at the Pensacola City Hall, a modern (five years old) seven story office building located in downtown Pensacola, Florida. The reported health complaints, which included fatigue, nausea, and headache, were thought to result from various indoor air quality problems. There is no union representing the city employees in this building.

An initial site visit to the building was conducted on February 21 to 22, 1991. During this survey NIOSH investigators met with the appropriate city officials, distributed a brief questionnaire to all city employees working in the building, and performed industrial hygiene measurements on floors 4 through 7 of the building.

III. BACKGROUND

The 7-story Pensacola City Hall, which was completed in 1985, is located in downtown Pensacola. Constructed of brick and glass, the building has approximately 70,500 square feet of total office space, including the main floor lobby and second floor conference rooms. An unusual feature of the building is the existence of numerous small outside balcony areas on floors 3 through 7 which are accessible from several locations on each floor, including the main elevator/lobby area.

This evaluation focused on floors 3 through 7, the areas where most of the workers are located. Each floor has approximately 11,000 square feet of available office space (only one-half of the office space on the 3rd floor, however, is currently finished and occupied). Since all the floors in this building have similar uses (general office space), and the separate heating, ventilating, and air conditioning (HVAC) systems are identically designed for each floor, it was assumed that the conditions found in the areas surveyed should be representative for the entire building.

A large atrium, several conference rooms, a snack bar, and a two-story lobby comprise the first and second floors of the Pensacola City Hall. Aside from the mayor's offices, which are also located on the second floor, both the first and second floors are typically unoccupied (with the exception of transient traffic entering and leaving the building, the receptionist's desk on the first floor, and the conference rooms where workers attend scheduled meetings). The third floor, as noted before, is only half finished, and houses the city Department of Transportation and Housing. The remaining city workers are located on floors 4 through 7 in the following departments:

4th Floor:	Treasury, Human Resources
5th Floor:	Leisure Services, Inspections, Engineering, Planning
6th Floor:	Risk Management, Finance, Port of Pensacola
7th Floor:	City Attorneys, City Managers

The occupancy level per floor (as determined from a walk-through conducted on February 21, 1991) is shown below:

Floor Number	Total Occupancy
3	
15	
4	42
5	34
6	42
7	24

A. VENTILATION

A variable air volume (VAV) system provides heating and cooling for all of the office areas. Pre-insulated flexible ducts run from each VAV distribution box to slot diffusers (0^{o} deflection bar-type linear side-wall registers with directional blades) located throughout the area serviced by the distribution box (including the perimeter offices.) A receiver/controller, based on a signal from an air velocity sensor located in the office area, maintains the outside air velocity in the system at a constant, preselected set point (via the OA booster fan.) A natural gas fired boiler, located on the first floor, provides hot water to the VAV boxes for heating purposes.

Each floor has a separate outside air (OA) intake (30" by 30" square louvered opening) located along the rear wall of the building. Each OA intake is provided with a booster fan prior to the mixing box (point where the return air from the office area is mixed with the OA prior to being returned to the offices) with a design OA requirement of 1200 cubic feet per minute (cfm) per floor. For acoustical and thermal purposes, fiberglass duct liner is used to line the metal ducts on all of the floors. A common return plenum (formed by the space between the suspended ceiling and the floor above) serves as the return air system for each floor (with the exception of the dedicated exhausts for the bathrooms).

When the office building was completed in 1985, an innovative "Thermal Storage System" was installed to provided cooling for the building. Consisting of two underground ice slurry tanks, this system was unfortunately greatly undersized, according to city representatives, and eventually proved incapable of providing the cooling needed daily for the building under maximum thermal load conditions. The system was disconnected several months after the building first opened. Air conditioning is now provided by a traditional chiller system which is located on the ground floor adjacent to the loading dock in the rear of the building.

As shown in the following table, the design capacities of the HVAC systems for each floor are very similar. Separate dedicated supply and exhaust systems, which are not listed here, are provided for the small darkroom and print shop which are located on the first floor of the building.

Location	Total CFM	Outside Air	Total Capacity
3rd Floor	12,000	1200	335,219 BTU/HR
4th Floor	12,000	1200	335,219 BTU/HR
5th Floor	12,000	1200	335,219 BTU/HR
6th Floor	12,000*	1200	335,219 BTU/HR
7th Floor	10,800	1200	329,557 BTU/HR

***NOTE: The sixth floor has an auxiliary system (6,000 CFM, no outside air) which cools the computer room.]**

Air filtration for the building when it first opened consisted of standard "furnace" type filters on each of the HVAC units. In 1989 these filters were replaced with pleated filters which had a higher efficiency rating (approximately 60%). These filters are reportedly changed monthly by the building's maintenance staff regardless of condition.

B. SMOKING POLICY

Implementation of the smoking policy at the Pensacola City Hall is left up to the individual departments. Smoking is permitted in designated areas which may include an employee's work space (i.e. cubicle or office), a open area of an office, locations such as the snack area, or any of several outside balconies which are located along the perimeter of the upper floors of the building.

IV. METHODS

A. ENVIRONMENTAL

The monitoring and analytical procedures used in this survey included the following three measurements:

1. Temperature and Relative Humidity (RH).

Real-time temperature and RH measurements were made using a Vaisala Model HM 34 humidity and temperature meter. The HM 34 is a battery-operated meter which uses humidity and temperature sensors housed at the tip of an extendable probe. Humidity measurement is performed by a Humicap© sensor which has a measurement range from 0 to 100%. The temperature sensor has a measurement range from -4 to 140^{o}F.

2. Carbon Dioxide (CO_2).

Real-time CO_2 levels were determined using a Gastech Model RI-411A, Portable CO_2 Indicator. This portable, battery-operated instrument monitors

CO_2 (range 0-4975 ppm) via non-dispersive infrared absorption with a sensitivity of 25 ppm. Instrument zeroing and calibration was performed daily prior to use with zero air and a known CO_2 span gas (800 ppm).

3. Respirable Particles (RSP):

Real-time RSP concentrations were measured using a GCA Environmental Instruments Model RAM-1 monitor. This portable, battery-operated instrument assesses changes in particle concentrations via an infrared detector, centered on a wavelength of 940 nanometers. Indoor air is sampled (2 liters per minute) first through a cyclone preselector which restricts the penetration of particles greater than 9 micrometers in diameter. The air sample then passes through the detection cell. Operating on the 0-2 milligram per cubic meter (mg/m3) range with a 32 second time constant yields a resolution of 0.001 mg/m3 [equivalent to 1 microgram per cubic meter of air (ug/m^3)].

B. QUESTIONNAIRES

Brief (one-page) self-administered questionnaires were distributed to all Pensacola city employees on February 21, 199l. The questionnaires collected information about various aspects of the work environment, including temperature, humidity, lighting, and noise. Employees were also asked to evaluate other factors in their work environment such as "stuffiness," the amount of dust they perceived at their workstations, and physical conditions which they would most like to adjust, if permitted.

C. VENTILATION SYSTEM

Several city employees had expressed concern that the limited use of the unsuccessful "Thermal Storage System" had damaged the coated fiberglass material which lines the interior of the ventilation ducts. They attributed the damage to the very humid conditions which existed in the building when it first opened in 1985. As previously mentioned, the thermal storage system was undersized and could not adequately cool the building.

A limited visual inspection of the duct liner on several of the floors did not suggest any moisture damage or other physical damage to the fiberglass. However, bulk settled dust samples were collected at several locations, including the vanes on several slot diffusers and return air grilles. The results from these bulk samples are discussed later in this report.

V. EVALUATION CRITERIA

A. ENVIRONMENTAL

Standards for indoor air quality in office buildings do not exist. The Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulations and recommended limits, respectively, for occupational exposures. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building design criteria. With few exceptions, pollutant

concentrations observed in the office work environment fall well below these published standards or recommended exposure limits. It is possible that work-related complaints may be attributable not to individual environmental species, but to the cumulative effect resulting from exposures to low concentrations of multiple pollutants.

The basis for monitoring individual or classes of environmental parameters are presented below:

1. Temperature and Relative Humidity (RH).

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.[1]

2. 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. ASHRAE's newly published Ventilation Standard, ASHRAE 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, 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors, and 60 cfm/person for smoking lounges, and provides estimated maximum occupancy figures for each area.[2]

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. Maintaining the recommended ASHRAE outdoor air supply rates should provide for acceptable indoor air quality, barring any unusual emission source and assuming good quality outdoor air.

3. Respirable Suspended Particles (RSP) and Inhalable Particles (PM_{10}).

Respirable suspended particles (smaller then 2.5 micrometers) are associated with combustion source emissions. The greatest contributor to indoor RSP is environmental tobacco smoke (ETS).[3-8] 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. PM_{10} concentrations (particles smaller than 10 micrometers in diameter) combine combustion, soil, dust, and mechanical source particle 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 (150 ug/m3 for 24 hours).[9]

VI. RESULTS AND DISCUSSION

A. ENVIRONMENTAL MONITORING

1. Carbon Dioxide

During this evaluation the CO_2 concentrations on floors 4 through 7 were below 1000 parts per million (ppm), a guideline which NIOSH uses to determine the adequacy of the ventilation in an office work area. These low CO^2 concentrations are likely a reflection of both the low employee density levels in the building and the quantity of outside air which the ventilation systems are introducing into the various office areas (based on the design specifications.) The ambient CO_2 concentration outside the office building ranged from 400 to 425 ppm. The results of all of the direct reading measurements taken for CO_2 throughout the work day are shown in Figure 1.

2. Particulates and Trace Elements

As shown in Figure 2, the concentrations of respirable particulate matter measured on floors 4 through 7 ranged from 2 to 70 ug/m^3, levels which are below guidelines used by the EPA (PM_{10} standard, 150 ug/m^3 for 24 hours) for respirable particulate matter. Interestingly, the 5th floor respirable particulate levels were much lower than those on the three remaining floors which were surveyed. Particulate levels on the 5th floor ranged from 2 to 6 ug/m^3, compared to the 7th floor, which had among the highest particulate concentrations, ranging from 19 to 70 ug/m^3. This difference may be accounted for by several factors, including recent cleaning activities on the floors with the higher particulate levels, the number and placement of designated smoking areas on each floor, and the overall number of smokers on the floor.

In addition to the direct reading aerosol monitor used in this survey, three general area air samples were collected on February 22, 1991, on floors 5 and 6 (one sample on the 5th floor was situated on a balcony and thus outside the building) to measure total particulate concentrations. The samples were analyzed gravimetrically following NIOSH Method 0500. Total particulate concentrations from these air samples were extremely low (at the method's limit of detection (LOD) of 10 ug per sample).

General area air samples were also collected over the entire workday on the 5th and 6th floors to measure trace elements (minerals and metals) which might be present. Concentrations of the 30 different analyzed elements in these air samples (listed below) were extremely low (below the LOD for this method) and below all relevant exposure criteria.

Aluminum	Cobalt	Manganese	Selenium	Titanium
Arsenic	Chromium	Molybdenum	Silver	Tungsten
Barium	Copper	Nickel	Sodium	Vanadium
Beryllium	Iron	Lead	Tin	Yttrium
Calcium	Lithium	Phosphorus	Tellurium	Zinc
Cadmium	Magnesium	Platinum	Thallium	Zirconium

The bulk samples collected during this evaluation were analyzed for these same elements. The more toxic "heavy" metals such as lead, nickel, and cobalt were either not detectable or present in very low concentrations (< 0.1 percent). All of the remaining elements which exceeded 0.1 percent in each bulk sample are shown in the following table:

Duct, 4th Floor*	**Duct, 7th Floor**	**Vent, 4th Floor**
Calcium (0.13%)	Aluminum (3.9%)	Aluminum (1.1%)
Iron (58%)	Calcium (7.4%)	Calcium (3.0%)
Manganese (0.22%)	Iron (0.13%)	Iron (0.84%)
Sodium (0.13%)	Sodium (0.27%)	Magnesium (0.4%)
Zinc (1.1%)	Phosphorus (0.16%)	
	Sodium (0.78%)	
	Zinc (0.29%)	

* Sample collected inside the ventilation duct and resembled granular rust particles.

3. Temperature and Relative Humidity

All work areas surveyed were within the ASHRAE guidelines for both temperature and RH. The ASHRAE "comfort chart," which presents temperature and RH ranges considered to be both comfortable and healthful, lies between 73 and 77°F and 20 to 60% RH. All of the temperature and RH measurements collected on floors 4 through 7 are shown in Figure 3.

B. QUESTIONNAIRE

Approximately 150 self-administered questionnaires were distributed to city employees throughout the building on February 21, 1991. Of those distributed, a total of 102 completed questionnaires (68%) were returned for analysis. The results from these questionnaires are presented in Figures 4 and 5.

The responses obtained from the questionnaires are arranged to reflect the fact that the majority of the employees in the building are located on floors 3 through 7. In general, employees on all four floors were nearly equally divided on their

assessment of the temperature of their work space (either too hot, too cold, or just right).

Most employees considered the humidity levels acceptable throughout the building. Employees on the 3rd, 4th, 6th, and 7th floors were the most satisfied (percent reporting RH levels as "just right" ranged from 73 to 100%). On the 4th floor, 54% of those employees who completed a questionnaire described the RH levels as "just right" while the remainder were almost equally split between "too dry" and "too humid."

Most of the employees felt the illumination levels in their work area was adequate, with the highest acceptance levels obtained from workers on floors 3 and 7. More than one-half of the respondents on floors 4 and 6 felt that their work area was "too dusty." The percentages of workers who considered their work environment "too noisy" ranged from 8% (7th floor) to 58% (5th floor). The majority of employees on the 3rd floor (63%) who responded to the questionnaire felt their work area was "too stuffy."

C. VENTILATION SYSTEM EVALUATION

This qualitative evaluation was directed at observing the operation of the ventilation systems supplying the Pensacola City Hall. Drawings of the ventilation system were consulted with help from the engineering department to locate and identify the air handling units (AHUs) that supply air to the building. Each of these air handlers on floor 3 through 7 was visited to perform a visual check and record operating parameter data. First, the outside air dampers on all floors were checked for position. Second, the pre- and main filters were checked on some of the HVAC units for loading, visible damage, or other problems.

Except for the 3rd floor, all of the OA dampers were open on the day of this evaluation (according to the position of the damper controller on the outside of the duct). The position of the controller on the 3rd floor suggested that this OA damper was in the "closed" position. It should be stressed that no visual verification was made to determine if any of the OA dampers were actually open on the day of this survey.

All except one OA damper "booster" fan (again located on the 3rd floor) appeared to be operating normally. The booster fan on the 3rd floor did not appear to be running.

There was insufficient time during this limited survey to open up and visually check the interior of the individual HVAC units for standing water, debris, slime growth, etc. There was no evidence of any of these problems, however, on the exterior of the HVAC units. The interior of the ducts, however, were visually examined on all floors via access panels. The following are descriptions based on these examinations:

Location	Description
4th Floor	Relatively clean and void of any large pieces of debris. The grille on the supply register located in main lobby was dusty but the interior of the duct was clean.
5th Floor	Interior of duct clean except for the presence of metal screws. Some relatively large pieces (approximately 1/2 inch in diameter) of debris (either drywall or hardened adhesive) were observed.
6th Floor	Ducts appeared relatively clean. Some large chunks of debris noted (similar to the 5th floor).
7th Floor	Ducts and registers appeared clean and in good shape.

IX. CONCLUSIONS

Based on the data collected during this survey, NIOSH investigators concluded that the indoor air quality parameters which were measured (carbon dioxide, temperature, relative humidity, and particulates), were within acceptable levels. An indoor air quality problem did exist, however, in that the existing smoking policy at the Pensacola City Hall did not restrict smoking to smoking areas/lounges which were provided with a dedicated air handling system to reduce the possibility of reentrainment and recirculation of any secondary cigarette smoke. Although the qualitative assessment of the building's ventilation system by NIOSH investigators did not identify any significant problems, further examination is suggested to verify (at least visually) the proper operation of the various outside air dampers, booster fans, and other ventilation system components which could influence the quality of the indoor air in the building.

X. RECOMMENDATIONS

1. Exposure to environmental tobacco smoke is one of the most important indoor air particulate problems and can be a major source of complaints. With this in mind, the existing smoking policy at the Pensacola City Hall should be modified to permit smoking only outside or in designated smoking areas/lounges. These smoking areas, unless they are located on the outside balconies situated around the perimeter of the building, should be provided with a dedicated exhaust system which would reduce the possibility of re-entrainment and recirculation of any secondary cigarette smoke. In addition, the smoking areas should be under slight negative pressure as compared to surrounding occupied areas. The ventilation system supplying the smoking lounge should be capable of providing at least 60 cfm of outdoor air per person.[2]

2. One of two ceiling exhaust fans in the men's restroom located on the mezzanine level was not operating and should be repaired.

3. In one office on the 5th floor (room 504) the occupant used plastic sheeting to block and redirect the air flow away from his work area. In place of this technique, it should be possible to adjust the directional vanes on the wall diffuser to both reduce and redirect the air flow.

4. The OA damper controller on the 3rd floor should be checked for proper operation (it appeared to be in the closed position on the day of this evaluation). In addition, the booster fan on the 3rd floor should be checked to determine if it is operating. As a additional safeguard, all of the OA dampers in the building should be visually examined to verify proper operation.

XI. REFERENCES

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XII. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by: Gregory A. Burr, CIH
Supervisory Industrial Hygienist
Industrial Hygiene Section

Field Assistance by: Kevin Hanley, MS
Industrial Hygienist
Industrial Hygiene Section
Hazard Evaluations and Technical Assistance Branch

Report Typed by: Gregory A. Burr

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