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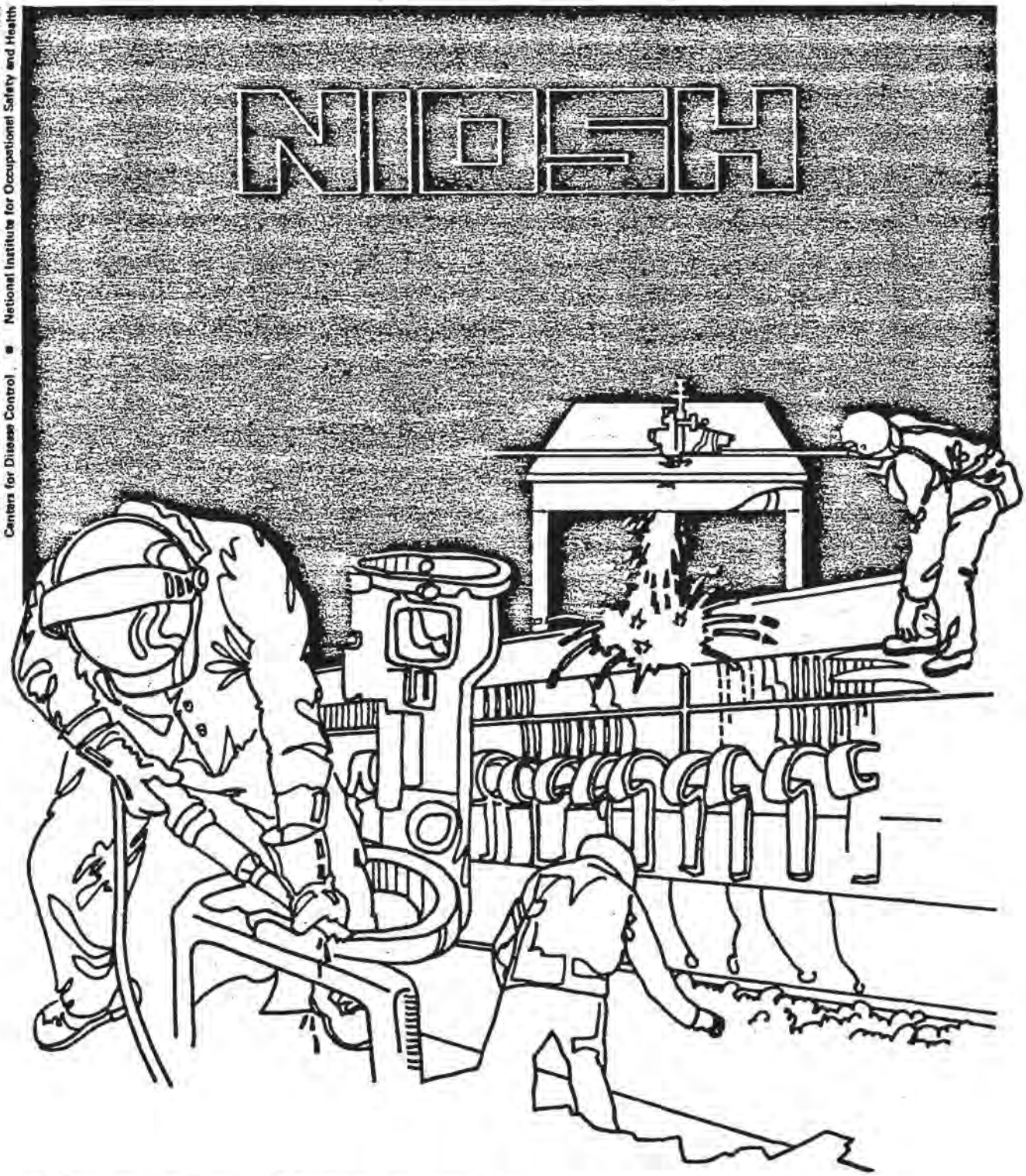
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 83-035-1317
BOONE COUNTY PUBLIC
ADMINISTRATION BUILDING
BURLINGTON, KENTUCKY

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 83-035-1317
MAY 1983
BOONE COUNTY PUBLIC ADMINISTRATION BUILDING
BURLINGTON, KENTUCKY

NIOSH INVESTIGATORS:
Kenneth M. Wallingford, I.H.
David B. McAuley, M.D.

I. SUMMARY

On November 3, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request for immediate technical assistance from the Boone County public administration offices in Burlington, Kentucky, concerning a suspected toxic gas or vapor reportedly concentrated in the Sheriff's Department. Employees in the Sheriff's Department were reporting headaches, dizziness, nausea, eye irritation, sore throats, and allergic symptoms causing some of them to leave work early.

NIOSH personnel conducted an initial investigation on November 3, 1982, to determine if a serious health problem existed. It was determined during this investigation that toxic concentrations of gases or vapors were not present. Therefore, a follow-up investigation was conducted on November 18, 1982, to more fully evaluate indoor air quality and air distribution throughout the Sheriff's Department. During these investigations, Sheriff's Department employees were interviewed regarding medical symptoms experienced at work. Air samples were collected to measure the concentration of carbon monoxide, carbon dioxide, formaldehyde, methane, nitrogen dioxide, ozone, and hydrocarbon vapors. Ventilation and relative humidity measurements were also obtained.

Three of the eleven employees interviewed reported nasal congestion and headaches while at work. The other eight employees were asymptomatic but did complain of physical discomfort due to the stuffy environment. The concentration of the air contaminants measured in the Sheriff's Department were all well within established limits. The ventilation measurements, however, indicated that the system supplying air to the Sheriff's Department was not adequate to meet the 20 cubic feet per minute (cfm) of fresh outdoor air per person currently recommended by the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) for office environments in which smoking is permitted.

Ventilation measurements indicated that the air handling system supplying air to the Sheriff's Department was not adequate to meet the 20 cfm per person of fresh outdoor air currently recommended by ASHRAE for office environments in which smoking is permitted. This, along with the absence of toxic contaminants, suggests that the employees' symptoms may be caused by inadequate ventilation. Recommendations which may alleviate these symptoms are described in Section VII of this report.

KEYWORDS: SIC 9221 (Sheriff's Offices), office buildings, indoor air pollution, tight building syndrome.

II. INTRODUCTION

On November 3, 1982, a representative of the Boone County public administration offices in Burlington, Kentucky, requested immediate technical assistance from the National Institute for Occupational Safety and Health (NIOSH) concerning a suspected toxic gas or vapor reportedly concentrated in the Sheriff's Department. Employees in the Sheriff's Department were reporting headaches, dizziness, nausea, eye irritation, sore throats, and allergic symptoms causing some of them to leave work early.

An initial investigation was conducted by NIOSH on November 3, 1982, within two hours of the telephone request for immediate technical assistance. The primary purpose of this initial investigation was to determine if a life-threatening situation existed. A follow-up investigation was conducted by NIOSH on November 18, 1982, to more fully evaluate air quality and air distribution throughout the Sheriff's Department. Preliminary recommendations concerning the Sheriff's Department were forwarded to Boone County officials on December 17, 1982.

III. BACKGROUND

The Boone County public administration offices are housed in a four-floor building (including a basement) located in Burlington, Kentucky. The building was initially occupied in February 1982, and is designed to be energy efficient. The Sheriff's Department is located on the ground floor in the southeast corner of the building and consists of five separate rooms of different sizes. One large room can be entered from the exterior hallway through either of two doors and serves as an area for the clerks to administer the routine business of the department. The four remaining smaller rooms (located off of a short hallway at the rear of the large room) serve as offices for the Sheriff, deputy officers, and dispatcher.

The building is divided into four zones, each supplied by a separate heating, ventilation, and air conditioning (HVAC) system of a unique variable air volume (VAV) design. The HVAC unit that supplies the Sheriff's Department (AC-1) also supplies the Police Department located next to the Sheriff's Department and the jail located in the basement. Because the jail is always occupied, AC-1 is on continuously. The other three HVAC units are turned off at night and on weekends. As with the remainder of the building, air is supplied to the Sheriff's department through a slot diffuser located next to each ceiling light fixture. The volume of incoming air through these slots is regulated by ball dampers in the inlet ducts which are controlled by room thermostats. The supplied air is heated and humidified in the winter and conditioned in the summer. Auxillary heating is supplied by radiant hot water baseboard units located along the exterior walls. Air is exhausted through 8" square grills located in the ceiling. The space above the suspended ceiling acts as the return air plenum. The return air is mixed with a percentage of fresh outside air and recirculated. Outside make-up air is supplied from a grill located below ground level on the north face of the building near the parking lot.

IV. METHODS AND MATERIALS

A. Environmental

An initial environmental investigation was conducted by NIOSH on November 3, 1982, within two hours of the telephone request for immediate technical assistance. The primary purpose of this initial investigation was to determine if a life-threatening situation existed. Direct reading measurements for carbon monoxide (CO), carbon dioxide (CO_2), and methane were made throughout the Sheriff's Department using a National Draeger multi-gas detector pump with the appropriate detector tubes. Ventilation measurements were obtained throughout the Sheriff's Department using a Kurz Model 480 pocket anemometer.

A follow-up investigation was conducted by NIOSH on November 18, 1982, to more fully evaluate air quality and air distribution throughout the Sheriff's Department. Direct reading measurements for CO, CO_2, formaldehyde, nitrogen dioxide (NO_2), and ozone were made using a National Draeger multi-gas detector pump with the appropriate detector tubes. Additionally, long-term direct reading CO measurements were made using National Draeger long-term CO detector tubes and SKC Model 222-3 low-flow sampling pumps calibrated at 20 cubic centimeters per minute. Hydrocarbon vapors were measured using a direct reading Hnu Model PI101 photoionizer. Relative humidity was measured with a Bendix Model 566 psychrometer. Ventilation measurements were obtained using a Kurz Model 440 air velocity meter. Additionally, air exchange in the large room of the Sheriff's Department was measured using a tracer dilution technique.[1] A small amount of sulfur hexafluoride (SF_6) tracer gas was released in the large room of the Sheriff's Department. A floor fan was used to ensure complete mixing. The rate of SF_6 decay was measured using a Miran-1A portable infrared air analyzer positioned near the center of the room. The air exchange rate was then determined from the logarithmic decay rate of the SF_6 tracer gas concentration with respect to time.

B. Medical

There were eleven employees in the Sheriff's Department during the investigation. The sheriff spent the entire day in his office at the rear of the department, the secretaries and clerks were in the main room at the front of the department. All eleven employees were interviewed regarding medical symptoms experienced at work. The deputy sheriffs were only transiently in the office and were not interviewed.

V. EVALUATION CRITERIA

Building-related illness episodes have been reported more frequently in recent years as buildings have been made more air-tight in order to conserve energy and to reduce air conditioning expenses. Modern high-rise office buildings are constructed primarily of steel, glass, and concrete, with large windows that cannot be opened, thus making the building totally dependent on mechanical systems for air conditioning.

Contaminants may be present in make-up air or may be introduced from indoor activities, furnishings, building materials, surface coatings, and air handling systems and treatment components. Symptoms often reported are eye, nose, and throat irritation, headache, fatigue, and sinus congestion. Occasionally, upper respiratory irritation and skin rashes are reported. In some cases, the cause of the symptoms has been ascribed to an airborne contaminant, such as formaldehyde, tobacco smoke, or insulation particles, but most commonly a single cause cannot be pinpointed.

Imbalance or malfunction of the HVAC system is commonly identified, and in the absence of other theories of causation, illnesses are usually attributed to inadequate ventilation, heating/cooling, or humidification.

In 1981, the National Research Council (National Academy of Sciences) issued a report urging a major national effort be mounted to study the subject of indoor air pollution. Some of the major types of contaminants found in indoor air are:

1. Products of Combustion

Carbon monoxide and NO_2 are often considered the most important toxic products of the combustion of fossil fuels and other organic materials. Gas stoves may be a significant source of these pollutants. Carbon monoxide is an asphyxiant, and NO_2 a pulmonary irritant.

2. Formaldehyde

Formaldehyde and other aldehydes may be released from foam plastics, carbonless paper, particle board, plywood, and textile fabrics. Formaldehyde is an irritant to the eyes, nose, mouth, and throat. It is also a possible human carcinogen, based on its ability to produce nasal cancer in rats.

3. Sprayed-On Insulation Materials

Asbestos, fibrous glass, and mineral wool fibers have been used in some buildings in sprayed-on fireproofing insulation for walls, ceilings, and structural steel beams. Fibers and dust particles may be dislodged from the insulation and become airborne. Asbestos fibers can cause pulmonary disease and cancer. Mineral wool and fibrous glass particles are irritants.

4. Tobacco Smoke

Tobacco smoke contains several hundred toxic substances, the more important of which are: CO, NO_2, hydrogen cyanide, formaldehyde, hydrocarbons, ammonia, benzene, hydrogen sulfide, benzo(a)pyrene, tars, and nicotine. Tobacco smoke can irritate the respiratory system and, in allergic or asthmatic persons, often results in eye and nasal irritation, coughing, wheezing, sneezing, headache, and other related sinus problems. People who wear contact lenses often complain of

burning, itching, and tearing eyes when exposed to cigarette smoke. While cigarette smoking is the leading cause of lung cancer in the United States, currently available evidence is not sufficient to conclude that passive or involuntary smoking causes lung cancer in non-smokers.[2]

5. Microorganisms and Allergens

Microorganisms have been spread through ventilation systems in buildings where air filters became wet and moldy, where pools of stagnant water accumulated under air conditioning cooling coils, and where decaying organic matter was found near air conditioning intakes. Health effects may be infections, irritation, or allergic symptoms.

6. Hydrocarbon Vapors

Hydrocarbon vapors are released from dispersants and toners used in photocopying machines and telecopiers, from printing processes, and from certain cleaning compounds. Hydrocarbons can be irritants and, at high concentrations, are central nervous system depressants.

A. Air Contamination Evaluation Criteria

The primary sources of air contamination criteria generally consulted include: (1) NIOSH Criteria Documents and recommendations for occupational exposures, (2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's), (3) the U.S. Department of Labor (OSHA) federal occupational health standards, and (4) the indoor air quality standards developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The first three sources provide environmental limits based on airborne concentrations of substances to which workers may be occupationally exposed in the workplace environment for 8 to 10 hours a day, 40 hours per week for a working lifetime without adverse health effects. The ASHRAE standards are general air quality standards for indoor environments, and are applicable for the general population exposed for up to a 24-hour day of continuous exposure without known toxic effects.

Indoor air should not contain concentrations of contaminants known to impair health, or to cause discomfort to a substantial majority of the occupants. Ambient air quality standards/guidelines available from federal, state, or local authorities should be consulted. If the air is thought to contain any other contaminants, reference to OSHA, ACGIH, and NIOSH recommendations should be made; for application to the general population, the concentration of these contaminants should not exceed 1/10 of the limits which are used in industry.

The evaluation criteria concerning gases and vapors sampled for in the Sheriff's Department are summarized in Table I.

B. Ventilation Evaluation Criteria

Neither NIOSH nor OSHA has developed ventilation criteria for general offices. Criteria often used by design engineers are the guidelines published by ASHRAE.

Until recently, the ASHRAE Ventilation Standard 62-73 (1973) was utilized, but recommendations were based on studies performed before the more modern, air-tight office buildings became common. These older buildings permitted more air infiltration through leaks in cracks and interstices, around windows and doors, and through floors and walls. Modern office buildings are usually much more airtight and permit less air infiltration. Due to the reduced infiltration, ASHRAE questioned whether the 1973 minimum ventilation values assure adequate outdoor air supply in modern, air-tight buildings.

Subsequently, ASHRAE has revised its standard and has published the new standard, ASHRAE 62-1981, "Ventilation for Acceptable Indoor Air Quality." The new standard is based on an occupant density of 7 persons per 1000 ft^2 of floor area, and recommends higher ventilation rates for areas where smoking is permitted. The new ASHRAE standard states that indoor air quality for "General Offices" shall be considered acceptable if the supply of outdoor air is sufficient to reduce CO_2 to less than 2500 parts per million (ppm) and to control contaminants, such as various gases, vapors, microorganisms, smoke, and other particulate matter, so that concentrations known to impair health or cause discomfort to occupants are not exceeded. However, the threshold levels for health effects from these exposures are poorly documented. For "General Offices" where smoking is not permitted, the rate recommended under the new standard is 5 cubic feet per minute (cfm) of outdoor air per person. Higher ventilation rates are recommended for spaces where smoking is permitted because tobacco smoke is one of the most difficult contaminants to control at the source. When smoking is allowed, the amount of outdoor air provided should be 20 cfm per person. Areas that are nonsmoking areas may be supplied at the lower rate (5 cfm/person), provided that the air is not recirculated from, or otherwise enters from, the smoking areas.[3]

The ASHRAE Standard 62-1981 also provides ventilation requirement guidelines for a wide variety of commercial, institutional, residential, and industrial facilities and should be consulted for application to the specific situation under evaluation.

VI. RESULTS

A. Environmental

Detector tube measurements for CO, CO_2, and methane made during the initial investigation were all well below any existing criteria as listed in Table I. Ventilation measurements indicated that the HVAC system supplying the large area of the Sheriff's Department supplied 800 cfm of circulating air when operating in the air-conditioning mode at maximum demand (room temperature above thermostat setting). This dropped to 265 cfm when the room temperature was at or near the

thermostat setting. When the room temperature was below the thermostat setting, the system shut off providing no air circulation whatsoever. Observations indicated the system was off a considerable percentage of the time. In addition, heavy curtains on a large south-facing window were not drawn allowing full sun into the room. This heated the air considerably on that side of the room causing a temperature gradient. It also was observed that the ball damper regulating the airflow into the large area was malfunctioning and not always opening when demanded by the thermostat.

Detector tube measurements for CO (short-term and long-term), CO_2, formaldehyde, NO_2, and ozone made during the follow-up investigation were all well below any existing criteria as listed in Table I. No hydrocarbon vapors were detected using the Hnu photoionizer. Relative humidity was measured at 53%. Ventilation measurements indicated that the HVAC system supplying the large area of the Sheriff's Department supplied 265 cfm of circulating air when operating in the heat mode at maximum demand (room temperature at or below thermostat setting). The system was off when the room temperature was above the thermostat setting providing no air circulation. In addition, it was observed that the ceiling slot diffusers forced the incoming air in a laminar profile along the ceiling surface, resulting in poor mixing.

The tracer dilution technique indicated about 200 cfm of building air infiltrates the large area around the two entrance doors when they are closed. This increases to about 400 cfm when the two doors are open and indicates that the Sheriff's Department is under negative pressure.

Additional ventilation measurements indicated that about 20% fresh outdoor air was introduced to the HVAC AC-1 unit, resulting in 80% of the room air being recirculated. Also, the fresh air intake for this unit was slightly below ground level near the rear parking lot and could draw exhaust gases from vehicles idling near the intake.

B. Medical

Three of the eleven employees in the department reported experiencing symptoms at work, while the other employees complained of the uncomfortable, stuffy environment but were asymptomatic. All three of the employees with symptoms reported nasal congestion and headaches. One employee had a history of allergies and reported symptoms of sneezing, tearing eyes, and rhinorrhea which were noticeably aggravated while at work. Relief from these symptoms was noted on the weekends and at night, while away from the department.

Interestingly, the three employees reporting the most severe symptoms were the employees who worked toward the rear of the department. Presumably, the front doors provided an entrance for fresh air which helped to lessen the complaints of employees in the front of the department. Although the symptoms were all rather non-specific, upper-respiratory complaints, they appeared to be very real symptoms, witnessed by others in the department. The reported symptoms also were closely correlated with time spent at work.

VII. DISCUSSION AND CONCLUSIONS

Levels of air contaminants measured throughout the Sheriff's Department were all well within the current limits established by OSHA, NIOSH, ACGIH, or ASHRAE as listed in Table I. The ventilation measurements, however, indicated that the HVAC system supplying air to the Sheriff's Department was not adequate to meet the guidelines for fresh air volume in office areas recommended by ASHRAE. The HVAC-VAV system is designed to supply 100% of the designed rate to the Sheriff's Department when demanded by the thermostat to maintain temperature. When the designed temperature is reached, the system should still provide 50% of the design rate at all times to control smoke and odors, and to provide physical comfort for the employees. Ventilation measurements indicated the system does not do this. The design rate for the large area of the Sheriff's Department is 800 cfm. This was reached during the initial visit only when the system was operating in the air-conditioning mode at maximum demand. The 50% maintenance rate of 400 cfm was not reached on either visit being measured at only 265 cfm. Additionally, the system was off completely a large percentage of the time creating very uncomfortable working conditions. Considering that 20% fresh outdoor air is introduced, the system would supply 160 cfm of fresh air at 800 cfm maximum design rate as measured, 53 cfm fresh air at 265 cfm maintenance rate as measured, and 0 cfm fresh air (excluding infiltration) when the system is completely off. ASHRAE guidelines require 20 cfm of fresh outdoor air per person at all times in office areas where smoking is permitted (as is the case in the Sheriff's Department). Considering up to 8 persons could normally occupy the large area (including visitors), 160 cfm of fresh outdoor air should be constantly provided. The only time this amount is provided is when the HVAC-VAV system is operating in the air-conditioning mode at maximum demand.

Direct correlation of inadequate ventilation with the employees' reported symptoms is practically impossible. However, several employees commented that leaving the two entrance doors open seems to improve the feeling of physical comfort. Additionally, fans used at times also seem to improve the feeling of physical comfort. This, in conjunction with the ventilation measurements, suggests that inadequate ventilation may be the primary cause of the symptoms experienced by the Sheriff's Department employees.

VII. RECOMMENDATIONS

The following recommendations are offered as actions which may help alleviate some of the symptoms reported.

1. Adjust the HVAC-VAV system supplying the Sheriff's Department so that a minimum of 20 cfm fresh outdoor air per person is provided continuously thereby meeting current ASHRAE guidelines for office areas where smoking is permitted.

2. Consider using a heating/air conditioning maintenance contractor to routinely monitor the systems' performance and make adjustments as necessary.

3. Place a tamper-proof box over the thermostat in the large room in the sheriff's department so that temperature settings can be maintained consistently.

4. Consider modification of the ceiling slot diffusers to provide better mixing.

5. Do not allow cars to idle in the parking lot row closest to the building. This will minimize entrainment of exhaust gases by the air inlets located in the well next to the parking lot.

6. Consider using 1" mini blinds on the large south-facing window in the large room of the sheriff's department to reduce radiant heating.

VIII. REFERENCES

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:

Kenneth M. Wallingford, M.S.
Industrial Hygienist
Industrial Hygiene Section

David B. McAuley, M.D.
Medical Officer
Medical Section

Environmental Evaluation:

Dennis M. O'Brien, C.I.H.
Industrial Hygienist
Engineering Control Technology Branch

Paul E. Caplan, C.I.H.
Research Industrial Hygienist
Engineering Control Technology Branch

Originating Office:

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

Report Typed By:

Jacqueline Grass
Clerk/Typist
Industrial Hygiene Section

X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Boone County Public Administration representative
2. Kentucky Department of Labor
3. NIOSH, Region V
4. 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 I

Environmental Sampling Results and Evaluation Criteria

Sheriff's Department
Boone County Public Administration Office Building
Burlington, Kentucky
HETA 83-035

November 3 and 18, 1982

Substance	Concentration (ppm)	NIOSH Recommended Criteria (ppm)	OSHA Permissible Exposure Limit[8] (ppm)	ACGIH Threshold Limit Value[9] (ppm)	ASHRAE Guideline[3] (ppm)	Health Effects[10]
Carbon Monoxide	3-4	35 (10 hr.)[4]	50	50	-	headache, nausea, dizziness, weakness, rapid breathing, cyanosis, angina
Carbon Dioxide	400-800	10,000 (10 hr.)[5]	5000	5000	2500+	headache, dizziness, sweating, depression, rapid breathing and heart rate, asphyxiation
Formaldehyde	N.D.	(LFL)[6]	3	1	0.1+	irritation of eyes, nose, and throat, watery eyes, cough, dermatitis
Methane	N.D.	-			-	asphyxiation
Nitrogen Dioxide	N.D.	1 (c)[7]	5	3	-	irritation of eyes, nose, and throat, cough, pulmonary edema
Ozone	N.D.	-	0.1	0.1	0.05+	irritation of eyes, dry nose, and throat, cough

+ Maximum for acceptable indoor air quality, continuous exposure
N.D. - None Detected
(LFL) Lowest feasible limit
(c) ceiling concentration
All criteria are for 8-hour TWA's except where otherwise noted

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