U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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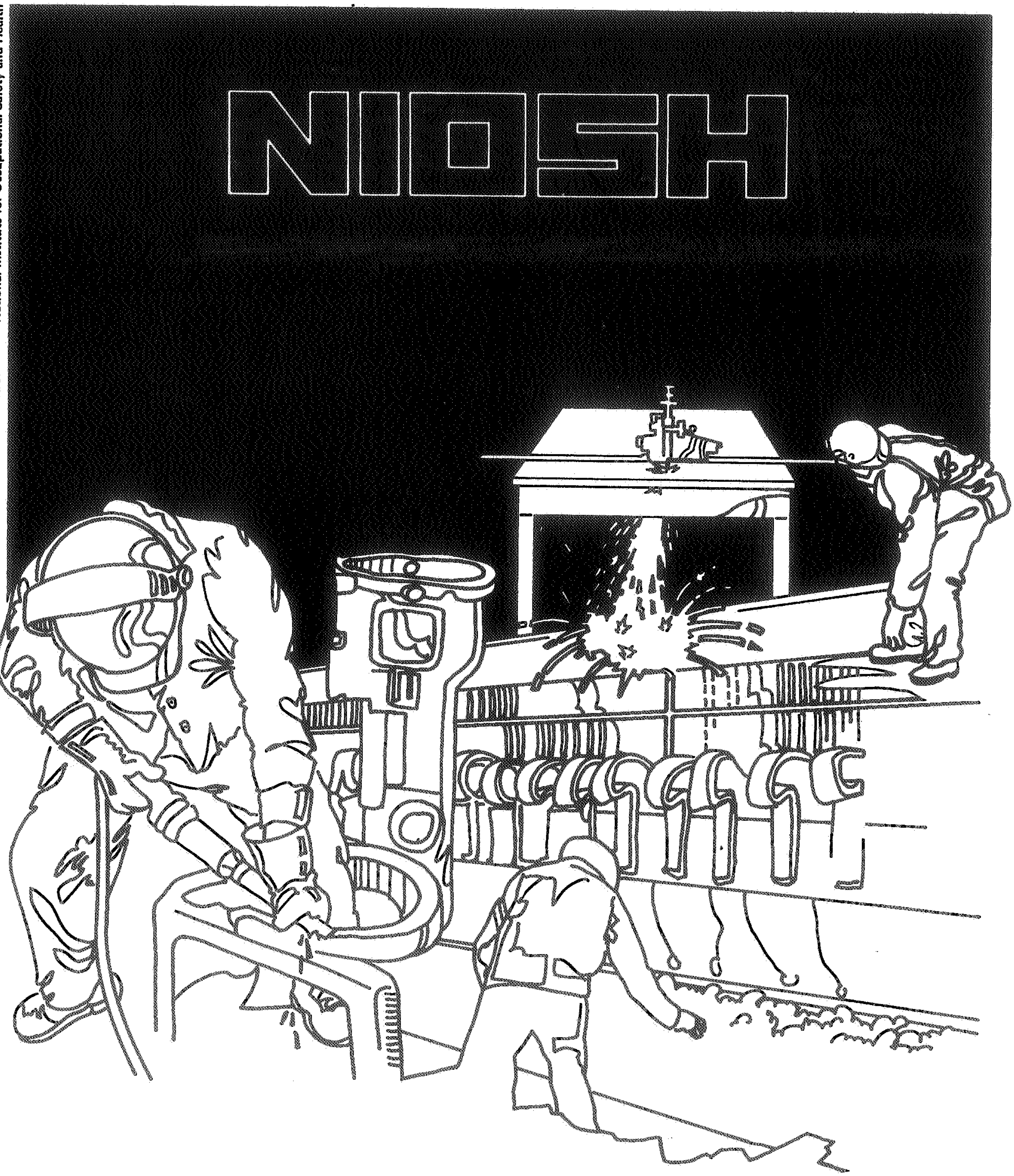

Health Hazard Evaluation Report

HETA 81-353-981
GRAY CONCRETE PIPE COMPANY
THOMASVILLE, NORTH CAROLINA

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.

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Gray Concrete Pipe Company
Thomasville, North Carolina

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I. SUMMARY

In response to a letter of request dated June 2, 1981, from the Company a health hazard evaluation was made July 6, 1981 at the Gray Concrete Pipe Company, Thomasville, N.C. Of concern was pulmonary illness (thought to be Legionnaires' disease) in an office employee, apparently associated with odors in the air conditioning system of the Company office building.

The air conditioned building houses 18 employees and is used for office activities only. Indoor humidity is very high in summer (> 80%). There is a musty, moldy smell throughout the building.

The affected employee and 17 others working in the same building were interviewed by the team physician. These interviews and subsequent information from the affected employee's physician revealed no information consistent with legionellosis. Serum specimens drawn from the affected employee and 15 others were negative for Legionella pneumophila antibodies.

An environmental survey revealed copious amounts of condensed water in the central air conditioning system ducts in and around the air cooling coils. Samples of this water and associated material were collected for microbiological evaluation. No evidence of L. pneumophila (the etiologic agent of Legionnaires's disease) was found, although the condensate fluids were grossly contaminated with bacteria and yeast, some of which are known to cause respiratory infections and/or allergenic manifestations. Condensate of the air conditioning unit serving the office occupied by the affected employee was highly contaminated with flavobacteria, which have been named as causative agents in "humidifier fever". In the absence of evidence of L. pneumophila, these flavobacteria and other endotoxin-contributing Gram-negative organisms are suspect as causative agents of disease in the affected employee. Four air samples taken in and around the office of the affected employee were analyzed for 22 organic vapors with negative results.

Data obtained in this investigation demonstrated that a potential biological hazard exists in the building from the large numbers of microorganisms, including several known to be respiratory pathogens, present in the ventilation system condensate fluids. Since these fluids are in direct contact with the air supply stream, aerosolized microorganisms could be carried to all parts of the building.

It is recommended that the humidity in the building and the copious amounts of condensate fluid in contact with the air supply stream be reduced. Periodic treatment of residual condensate with an effective disinfectant, should be done to reduce the biohazard of aerosolized microorganisms in the office environment.

KEYWORDS: SIC 3272, Legionnaires' disease, humidifier fever, respiratory symptoms.

II. INTRODUCTION

On June 2, 1981, the Gray Concrete Pipe Company, requested a health hazard evaluation of the Company's office building in Thomasville, N.C. (SIC 3272). The request stated that there are continuous obnoxious odors in the building which are a suspected health hazard and possibly associated with recurrent pulmonary disease (thought to be Legionnaires' disease) in an office employee.

A health hazard evaluation was conducted July 6, 1981, in the building by a team which consisted of a microbiologist, industrial hygienist, engineer, and physician.

The goals of the evaluation were to confirm the preliminary diagnosis of Legionnaires' disease, search for other evidence of similar infections among building employees, evaluate the environmental conditions (particularly the ventilation system) for possible sources of work-associated respiratory problems, determine the source of the odor problem if possible, and develop, based on findings, appropriate recommendations to management to alleviate the situation.

III. BACKGROUND

The office building has two-stories, is centrally air conditioned, and houses 18 employees. The building was built in 1964 and has not been altered except that its exterior was sand-blasted and sealed in 1979. Shortly thereafter, in the summer of 1980, the odors appeared, described as "damp, musty mildew". The building is physically isolated from the pipe-making process and other nearby plants, and conducts office-related activities only. There have been problems with roof leaks.

At a time when the odors were very strong, an employee became ill and was hospitalized with high fever. The request for the health hazard evaluation stated that the illness was diagnosed as Legionnaires' disease and that the diagnosis was confirmed by the Centers for Disease Control. Odors subsided with the fall heating season but returned when air conditioning resumed in the summer of 1981.

IV. METHODS AND MATERIALS

A. Environmental

Environmental evaluation consisted of interviews with company personnel about environmental conditions, a walk-through industrial hygiene survey, collection of samples of material in the air conditioning system for microbiological analyses, and collection of air samples for organic vapor analyses.

Microbiological evaluation began with collection of samples of central air conditioning condensates. The specific purpose of the field sampling was to establish whether condensate-borne Legionella pneumophila, the etiologic agent of Legionnaires' disease, was the probable cause of respiratory illness of the office employee. Corollary objectives included: (1) identification and enumeration of contaminating microorganisms, (2) determination of antibiotic susceptibility of predominant microorganisms, and (3) development of a preliminary disinfectant profile of the predominant microorganism.

Three sites were sampled for microbiological evaluation, one each from two air conditioner units and the third from a common condensate drain. Sterile apparatus was used for the collection of approximately 50 ml from each site; samples were immediately placed in crushed ice for transport to the School of Public Health, Chapel Hill.

The specific methodology used for the isolation of L. pneumophila has been described (1). In addition, standard bacteriologic and mycotic media were used for the identification and enumeration of microorganisms.

Media specific for L. pneumophila included Feeley-Gorman (FG) and charcoal yeast extract (CYE). Alternate media included Eosin Methylene Blue Agar (EMBA), MacConkey Agar (MA), Sheep Blood Agar (SBA), Trypticase Soy Agar (TSA), and Sabouraud Dextrose Agar (SDA). Dilutions were prepared from the condensates (i.e., 10^{-1} through 10^{-4}), and 0.1 ml aliquots of undiluted condensate and dilutions therefrom were plated onto media in triplicate. Both the FG and CYE plates were incubated at 35°C for 21 days; other media were incubated at 35°C for 24 hours, then at room temperature. Periodic observations and notations of growth on artificial media were made.

For purposes of enumeration of contaminating microorganisms, dilutions from each collected sample were streaked onto five plates each of bacteriologic media. Identification and speciation of bacteria and fungi were conducted by colonial morphology, microscopic observation, biochemical differentiation using the API-20 identification system, and consultation.

Because the office worker with a pneumonia-like illness was administered erythromycin, the antibiotic of choice in the treatment of Legionnaires' disease, it seemed relevant to conduct antibiotic susceptibility profiles of the predominant bacteria isolated at the building. Standardized Kirby-Bauer testing included the following antimicrobial agents: ampicillin, streptomycin, tetracycline, penicillin, chloramphenicol, sulfadiazene, cephalothin, sulfamethoxazole/trimethoprim, gentamicin, colistin, and erythromycin.

VI. RESULTS AND DISCUSSION

A. Environmental

The building has central heating and air conditioning provided by three heat pump units. The indoor heat exchange/blower units are located in a single mechanical room; this room serves as both the fresh air intake plenum and the return air plenum. A schematic drawing of this room, with air flows as measured on July 6, and a sketch of a typical heat exchanger/blower unit are shown in Figures 1 and 2. The three exterior heat exchanger/compressors are located adjacent to the building. They are air-cooled units. No spray humidifers or evaporative coolers are used in this system so there is no source of artificially warmed water, the usual source of problems involving *L. pneumophila* in ventilation systems.

The building in general is under a slight positive air pressure with respect to the outside air. The mechanical room is under a strong negative air pressure with respect both to the rest of the building and to the outside air.

The building has two stories and a mezzanine, for a total of 6540 square feet with 8- or 9-feet ceilings except in the central ground floor area. The ventilation units serve separate areas; Unit A serves the north side, Unit B the south side, and Unit C the central ground floor area.

The ventilation system is rated at 7600 cfm (3000 cfm each for Units A and B and 1600 cfm for Unit C). Return air drifts from upper and lower floors back to the mechanical room and enters the room through return air registers and a slatted door (See Figure 1). Air flow measurements made July 6 are shown on Figure 1. Total circulated flow was 6,800 cfm. Assuming an average ceiling height of 10 feet, the air turnover is about 6 air turnovers per hour. Air flow was reversed in unit C; it was not operating. This unit is reported to be rarely operated. Fresh air makeup is an estimated 10 percent of air flow (630 cfm), approximately 5.2 changes of fresh air per working day (8 AM to 5 PM).

The odor problems were reported to be associated with summertime operations; i.e., the cooling season. It was reported by Company personnel that odors disappeared soon after the fall heating season of 1980 began and returned in the summer of 1981. The day of the visit was hot and humid and units A and B of the air conditioning system were operating. OHSG team members all recognized a "musty moldy" odor upon first entering the building. The Company employee affected works in an office served by blower Unit A.

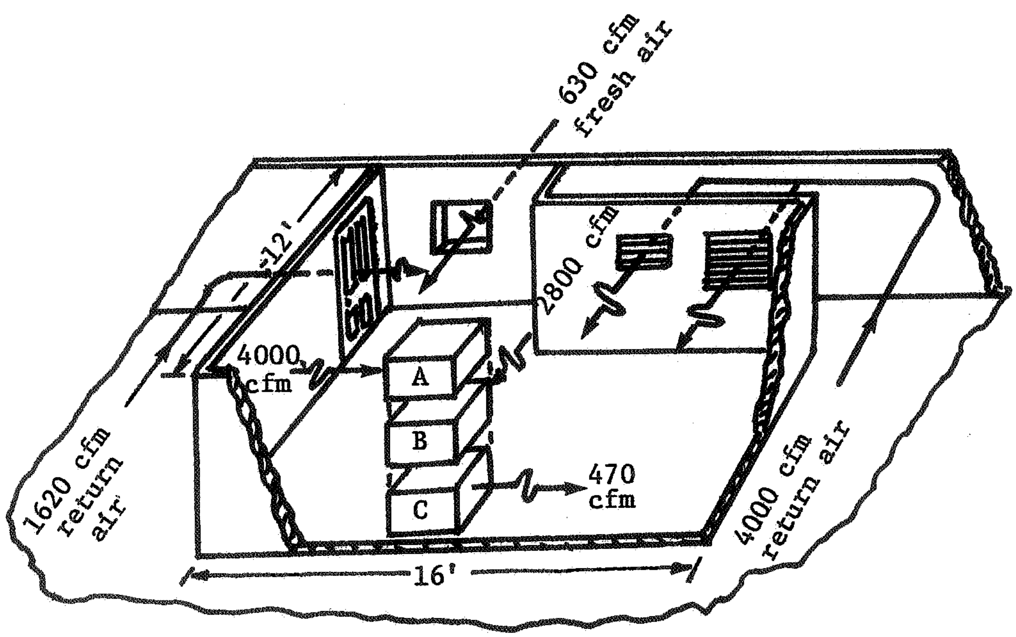


FIGURE 1 - CUTAWAY VIEW OF MECHANICAL ROOM

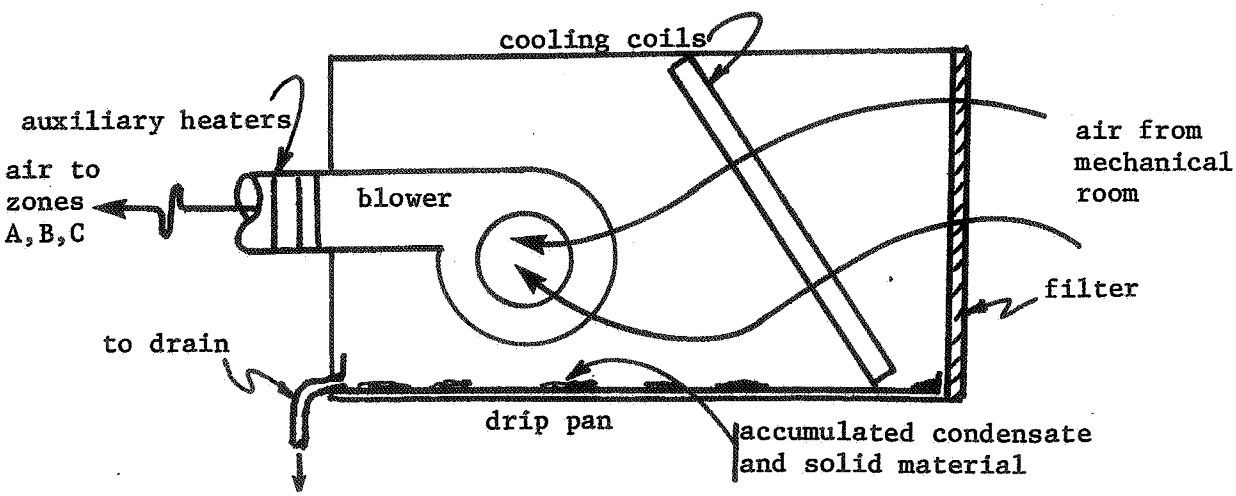


FIGURE 2 - TYPICAL BLOWER UNIT

Recent records (July, 1981) from a 24-hour recording thermometer/relative humidity (T/RH) indicator in the building show that the temperature varies between 72-78°F and the relative humidity between 55-84 percent. Examination of the T/RH recordings show that the cooling unit cycle is every 20 minutes, and the cooling units operate for about 5 to 6 minutes per cycle. Circulation fans A and B operate continously.

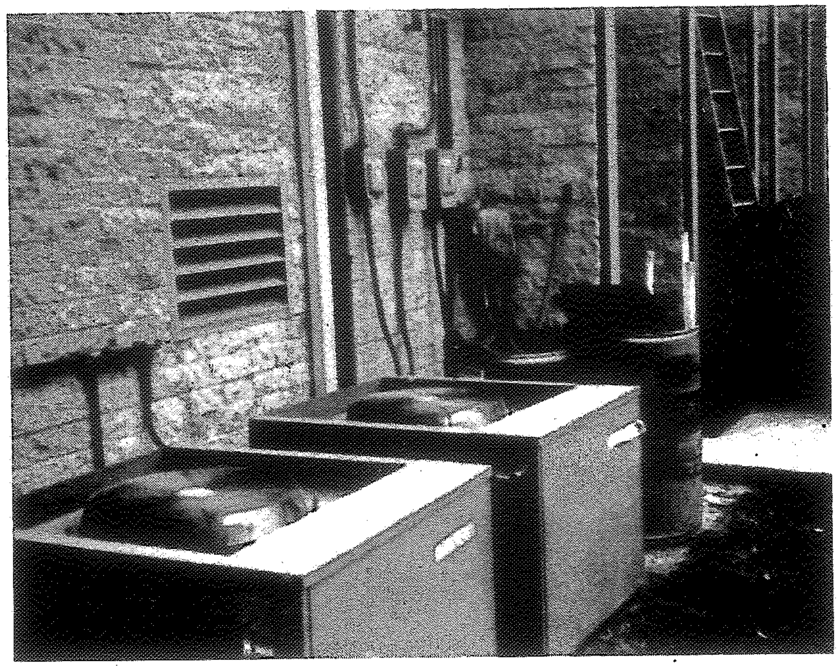
There is a crawl space beneath the building which was partly wet and partly dry, and did not exhibit the musty odor noticed in the building. There appeared to be several small openings (around sinks, ducts, and pipes) between the mechanical room and the crawl space. Air flow was generally into the mechanical room through these openings, but the amount of air so entering was small. There was no access to the crawl space area immediately below the mechanical room, so this space could not be explored. The one floor drain in the mechanical room appeared adequately trapped to prevent backflow of air into the room.

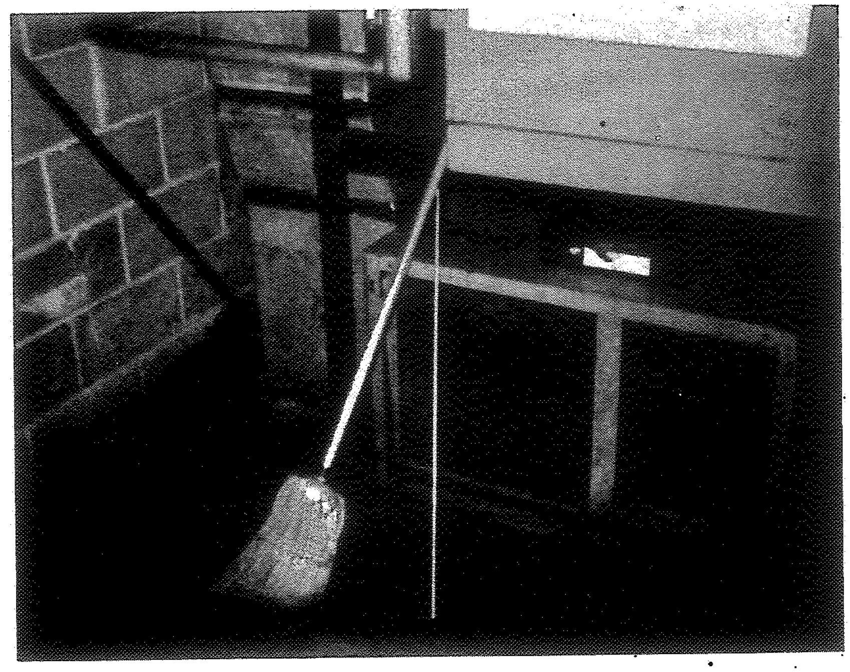
The interior blower units (Figures 2, 4, and 5) have furnace-type disposable filters. The cooling coils also dehumidify incoming air to some extent. The condensate drains to a drip pan inside each unit and thence to the floor drain. Considerable buildup of sludge-like material in the drip pans was observed. Mops and other equipment and material are stored in the mechanical room. The fresh air intake is located just above one of the outdoor heat exchangers (Figure 3).

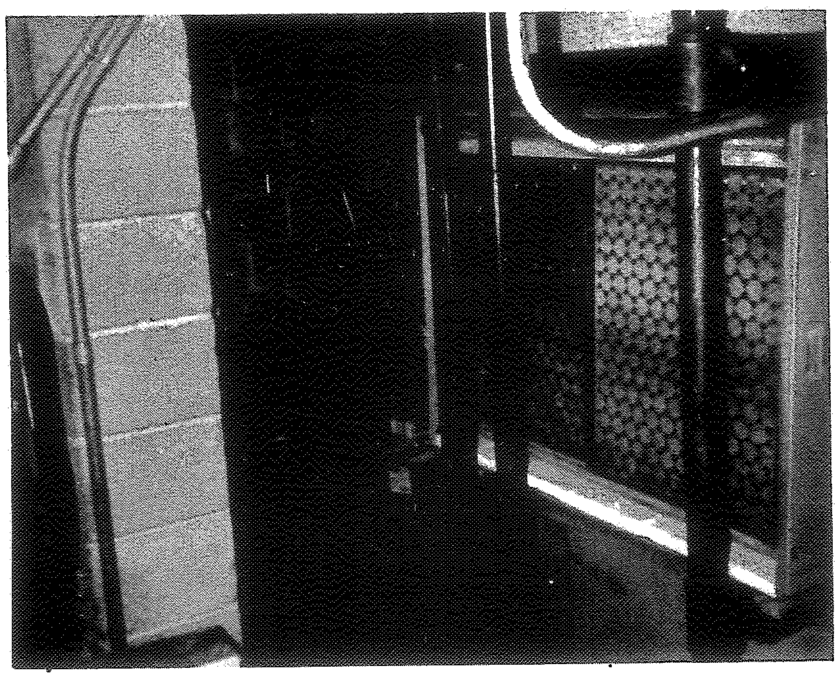
The odors reported and noticed in the building did not appear to be entering from outside sources. Grain dusts from a feed mill 200 ft. away occasionally blow past the building but have not been associated with the odor in the building. No specific internal odor source was found. Rather, the odors appear to be the result of the unusually high relative humidity in the building, which allows moisture to accumulate inside ducts and encourages microbial growth. Mold was also observed on interior building walls.

Three 3 to 4 hour air samples were collected in the office of the affected employee, the Company engineer's office and the mechanical room. These were analyzed for the 22 vapors listed in Section V. Concentrations in air of 0.07 to 0.08 ppm of 1,1,1-trichloroethane were found at all locations. Isopropanol at 0.21 ppm was found in the affected employee's office. None of the other chemicals were detected.

Total air circulation was calculated to be 1.0 cfm/sq. ft. of floor area, within the 0.75 to 2.0 cfm/sq. ft. range recommended by ASHRAE for office buildings. Fresh air supply was calculated to be 0.1 cfm/sq. ft. of floor area, below the ASHRAE recommended range of 0.25 to 0.4 cfm/sq. ft. (5).







UPPER LEFT: Figure 3 - Fresh air inlet to mechanical room and exterior heat exchangers.

UPPER RIGHT: Figure 4 - Interior of mechanical room showing filter of blower unit C.

LOWER LEFT: Figure 5 - Interior of mechanical room showing filter of blower unit B.

The T/RH records for early July indicate usual daytime temperatures in the building of 73-76°F and relative humidities of 64-87 percent. ASHRAE recommends a temperature of 76°F and a desirable relative humidity of 40 percent (but no more than 60 percent in summer or less than 20 percent in winter) for optimum comfort conditions (6).

Because of the low building population and lack of any heavy contaminant producing activity, it is not likely that the low fresh-air turnover is of real concern. The high humidity is of concern and it probably contributes both to employee discomfort and to the microbial growth mentioned above.

B. Microbiological

No evidence of L. pneumophila was found in any of the condensate fluids. All colonies that grew on either FG or CYE media and were suspect on the basis of colonial morphology were subcultured on SBA and either FG or CYE (Note: since L. pneumophila will not grow on SBA, this approach was used to confirm the presence of other than L. pneumophila or the potential presence of L. pneumophila). All isolates grew on SBA; they were not L. pneumophila.

Although numerous bacterial and fungal species were isolated, the predominant microorganisms contaminating condensate fluids were Gram-negative bacteria and yeasts. The most predominant Gram-negative bacteria were Flavobacterium sp., Pseudomonas sp., Ps. maltophila, Acinetobacter calcoaceticus, and Serratia marcescens. The fungi predominant in the samples were Cryptococcus albidus, Fusarium sp., and Rhodotorula sp. Gram-positive bacteria isolated included Corynebacterium sp., Micrococcus sp., and Bacillus sp.; other fungi included Epicoccum sp., Phoma sp., and Aureobasidium sp. Thus, although some differences existed among the three sites sampled (i.e., flavobacteria more evident in top unit and yeast cells more evident in lower unit and common drain), the three most prevalent microorganisms encountered as contaminants in air conditioner condensates were flavobacteria, pseudomonads, and yeast (i.e., Cryptococcus albidus).

Flavobacteria comprised more than 25 percent of the microbial population in the top air conditioning unit as compared to approximately 2 percent in the lower unit and common drain. When wet preparations of raw condensates were examined microscopically, the top unit showed primarily bacterial organisms with rare yeast cells whereas the bottom unit and common drain showed many budding yeast cells along with contaminating bacteria. The total microbial burden of the condensate fluids was similar; 2 x 10^6, 1.3 X 10^6, and 1.2 x 10^6 microorganisms per ml, respectively, in the top, lower, and common drain condensates.

The antibiotic-susceptibility profiles of the predominant microorganisms isolated from condensate fluids are presented in Table I.

The disinfectant tests with flavobacteria indicate that a quaternary ammonium compound, a formaldehyde/alcohol preparation, and 1:100 Chlorox probably killed the flavobacteria. Due to possible toxicity of the recovery medium for flavobacteria, the results are inconclusive.

In summary, the condensate water residing within the two air conditioner units and the common floor drain were all grossly contaminated with bacteria and yeasts, some of which are known to cause human respiratory infections and/or allergic manifestations (i.e., endotoxin-mediated). The condensate of the unit supplying air to the office occupied by the affected employee was highly contaminated with flavobacteria (i.e., 590,000 bacteria/ml); microorganisms which have been incriminated as causative agents in "humidifier fever" (7). With inconclusive findings related to the etiology of L. pneumophila, based on apparent lack of serologic evidence (i.e., sero-conversion), atypical chronicity of clinically-evident respiratory distress, and no isolation of L. pneumophila from condensates, the flavobacteria and other endotoxin-contributing Gram-negative microorganisms become suspect as causative agents of disease in the cited office worker. Appropriate follow-up serology could provide more definitive data.

C. Medical

The affected office employee experienced chest pain in July, 1980, some time after the odors began. Upon recurrence and a positive chest x-ray she was hospitalized for three weeks. She returned to work in September 1980 but continued to have intermittant episodes of fever. Three further hospitalizations occurred in the winter and spring of 1981. A serum specimen obtained July 6, 1981 was negative for Legionella antibodies (less than IFA·64). Further communication with the employee's personal physician gave no indication of legionellosis.

Based on the atypical history, negative serum results, and a negative report from the employee's physician, the team physician's interim opinion, subject of course to revision with further information, is that Legionella pneumophila is not responsible for the recurrent pulmonary disease.

Survey of 17 other employees who work in the same building with the affected employee revealed no employees with illnesses in the recent past possibly consistent with legionellosis (one employee with pneumonia in 1979; one with 3-4 days of fever in 1980). Serum was drawn on 15 of these, including the two mentioned above. All 15 were negative for Legionella antibodies (IFA less than 64).

TABLE I - Antibiotic Susceptibility Profiles of Thomasville Isolates

Antimicrobial	Microorganism				
	Flavobacterium sp.	*Pseudomonas maltophila*	*Pseudomonas* sp.	*Acinetobacter calcoaceticus*	*Serratia marcescens*
Ampicillin	R	R	R	R	S
Streptomycin	S	R	R	S	R
Tetracycline	S	R	S	S	R
Penicillin	R	R	R	R	R
Chloramphenicol	S	I	S	S	S
Sulfadiazene	R	S	S	S	R
Cephalothin	R	R	R	R	R
Sulfamethoxazole/ trimethoprim	S	S	S	S	S
Gentamicin	S	S	R	S	S
Colistin	R	R	R	S	R
Erythromycin	S	R	R	S	R

Note: R (resistant); I (intermediate); S (sensitive).

VII. CONCLUSIONS

No medical or serologic evidence of Legionnaires' disease in any employee was found in this evaluation. With inconclusive findings related to the etiology of L. pneumophila, based on apparent lack of serologic evidence (i.e., sero-conversion), atypical chronicity of clinically-evident respiratory distress, and no isolation of L. pneumophila from condensates, the flavobacteria and other endotoxin-contributing Gram-negative microorganisms become suspect as causative agents of disease in the cited office employee. It is also conceivable that the affected employee's recurrent pulmonary disease may have an allergenic component, which might be a reaction to microorganisms of the types present on wall surfaces and in the air conditioning system.

No chemical air contaminants or other obvious specific hazards were found which might explain the odors or the affected employee's symptoms.

It is concluded that the excessive humidity in the building is the initiating cause of the odors, and that the high humidity creates an environment in which microorganisms can multiply in the air conditioners and elsewhere, from where they may become air-borne and be inhaled.

From the viewpoint of corrective action and prophylaxis, it would be highly desirable to reduce the accumulation of the copious amounts of condensate fluids found in the proximity of the cooled air supply, whereby aerosols of microorganisms could readily gain access to all ventilated parts of the building. In addition, periodic treatment of residual condensates with an effective disinfectant would further reduce the biohazard of aerosolized microorganisms in the office environment. Unless remedial action is taken, the possibility of further respiratory problems among occupants, especially those possibly sensitized, will continue.

VIII. RECOMMENDATIONS

1. Steps should be taken to reduce the accumulation of condensate in the air cooling units and adjoining ducts.

2. The relative humidity in the building should be lower. At the normal temperature observed from the records (75-76°F), the summer relative humidity should be about 40 percent, and no more than 60 percent, for continued comfort.

3. Periodic treatment of residual condensates with an effective disinfectant would further reduce the hazard of aerosolized microorganisms in the office air; a 1:100 dilution of household Chlorox appears suitable.

4. A search should be made for sources of excessive moisture in the building (other than incoming humid fresh air). If found, they should be controlled.

5. Some other conditions noticed are also deserving of attention.

a. The mechanical room is part of the supply air duct system and is under negative pressure. Although the air supply is filtered after it passes through this room, it would be desirable to seal any openings into this room from the walls and crawl space, as this air would be a potential source of odors or moisture.

b. The air filters are of a low-efficiency grade. If other steps do not completely eliminate the problems, consideration should be given to providing more efficient filters on the blower units.

c. The mechanical room doubles as a storeroom (Figures 4 and 5). Care should be taken not to store volatile or odorous materials therein (there was none during the visit July 6). Mops should be stored elsewhere; they are notorious as microorganism breeding beds.

d. Air was flowing backward through blower unit C. This condition should be eliminated if possible, particularly because of possible reentrainment of particulates on the rare occasions it is operated.

e. The fresh air intake to the mechanical room is directly in the discharge airstream of one of the exterior heat exchangers (Figure 3). As a result, unnecessarily hot air is drawn into the building during the cooling season, which probably increases cooling costs. Also, the upward flow of air from the heat exchanger encourages the aerosolization of microorganisms and debris from the ground into the air intake. Extension of the air intake to a higher level by means of a simple stack should alleviate this situation.

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X. AUTHORSHIP AND ACKNOWLEDGEMENTS

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