



CONGRESSIONAL TESTIMONY

PB90193822



TESTIMONY OF

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Before the

SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH, AND ENVIRONMENT

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

September 27, 1989

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I am Philip J. Bierbaum, Director of the Division of Physical Sciences and Engineering, of the National Institute for Occupational Safety and Health (NIOSH) of the Centers for Disease Control. I appreciate this opportunity to report to you on the activities of NIOSH in the area of indoor air quality.

Our experience with evaluating and understanding indoor air quality problems is based on the research and technical assistance that we have conducted under the mandates of the Occupational Safety and Health Act (OSH Act). Our knowledge, therefore, relates to the health effects on workers in nonresidential and nonindustrial workplaces, including Federal buildings, schools, and other public buildings, commercial buildings and portions of commercial vehicles occupied by workers. In addition to dealing with air quality, this knowledge base includes data on ergonomic and psychosocial problems that also affect workers.

More specifically, most of our knowledge on indoor air quality problems has been generated on the "technical assistance side" of our responsibilities under the OSH Act. This assistance is conducted under Section 20(a)(6) of the OSH Act through our Health Hazard Evaluation (HHE) Program, where we respond to requests from employers, employees, employee representatives, State and local agencies and other Federal agencies. Presented below is a brief narrative of how the HHE Program is utilized for indoor air quality investigations, and what we have learned from these investigations in regard to the extent of the problem. Additional details are shown in Enclosure I.

In the 1970's, following the Arab oil embargo, energy conservation programs were encouraged throughout the United States. The operations of buildings changed in an effort to conserve fossil fuels and operating costs. Ventilation rates were reduced and buildings were sealed to prevent infiltration of untempered outside air (hot, humid air in the summer months and cold, dry air in the winter months). At the same time, there was a revolution occurring in buildings throughout the country. Computers forced a change in office procedures and productivity leading to ergonomic and organizational stress problems. Some of these new office technologies brought with them chemical and physical hazards.

We saw the effect of the conservation measures, as well as problems associated with the shifts in office automation (e.g. video display terminals, vision problems), and concern about asbestos and radiation, through increases in requests for assistance in the HHE Program. Of the 1,200 Health Hazard Evaluations between 1971 and 1978, NIOSH investigated six indoor air quality problems or 0.5% of the total. From 1978 to 1980, the percentage of HHE's concerning indoor air quality increased to 7.4%, and since 1980 these HHE's have averaged 12% of all health hazard evaluations. More recently, on an annual basis, this has increased to approximately 20%. For example, in FY 1988 through the present, NIOSH's toll free information number has received an average of approximately 60 inquiries and requests for assistance per month on indoor air quality problems. In 1988, in addition to providing background information and a copy of NIOSH's indoor air quality guidance document

to most of these callers, NIOSH researchers conducted 45 field investigations.

Table 1 presents the number of HHE investigations by building type since the Program was initiated in 1971. (These totals do not include complaints arising from asbestos contamination--the number of which also is significant--or complaints regarding radon.)

TABLE 1

NIOSH Indoor Air Quality
Investigations by Building Type
(through December 1988)

<u>Building Type</u>	<u>Number Completed</u>	<u>Percent of Total</u>
Government and Business Offices	426	80
Schools and Colleges	68	13
Health Care Facilities	35	7
Total:	529	100

We have not seen a decrease in indoor air problems and we are concerned that as the U.S. moves more and more to a service and information economy, with increases in office workers, the problems will increase.

Indoor air quality problems may arise from a variety of sources including human metabolic activity, smoking, structural components of the building and contents, biological contamination, office and mechanical equipment, and outside air pollutants that enter the building. Commonly, the symptoms and health complaints reported by workers are diverse and not specific enough to readily identify the causative agent (Table 2). The workplace environment is implicated by the fact that these symptoms normally disappear on weekends away

from the buildings. At times, these symptoms can be severe enough to result in missed work, reassignment, and even termination. This causes increased anxiety among the workers and, often times, makes the investigation of these problems even more difficult.

TABLE 2

Common Health Complaints

Eye Irritation

Dry Throat

Headache

Fatigue

Sinus Congestion

Skin Irritation

Shortness of Breath

Cough

Dizziness

Nausea

Sneezing

Nose Irritation

Although some of these episodes may be made up of several factors combined, we have classified the results found in our HHE Program by primary type of problem found: contamination from the building materials (4%); microbial

contamination (5%); other contamination from inside the building (15%); contamination from outside the building (10%); inadequate ventilation (53%); and unknown (13%).

As mentioned above, in over half of our indoor air quality investigations, inadequate ventilation was found to be the cause of complaints. Heating, ventilating, and air conditioning (HVAC) conditions that can cause indoor air quality problems include migration of odors or chemical hazards between building areas, re-entrainment of building exhaust through heat recovery devices or improper placement of exhaust and intake stacks, buildup of microorganisms in HVAC system components and poor odor and environmental control due to insufficient "fresh" outdoor air. The insufficient use of "fresh" outdoor air has been compounded by reduction in ventilation airflows because of energy conservation. The inadequacy of building ventilation can be evaluated by monitoring ambient carbon dioxide (CO_2) concentrations, temperature, humidity, and airflow. However other chemical agents from sources other than human occupants also increase with inadequate building ventilation.

In 20-25% of our indoor air quality surveys, sources inside the building have been identified as the major generators of indoor air pollution. To date, common sources that have been identified include: duplicators-methyl alcohol; signature machines - butyl methacrylate; blueprint copiers--ammonia; acetic acid; pesticides; boiler additives--diethyl ethanolamine; cleaning agents; tobacco smoke and combustion gases; foam insulation, particle board, plywood, construction glues and adhesives--formaldehyde, and organic solvents; lined ventilation ducts--fibrous glass; silicone caulking and curing agents. In

these situations, we have found that low concentrations of agents need to be monitored since odor thresholds, comfort and unusual stimuli may be the significant factors rather than higher concentrations where health effects have been established. Also, in many instances no evaluation criteria exist, and the investigators must compare areas where complaints are frequent with areas which have no complaints to search for chemical, biological, physical, and organizational factors which may be the cause. Given the problems with identifying emission sources and the need to measure at low levels, sensitive and specific direct-reading instruments are useful as screening tools. Many times direct-reading instrument measurements need to be followed with highly specific, low level chemical analysis in the laboratory.

To complicate the investigations concerning poor air quality, ergonomics and psychosocial issues often are encountered. For example, our research teams, composed of behavioral scientists, physicians and industrial hygienists, have investigated a series of mass illness outbreaks in various work settings for which there was no apparent physical or chemical cause. The reported symptoms are typically vague and nonspecific, and frequently are described by workers as ill defined contaminants in the workplace (e.g., bad odors, stuffy or heavy air). Questionnaire surveys and interviews of both affected and unaffected workers suggest that the expression of the symptoms may have been exacerbated by a variety of ergonomic, organizational and psychosocial stresses which increase worker job and life-dissatisfaction.

NIOSH has also been engaged in coordinating Federal and other work on indoor air quality problems through its participation in the Interagency Committee on

Indoor Air Quality. The Committee is established to coordinate Federal indoor air quality research and a Federal response to issues in this area, and to serve as liaison among Federal agencies and with State and local governments, the private sector, and the general public. It meets quarterly and is co-chaired by EPA, the Consumer Product Safety Commission, the Department of Energy, and the Department of Health and Human Services (HHS), and includes representatives from 15 other Federal agencies. NIOSH serves as the HHS representative.

The Committee has operated very effectively. For example, it has been instrumental in coordinating the preparation of the EPA Report to Congress on Indoor Air Quality (to which all agencies contributed), coordinating the Library of Congress interagency health effects study (EPA, DOC, NIOSH, Yale University), coordinating research on ventilation, sampling and analytical methods development, radon epidemiology (EPA, NIOSH, DOL, DOC, DOE), and in coordinating the development of Federal guidance on conducting IAQ investigations.

Aside from the NIOSH experiences discussed above, there have been considerable activities by other governmental and nongovernmental groups worldwide. Some major examples of these are as follows:

1. The National Research Council, Assembly of Life Sciences, published "Indoor Air Pollutants" in 1981. The report lists a number of chemicals implicated in indoor air pollutant problems without assessing their importance. The Assembly also recommended that monitoring protocols and

special instruments be developed to assess indoor air pollutants; that complaints of malaise, headache, stuffiness, and eye and throat irritation be studied; that the lowering of work productivity due to indoor pollution and associated discomfort be investigated; and that the influences of building design on the concentration of pollutants in commercial facilities be studied.

2. The Environmental Protection Agency (EPA) published "EPA Indoor Air Quality Implementation Plan" in 1987 which not only described EPA's research agenda at that time, but dealt with those indoor air quality issues that concerned other Federal agencies. The document included a bibliography of indoor air quality literature containing over 2,000 entries.
3. In 1988, the Health and Safety Executive of Great Britain issued a report "Sick Building Syndrome: A Review." This report summarizes their experiences with "sick building syndrome," and discusses symptoms, common features of "sick buildings" and possible causes. Their experiences mirror that information found by our HHE Program.
4. A 1988 EPA publication, "Indoor Air Quality in Public Buildings" reported that concentrations of volatile organic compounds in new buildings were found to be as much as 100 times higher than those found outdoors.
5. Volume II of the Environmental Protection Agency's Report to Congress prepared in 1988/89 under Title IV of the Superfund Amendments and

Reauthorization Act of 1986 highlights an up-to-date summary of the "Assessment and Control of Indoor Air Pollution." This volume discusses such issues as (a) factors affecting indoor air quality; (b) sources of pollutants and health effects; and (c) economic impacts.

These examples illustrate the significance of indoor air quality problems associated with worker health and the need for continued vigilance in addressing them.

Finally, I will briefly discuss your question regarding how NIOSH activities would be affected if H.R. 1530 were enacted.

If the bill were enacted, NIOSH indoor air quality activities would have to be increased and modified to meet the requirements outlined in Section 13 of the legislation --the Building Assessment Demonstration Program. In general, Section 13 parallels the current activities of the NIOSH HHE program in addressing requests for indoor air quality investigations. As stated earlier, the HHE program has responded to requests with over 500 field studies, canvassing a broad array of building types and situations. Therefore an organizational and procedural framework for implementing Section 13 is already in place. However, we would have to substantially expand the current program to address the increased demand for assessments from Federal, State, local, and non-governmental buildings that we anticipate would accompany enactment of the bill. We would staff a program dedicated solely to conducting building assessments and preparing assessment reports, and we would obtain substantial support from experts outside of NIOSH. Our criteria for selecting buildings

for assessments would be modified according to Section 13(e). We also have further work to do in developing methods for these assessments (epidemiologic/environmental assessments, medical screening, contaminant control strategies), and we would develop follow-up evaluations to determine the effectiveness of response measures and their cost.

This concludes my prepared testimony. I will be pleased to answer any questions.

ENCLOSURE I

THE NIOSH APPROACH TO CONDUCTING INDOOR AIR QUALITY
INVESTIGATIONS IN OFFICE BUILDINGS

National Institute for Occupational Safety and Health

ABSTRACT

Since 1971, personnel from the National Institute for Occupational Safety and Health (NIOSH) have completed over 500 indoor air quality (IAQ) investigations in a variety of office building environments. Most of these investigations have been conducted since 1979, paralleling the energy conservation concerns of building owners and operators. These investigations have been conducted under the authority of the NIOSH Health Hazard Evaluation Program and have been in direct response to reported health complaints or illness. Therefore, these IAQ investigations are intended to establish the identity of a problem and to recommend solutions for its correction. Over time, we have developed a consistent methodology with a "solution-oriented" approach to conducting these IAQ investigations. To initiate the investigation, the NIOSH team gathers background information by telephone and then makes a site visit to interview the affected employees and establish symptom identity and prevalence. During this initial site visit, the investigators also attempt to identify sources of contaminants, evaluate comfort parameters, and assess ventilation system performance. A variety of applicable evaluation criteria may be used, including "rules-of-thumb" gleaned from the current scientific literature and our own experiences. If specific problems cannot be identified through these initial means, follow-up visits are then used to pursue a continually narrowing range of possibilities. This "solution-oriented" approach has resulted in the best allocation of our resources and has allowed the most efficient use of in-field as well as analytical personnel. In the IAQ investigations completed to date, problems were found to result from building material contaminants in 4%, microbiological contaminants in 5%, contaminants brought in from outside the building in 10%, contaminants from inside the building in 15%, and inadequate ventilation problems in 53%. The remaining 13% represent those investigations where no problem could be identified.

INTRODUCTION

The sometimes questionable quality of indoor air and the potential for health risks have become major concerns of building occupants, especially office workers. Some potential indoor exposures, such as to the carcinogen, asbestos, have well-documented health implications. But, more commonly, the health risks of other indoor air exposures are poorly understood. Nevertheless, office workers experiencing indoor air quality (IAQ) problems often demand a complete evaluation of their work environment and of the effect it may have upon their health.

At the National Institute for Occupational Safety and Health (NIOSH), the majority of our indoor air quality investigations are conducted as part of the Health Hazard Evaluation Program. We conduct these health hazard evaluations at the request of employee groups, unions, management, and local, state and Federal agencies. Generally, these requests are in response to existing worker health complaints and illness. Because we are essentially "invited" to conduct these investigations, the data presented here will not reflect a statistically valid cross-section of the indoor air quality problem. However, these findings are drawn from one of the largest single information bases currently available on the subject. In essence, this paper will summarize the NIOSH methodology currently used during our IAQ investigations and some of the data from these IAQ investigations completed since the start of the Health Hazard Evaluation Program.

METHODOLOGY

We have found that investigating IAQ problems can present a formidable challenge which, in some ways, is more difficult than evaluating industrial environments. In an industrial situation, the evaluation will be directed by investigations of the materials used by, or in the vicinity of, the affected workers. These materials can usually be chemically analyzed which permits characterizing exposures through the use of standard industrial hygiene techniques and potential health effects using standard medical and epidemiologic techniques. Frequently there are exposure criteria which can be applied to help interpret the data obtained. This is rarely the case with an indoor air quality problem.

Indoor air quality investigations tend to become more complicated as time passes without identification of a cause. Frustrations result in highly charged emotions which only further impede continued evaluation efforts. These situations are further complicated by the fact that symptoms are not easily attributed to a single cause and the application of standard industrial hygiene, medical and epidemiologic techniques may prove to be inconclusive.

Over time, our approach in evaluating this situation has changed. We have developed a more consistent, solution-oriented approach that systematically excludes a continually narrowing range of possibilities. Generally, this exclusion hierarchy, which has come about based on our past experiences, involves evaluation of physical, chemical and micro-biological factors, in the order presented. Each of these potential causation categories are discussed in more detail later in this presentation.

Since we anticipate that IAQ requests will continue to represent a substantial percentage of the total health hazard evaluation requests (currently about 20%), three response levels have been

developed. Based on information obtained during an initial telephone conversation with the requestor, the following responses are possible:

1. Provide "self-help evaluation" materials (attached). Remain available for consultation by telephone. Become more involved, if necessary.
2. NIOSH conducts an initial evaluation and provides recommendations to solve the problem or for further study on a "self-help" basis.
3. NIOSH conducts a full-scale investigation.

The NIOSH investigation team commonly includes an industrial hygienist and physician/epidemiologist, but can also include other professionals such as an engineer. Most investigations contain the following parts: background assessment, initial site assessment, and, if necessary, additional site assessments.

BACKGROUND ASSESSMENT

For the background assessment, we initially obtain, by telephone, as much information on the building as practicable, an idea of the symptoms being experienced, and a chronology of the problem. Much of this information can be collected using a standard questionnaire. We also request copies of other previous investigations which are relevant to the problem at hand. These data are then used to tailor the protocol for the initial site assessment so as to make it more efficient.

INITIAL SITE ASSESSMENT

For the initial site assessment, a common protocol includes five separate steps or parts: an opening conference, a walk-through evaluation, personal interviews, phase I of environmental monitoring, and a closing conference.

Opening Conference--The opening conference is attended by representatives of the employer and employees (where applicable) as well as someone who has knowledge of the operation, and maintenance of the building's heating, ventilating and air conditioning (HVAC) systems. This meeting serves to present NIOSH's role, discuss anticipated activities and arrange to receive copies of pertinent data not already received.

Walk-through Survey--The walk-through survey will involve all or part of the building including inspection of the HVAC systems with special attention given to the mechanism by which outside air enters each HVAC unit. Architectural plans and ventilation test and balance reports may also be reviewed during this phase. Potential sources of emission are identified so that each may be further evaluated, as needed.

Personal Interviews--Personal interviews are often conducted to determine the extent, prevalence and character of reported symptoms. The use of a questionnaire such as the one shown in Appendix 1, may be the most efficient means of collecting this type of information. It can be used as a guide during personal interviews or it can be self-administered.

Phase I Environmental Monitoring--Phase I environmental monitoring is usually conducted on each initial survey. The scope of this effort may vary, but usually will either evaluate certain aspects of the building environment, which we have come to believe are important factors in all investigations, or explore any other possibilities made apparent from the background assessment. Evaluation of the ventilation system using both actual measurement and/or carbon dioxide (CO₂) techniques, and monitoring temperature and relative humidity are useful procedures for all evaluations during the initial site assessment. Monitoring for formaldehyde is an example of a specific method which may be used if the background assessment indicates that respiratory system and eye irritation are prevalent complaints and the space has been recently built or renovated (a number of furnishings are potential sources of formaldehyde). Most of the monitoring accomplished on the initial survey is obtained using direct-reading instruments where possible because they provide results on-the-spot. Any deficiencies noted can be corrected and re-evaluated. Extensive and expensive sampling for other contaminants is not recommended initially unless a particular contaminant source is being evaluated. Trace concentrations of hundreds of compounds could be identified depending on the extent of the sampling and analytical effort; however, the concentrations usually detected would not be expected to cause adverse health effects in a normal healthy individual. Other techniques which I will now discuss have been consistently more useful.

Evaluating HVAC Systems--HVAC systems can be complicated and most industrial hygienists have received very little or no training in the design, maintenance and trouble-shooting of building ventilation systems. The most important aspect of evaluating HVAC systems is to gain an understanding of how they are supposed to be working and then use some relatively simple methods to convince yourself that the system is performing up to the design specifications, and whether this is adequate with respect to the complaint areas in the building. Once you are sure that outside air is entering the building, return to the complaint area(s) and measure supply and return air flows using either a velometer or a flow hood and compare the results to the design quantities. Note that in variable-air-volume (VAV) systems the supply air flows may vary during the day.

A method which is gaining popularity, and which is currently used by NIOSH for evaluating the adequacy of ventilation to an area is the measurement of CO₂ concentrations. Humans expire significant quantities of CO₂. The higher the CO₂ levels inside a building, the poorer the overall ventilation, in a general sense. We believe that complaints will not be prevalent if interior CO₂ concentrations are maintained at twice or less the outdoor levels (usually 250-300 ppm). At CO₂ concentrations above 1000 ppm, or 3 to 4 times the outdoor level, complaints of headaches, tiredness, eye, nose and throat irritation may be more prevalent. It is important to realize that it is not the CO₂ concentration that is causing the symptoms; but, if CO₂ increases, so may all the other normal airborne contaminants and it may be some combination of all these substances that make people uncomfortable. Carbon dioxide measurements can be obtained using standard detector tubes or portable CO₂ monitoring instruments. The use of CO₂ as an index of the general quality of indoor air is currently being evaluated by NIOSH as well as many other agencies.

Poor mixing of air is another potential problem sometimes found when air is delivered and returned through ceiling diffusers. Standard smoke tubes, and temperature and CO₂ measurements at 1 foot and 7 foot heights above the floor may be useful techniques in evaluating stratification resulting from poor mixing.

Monitoring Temperature and Relative Humidity-- Temperatures too cold, too warm or fluctuating can be a source of complaints. While individuals vary in their limits of thermal comfortability, if a significant number of workers in an area complain (more than 20%), then temperature and relative humidity may be creating an uncomfortable environment. If temperatures are too warm, complaints of tiredness, lack of concentration and headache may also be reported. Low relative humidities, not uncommon in the winter in a building or residence that is not humidified, can cause eye, nose and throat irritation.

CLOSING CONFERENCE

The closing conference of the initial site survey provides an opportunity to present the NIOSH activities accomplished, any results obtained and recommendations on corrective actions if potential problems were identified. If no problems were identified, recommendations may be made on how to continue studying the problem either on a self-help basis or through continued NIOSH involvement. Typical recommendations when we have not identified a probable explanation for the reported symptoms would include the formulation of a more formalized method of reporting worker symptoms on a daily basis and the generation of HVAC data logs to provide evidence that the HVAC system is performing in a consistent manner over time.

EVALUATION CRITERIA

Evaluation criteria used to interpret environmental measurements vary. In the classic industrial hygiene sense, the Occupational Safety and Health Administration's (OSHA) permissible exposure limits [1], the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values [2], and NIOSH's recommended exposure limits [3] are most commonly used in occupational exposure assessments. Because these criteria are based on health effects as they pertain to the manufacturing environment, they may not have the same relevance for workers in an office setting, whose primary concern may be for comfort or simply an absence of unusual sensory stimuli over their working period. The Environmental Protection Agency (EPA) has ambient air quality standards [4] for a variety of pollutants designed to protect the public over an entire day (not just an 8-hour workday). However, these, too, may not have relevance to an indoor office environment, especially from the perspective of problem-solving.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) guidelines for acceptable indoor air quality [5] have been developed for the indoor environment. We commonly use these as criteria in our office building evaluations, especially for assessing the performance of a ventilation system. We also use the ASHRAE comfort guidelines [6] as criteria for assessing the thermal performance of occupied space.

ADDITIONAL SITE ASSESSMENTS

If the background assessment and the initial site visit identify a problem that needs further definition, or if no problem can be isolated, an additional site assessment may be performed. During the additional site assessment, more specific and extensive monitoring may be conducted for chemical and/or microbiological contaminants of interest. Sampling for airborne microbiological contaminants is also outside of what is considered a standard industrial hygiene technique. Useful techniques are still under evaluation. Methodology is available, however, analytical support is somewhat limited. Nevertheless, the topic of potential microbiological contamination usually comes up as an investigation progresses. Close visual inspection of the various HVAC components will usually uncover a microbiological problem if present.

The condition most commonly associated with exposure to airborne organisms is hypersensitivity pneumonitis. This is a general term for a disease which occurs as a result of an immunologic inflammatory reaction to the inhalation of any of a variety of organic dusts. Terms like humidifier fever, ventilation pneumonitis, farmer's lung and cheese worker's lung are all the result of these exposures. Symptoms are usually described as a recurring "flu-like" syndrome. Diagnosis is based on a combination of characteristic symptoms, chest x-rays, pulmonary function abnormalities and sometimes immunologic studies [7].

Inspection of the HVAC system and confirmation of the diagnoses of hypersensitivity pneumonitis among workers may be more useful than air sampling for airborne microorganisms until investigative techniques are further refined.

DISCUSSION

Through December 1988, 529 NIOSH indoor air quality health hazard evaluations have been completed (Table 1). These do not include our investigations of asbestos-in-building problems, but only those where the building occupants were actually experiencing ill health effects. The number of investigations has increased markedly since 1979. This is most probably due to a couple of factors: increased energy conservation measures and increased worker awareness of their office environment. We now average about two indoor air quality investigations per week.

TABLE 1
NIOSH INDOOR AIR QUALITY INVESTIGATIONS
BY YEAR (THROUGH DECEMBER 1988)

Year	Number Completed	%
Pre-1978	6	1
1978	9	2
1979	12	3
1980	28	6
1981	82	18
1982	52	12
1983	61	14
1984	56	13
1985	81	18
1986	59	13
1987	38	8
1988	45	9
Total:	529	100

While the majority of our investigations have been conducted in government and private-sector office buildings (Table 2), we have also looked at problems in schools, colleges, and health care facilities.

TABLE 2
NIOSH INDOOR AIR QUALITY INVESTIGATIONS
BY BUILDING TYPE (THROUGH DECEMBER 1988)

Building Type	# Completed	%
Government And		
Business Offices	426	80
Schools And Colleges	68	13
Health Care Facilities	35	7
Total:	529	100

Commonly, the symptoms and health complaints reported by the office workers are diverse and not specific enough to readily identify the causative agent (Table 3). The workplace environment is implicated by the fact that these symptoms normally disappear on weekends away from the office. At times, these symptoms can be severe enough to result in missed work, reassignment, and even termination. This causes increased anxiety among the workers and, often times, makes the investigation of these problems even more difficult and frustrating.

TABLE 3
COMMON HEALTH COMPLAINTS

Eye Irritation	Shortness of Breath
Dry Throat	Cough
Headache	Dizziness
Fatigue	Nausea
Sinus Congestion	Sneezing
Skin Irritation	Nose Irritation

Although many of these problems may be multifactorial, we have classified our evaluations by primary type of problem found: contamination from the building material (4%); microbiological contamination (5%); contamination from outside the building (10%); contamination from inside the building (15%); inadequate ventilation (53%); and unknown (13%) (Table 4). There are some shortcomings to these data, however, in that they may not represent a "true" cross-section of the indoor air quality problem as previously discussed. For example, we have not used a standard protocol for all these evaluations, as our methods and criteria have evolved with time and experience. Also, since many of these investigations were reviewed retrospectively, there may be some misclassification due to the vagueness of earlier reports. Lastly, we have little follow-up data on many of these evaluations to enable us to determine the efficacy of our recommendations [8].

TABLE 4
NIOSH INDOOR AIR QUALITY INVESTIGATIONS
BY PROBLEM TYPE (THROUGH DECEMBER 1988)

Problem Type	# Completed	%
Building Materials Contamination	21	4
Microbiological Contamination	27	5
Outside Contamination	53	10
Inside Contamination	80	15
Ventilation Inadequate	280	53
Unknown	68	13
Total:	529	100

BUILDING MATERIALS CONTAMINATION

Contamination from building materials and products was the major problem in 4% of our investigations. Formaldehyde can off-gas from urea-formaldehyde foam insulation, particle board, plywood, and some glues and adhesives commonly used during construction. Other building fabric contamination problems encountered include dermatitis resulting from fibrous glass, various organic solvents from glues and adhesives, and acetic acid used as a curing agent in silicone caulking.

MICROBIOLOGICAL CONTAMINATION

Five percent of our investigations have involved some type of microbiological contamination. Even though this is not a common cause of

office problems, it can result in a potentially severe condition known as hypersensitivity pneumonitis. This respiratory problem can be caused by bacteria, fungi, protozoa, and microbial products that may originate from ventilation system components. A similar condition known as humidifier fever, most commonly reported in Europe, is also the result of microbiological contamination in ventilation systems. In our investigations, micro-biological contamination has commonly resulted from water damage to carpets or furnishings, or standing water in ventilation system components.

OUTSIDE CONTAMINATION

Contamination from sources outside the office space was the major problem identified in 10% of our investigations. Problems due to motor vehicle exhaust, boiler gases, and previously exhausted air are essentially caused by re-entrainment. This is usually the result of improperly located exhaust and intake vents or periodic changes in wind conditions. Other outside contamination problems include contaminants from construction or renovation such as asphalt, solvents, and dusts. Also, gasoline fumes infiltrating the basement and/or sewage system can sometimes be a problem and are usually caused by gasoline leaks from ruptured underground tanks at nearby service stations. One of the most common sources of outside contamination has been carbon monoxide fumes from basement parking garages being recirculated through the building ventilation system.

INSIDE CONTAMINATION

Contamination generated by sources inside the office space was the major problem identified in 15% of our investigations. Copying machines are often found to be a significant source. Examples of this type of problem would include methyl alcohol from spirit duplicators, butyl methacrylate from signature machines and ammonia and acetic acid from blueprint copiers. Still other inside contamination problems we have encountered include pesticides which were improperly applied; dermatitis from boiler additives such as diethyl ethanolamine; improperly diluted cleaning agents such as rug shampoo; tobacco smoke of all types; combustion gases from sources common to cafeterias and laboratories; and cross-contamination from poorly ventilated sources that leak into other air handling zones.

Contaminants from inside or outside the office space, and from the building fabric are essentially chemical contaminants. Many times odors are associated with some of these contaminants which may aide in source identification. Additionally, in most cases, these chemical contaminants were measured at levels above ambient but far below any existing occupational standard.

INADEQUATE VENTILATION

In 53% of our investigations, the building ventilation has been inadequate. When evaluating building ventilation, we normally use ASHRAE standards for comparison. ASHRAE standards 62-1981, "Ventilation for Acceptable Indoor Air Quality" (ASHRAE 1981) and 55-1981, "Thermal Environmental Conditions for Human Occupancy" (ASHRAE 1981) are both

used. Some of the ventilation problems we commonly encounter are: not enough outdoor air supplied to the office space; poor air distribution and mixing which causes stratification, draftiness, and pressure differences between office spaces; temperature and humidity extremes or fluctuations (sometimes caused by poor air distribution); and air filtration problems caused by improper or no maintenance to the building ventilation system. In many cases, these ventilation problems are created or enhanced by certain energy conservation measures. These include reducing or eliminating outdoor air; reducing infiltration and exfiltration; lowering thermostats in winter, raising them in summer; eliminating humidification or dehumidification systems; and early shut-down and late start-up of the ventilation system.

CONCLUSION

The major problems identified in these NIOSH indoor air quality investigations can be placed into three general categories listed with decreasing frequency: inadequate ventilation, chemical contamination, and microbiological contamination. Inadequate ventilation is the single largest problem we have seen in buildings. Although varied, these ventilation problems commonly can allow a build-up of any contaminants present in the occupied space to the point that adverse health effects are experienced or allow the environment to become annoyingly uncomfortable to the office workers. As our experience increased over time, we developed a solution-oriented approach to conducting these evaluations which places a high priority on building ventilation. This approach has resulted in the best allocation of our resources and has allowed more efficient use of in-field as well as analytical time.

Increasing office worker awareness and the current shift to office-based, service-type employment will no doubt increase concerns about the indoor air quality in offices and other non-industrial settings. More research into office building ventilation and its effect on background levels of contaminants will be necessary to provide additional and more appropriate guidelines for the evaluation and control of indoor air quality problems in the future.

Early recognition of a problem, with a timely and systematic evaluation, are key factors to a quick and effective resolution.

REFERENCES

- [1] OSHA, OSHA Safety and Health Standards, Occupational Safety and Health Administration, Washington, DC, 1983.
- [2] ACGIH, Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment and Biological Exposure Indices with Intended Changes for 1985-86, Cincinnati: American Conference of Governmental Industrial Hygienists, 1985.
- [3] CDC, "NIOSH Recommendations for Occupational Safety and Health Standards," Morbidity and Mortality Weekly Report, Vol. 34, 1985, pp. 35-315.
- [4] EPA, National Primary and Secondary Ambient Air Quality Standards, Washington, DC: Environmental Protection Agency, 1971.
- [5] ASHRAE, ASHRAE Standard 62-1981, "Ventilation for Acceptable Indoor Air Quality," Atlanta: American Society for Heating, Refrigerating and Air-Conditioning Engineers, Inc, 1981.
- [6] ASHRAE, ANSI/ASHRAE Standard 55-1981, "Thermal Environmental Conditions for Human Occupancy," Atlanta: American Society for Heating, Refrigeration and Air-Conditioning Engineers, Inc, 1981.
- [7] Levy, M.B. and Fink, J.N., "Hypersensitivity Pneumonitis", Annals of Allergy, Vol. 54, 1985, pp. 167-171.
- [8] Melius, J., Wallingford, K., Keenlyside, R., Carpenter, J., "Indoor Air Quality--the NIOSH Experience," Annals of the American Conference of Governmental Industrial Hygienists, Vol. 10, 1984, pp. 3-7.

APPENDIX 1
INDOOR AIR QUALITY QUESTIONNAIRE

1. Complaints Yes _____ No _____
(If yes, please check)

temperature too cold
 temperature too hot
 lack of air circulation (stuffy feeling)
 noticeable odors
 dust in air
 disturbing noises
 other
(specify) _____

2. When do these problems occur?

morning daily
 afternoon specific day(s) of the week
 all day which day(s)? _____
 no noticeable trend

3. Health Problems or Symptoms

Describe in three words or less each symptom or adverse health effect you experience more than two times per week.

Example: runny nose

Symptom #1 _____
Symptom #2 _____
Symptom #3 _____
Symptom #4 _____
Symptom #5 _____
Symptom #6 _____

Do the above symptoms clear up within 1 hour after leaving work?
Yes _____ No _____

If no, which symptom or symptoms persist (noted at home or at work) throughout the week? Please indicate by drawing a circle around the symptom number below.

Symptom: #1 #2 #3 #4 #5 #6

Do you have any health problems or allergies which might account for any of the above symptoms? Yes _____ No _____

If yes, please
describe. _____

_____ (over)

APPENDIX 1 (CONTINUED)

Do any of the following apply to you?

wear contact lenses
 operate video display terminals at least 10% of the work day
 operate photocopier machines at least 10% of the work day
 use or operate other special office machines or equipment
(specify) _____

currently taking medication
reason for taking medication (specify) _____

5. Do you smoke? Yes _____ No _____

6. Do others in your immediate work area smoke? Yes _____ No _____

7. Your office or suite number is _____

8. What is your job title or position? _____

9. Briefly describe your primary job tasks.

10. Can you offer any other comments or observations concerning your office environment? (optional)

11. Your name? (optional) _____

12. Your office phone number? (optional) _____

ENCLOSURE II

NIOSH PROJECTS ON INDOOR AIR QUALITY THAT WERE INITIATED IN FISCAL YEAR 1989
(DOES NOT INCLUDE HEALTH HAZARD EVALUATION PROGRAM
AND INFORMATION TOLL FREE NUMBER)

These projects were initiated in Fiscal Year 1989 as part of a modest start-up effort to conduct some of the research and dissemination that is envisioned in a more rigorous and long-term program agenda.

- INDOOR AIR QUALITY AND WORK ENVIRONMENT QUESTIONNAIRE
 - o Goal
To generate a valid tool to assess effects and risk factors of working in an indoor office environment.
 - o FY'89 Resources
Discretionary funds - \$18,000
- SURVEY ASSESSMENT OF PHYSICAL JOB ATTRIBUTES AND THE WORK ENVIRONMENT
 - o Goal
To develop reliable and valid psychometric (e.g., self-report) measures for use across a wide variety of occupations, including workers in nonresidential, nonindustrial workplaces.
 - o FY'89 Resources
Discretionary funds - \$7,000
- ANALYSIS OF INDOOR AIR CONTAMINANTS USING SOLID-SORBENT SAMPLING AND THERMAL DESORPTION/GC/MS
 - o Goal
To detect and identify, in a single air sample, most of the volatile organic compounds present at or above part per billion levels for use in investigations of indoor air quality.
 - o FY'89 Resources
Discretionary funds - \$5,000

BH/10

- METHODS FOR EVALUATING INDOOR AIR VENTILATION SYSTEMS
 - o Goal
To develop effective ventilation system measurement tools for indoor air quality investigations.
 - o FY'89 Resources
Discretionary funds - \$29,000
- INDOOR AIR QUALITY TRAINING INITIATIVE
 - o Goal
To develop a comprehensive, up-to-date, training module for occupational safety and health paraprofessionals, professionals, and others with indoor air quality responsibility but without relevant training.
 - o FY'89 Resources
Discretionary funds - \$25,000
- FOLLOW-BACK ACTIVITY TO DETERMINE THE EFFECTIVENESS OF THE CURRENT INDOOR AIR QUALITY INVESTIGATIONS CONDUCTED UNDER THE NIOSH HEALTH HAZARD EVALUATION PROGRAM
 - o Goal
To evaluate if (1) NIOSH's involvement led to a resolution of the indoor air quality problem that was being investigated and (2) if so, which parameters changed to improve the situation.
 - o FY'89 Resources
Discretionary funds - \$35,000
- LIBRARY OF CONGRESS INDOOR AIR QUALITY STUDY
 - o Goal
To conduct an epidemiologic/environmental investigation in collaboration with EPA, NIST, and Yale University at the Library of Congress Madison Building.
 - o FY'89 Resources
Discretionary funds - \$120,000

REPORT DOCUMENTATION PAGE		1. REPORT NO.	2.	3.	PB90-193822
4. Title and Subtitle NIOSH Testimony on Indoor Air Quality by P. J. Bierbaum, September 27, 1989			5. Report Date	89/09/27	
			6.		
7. Author(s) NIOSH			8. Performing Organization Rept. No.		
9. Performing Organization Name and Address NIOSH			10. Project/Task/Work Unit No.		
			11. Contract (C) or Grant(G) No. (C) (G)		
12. Sponsoring Organization Name and Address			13. Type of Report & Period Covered		
			14.		
15. Supplementary Notes			<p><i>This testimony considered the activities of NIOSH in the area of indoor air quality. Energy conservation concerned in the 1970s forced the construction of buildings with the key element being preventing infiltration of untempered outside air. Many buildings were effectively sealed against air entry. Requests for health hazard evaluations due to a suspected poor quality of indoor air have increased dramatically in recent years. Indoor air quality problems may arise from a variety of sources including human metabolic activity, smoking, structural components of the building and contents, biological contamination, office and mechanical equipment, and outside air pollutants that enter the building. Many times the symptoms and health complaints reported by workers were diverse and not specific enough to readily identify the causative agent. The results from the health hazard evaluations have enabled NIOSH to classify the findings by primary type of problem: contamination from the building materials, 4 percent; microbial contamination, 5 percent; other contamination from inside the building, 15 percent; contamination from outside the building, 10 percent; inadequate ventilation, 53 percent; and unknown, 13 percent. Sources inside the building include duplicators, signature machines, blueprint copiers, pesticides, boiler additives, cleaning agents, tobacco smoke, combustion gases, construction glues and adhesives, lined ventilation ducts, and organic solvents. Ergonomic and psychosocial issues often complicated the findings.</i></p>		
16. Abstract (Limit: 200 words)					
17. Document Analysis a. Descriptors					
b. Identifiers/Open-Ended Terms NIOSH-Publication, NIOSH-Author, NIOSH-Testimony, Bierbaum-P-J, Air-quality-monitoring, Closed-building-syndrome, Office-workers, Worker-health, Air-sampling, Indoor-air-pollution					
c. COSATI Field/Group		REPRODUCED BY U.S. DEPARTMENT OF COMMERCE NATIONAL TECHNICAL INFORMATION SERVICE SPRINGFIELD, VA. 22161		18. Security Class (This Report)	
19. Availability Statement				21. No. of Pages <i>28</i>	
				22. Security Class (This Page)	
				23. Price	

