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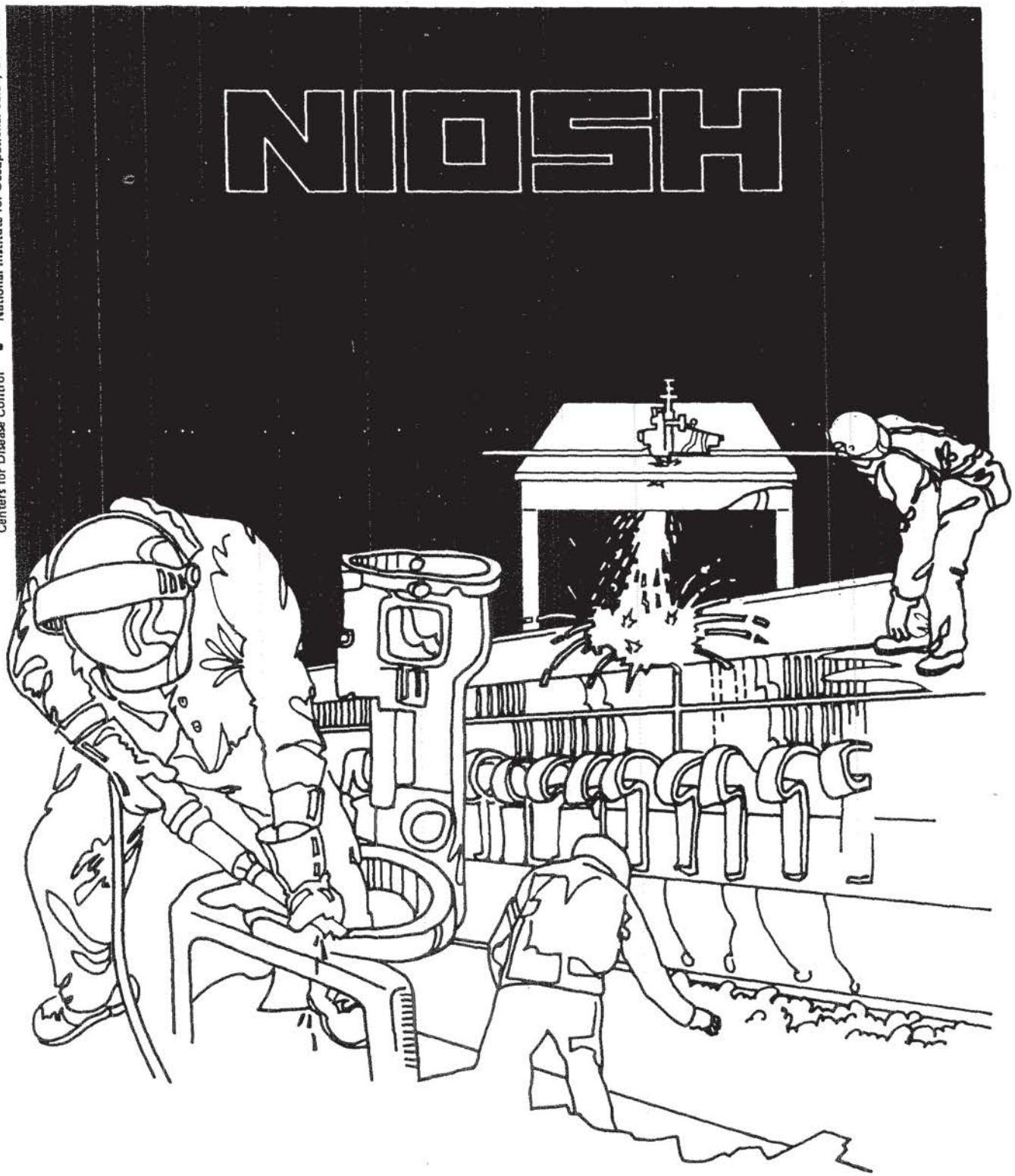

Health Hazard Evaluation Report

HETA 82-167-1460
UPPER SCHOOL
ENGLEWOOD CLIFFS, NEW JERSEY

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 82-167-1460
April, 1984
UPPER SCHOOL
ENGLEWOOD CLIFFS, NEW JERSEY

NIOSH INVESTIGATORS:
Peter Gann, M.D.
Joseph Schirmer, I.H.
New Jersey Department of Health

I. SUMMARY

In March 1982, the National Institute for Occupational Safety and Health (NIOSH) was requested by the school superintendent in Englewood Cliffs, New Jersey, to evaluate complaints of fatigue, lightheadedness, headache, dizziness and ear disturbances among teachers in the Upper School. Symptoms were attributed to poor air quality in a particular wing at the school. Six of the affected teachers were medically interviewed and eight were examined by an Ear, Nose, and Throat specialist during the spring of 1982. No students were identified as being affected. All eight teachers examined were diagnosed as having middle ear disturbances attributable to eustachian tube dysfunction.

A mechanical engineer hired by the school system inspected the boiler in March, 1982, and found leaks which may have been causing infiltration of fuel exhaust into the heated air distributed to the classrooms. The affected wing is the first area to receive heated air from the boiler. Leaks in the boiler system were promptly sealed. In May, 1982, we took detector tube samples for nitrogen dioxide, sulfur dioxide, formaldehyde and carbon monoxide with the boilers running at full capacity. Results were below detectable limits in all of the classrooms. High volume air samples for volatile organics also taken in May, 1982, detected traces (7 ppb) of n-hexane near the heat ducts in two of the classrooms. In the Interim Report issued in June, 1982, we concluded that it appeared likely that low levels of fuel exhaust contaminating the forced hot air had caused mild upper respiratory irritation leading to the symptoms observed. In addition, inadequate overall ventilation in the classrooms was identified. Recommendations were made to increase the air turnover.

During the Summer of 1983, renovations in the ventilation system were completed. We returned to the school in August and September of 1983 in order to assess the ventilation system and found that the supply air was increased 3.5 to 8.0 times as compared to the air supply measured in 1982.

The association of middle ear disturbances with faulty ventilation and the presence of low level irritants is somewhat surprising. It suggests the need to consider this type of health effect in the evaluation of "stuffy building syndrome".

Based on these results, NIOSH concluded that there had been a health hazard from exposure to boiler exhaust and inadequate ventilation at the Upper School in Englewood Cliffs. Improvements in the boiler system and subsequently, in the general ventilation, have eliminated any hazard from low level irritants in the classroom air. Symptoms of middle ear disturbance attributed to this situation are expected to be transient and reversible. Recommendations made in an Interim Report regarding improvements in ventilation have been followed. Additional recommendations regarding maintenance of the air system are made in this Final Report.

KEYWORDS: SIC 8211, fuel oil exhaust, room ventilation, middle ear disturbance, stuffy building syndrome, indoor air pollution.

II. INTRODUCTION

In March, 1982, NIOSH received a request for a health hazard evaluation at the Upper School in Englewood Cliffs, New Jersey. The request was initiated by the school superintendent, and was assigned by NIOSH to the Occupational Health Program at the New Jersey State Department of Health under their Cooperative Agreement. The request concerned complaints of fatigue, lightheadedness, headache, and ear disturbances (including imbalance) among teachers in a particular area of the school.

The evaluation consisted of a walkthrough during which affected staff were medically interviewed, examinations by an Ear, Nose and Throat consultant, and follow-up visits for air sampling in the building. An interim report was issued in June, 1982.

III. BACKGROUND

The Upper School in Englewood Cliffs is a School with 300 students in grades 4 through 8. The physical plant consists of two buildings connected by a walkway. The older building was constructed in 1960 and the addition was made in 1969.

The teachers and staff experiencing symptoms worked mainly in offices and classrooms in a single wing of the first floor of the older building. The boiler room, which extends into a basement level, is located on the same hallway. Heated air is circulated through ducts and reaches the adjacent classrooms before any others. The newer building is served by a separate boiler and heating system. The classrooms in the affected wing housed the industrial arts, art, arts and crafts, and home economics classes.

In January, 1982, an industrial hygienist with the School's insurance carrier made a visit and sampled for carbon monoxide, and for combustible gas or vapor using a "TLV sniffer". Carbon monoxide results were negative. However, the TLV sniffer did detect the presence of a combustible gas or vapor in the boiler and art rooms. This was assumed to have been due to leaks from stored art materials.

A mechanical engineer examined the heating system in March, 1982. Numerous leaks in the boiler were found and it was noted that the plenum for air being drawn into the heat exhanger was located within three feet of the boilers, with no intervening barrier. Joints in the sheet metal of the air plenum were open due to missing screws or loose fittings and were uncaulked. Since the boilers were designed to operate at high pressure for fuel efficiency, and the air plenum contains a fan which generates negative internal pressures, there was a pattern of air flow from the boilers to the air handling unit. This flow was demonstrated by maximal firing of the boiler with discharge of visible smoke from the boiler leaks. Compounding this problem, the fresh air exchange in the boiler room was inadequate, leading to a less than optimal air volume for complete combustion.

The mechanical engineer's written report was not available until after the walkthrough, but did provide the leading hypothesis which the assembled data was used to test. The storage areas were inspected to evaluate potential toxicity of the various woodworking and arts and crafts supplies; the quantities and conditions of storage were not judged to be consistent with the observed health effects.

Following the issuance of the NIOSH interim report in June 1982, the school administrators began to develop plans to change the building ventilation system. The renovations were finished during the summer of 1983.

In August and September, 1983, NIOSH returned to the school to evaluate the changes in the ventilation system. A new three horsepower fan has been added to increase the supply of air to the four classrooms located nearest the boiler room. These are the arts and crafts, home education, art and woodworking rooms. New ductwork has been installed to carry this supply air and new duct openings have been added to these classrooms. The corridor ceiling has been altered also to increase its efficiency as a return air plenum.

A. Medical

During the walkthrough visit, the names and work locations of teachers and staff who had reported symptoms were reviewed with the superintendent and school nurse,who had been monitoring the situation. Six of these staff members were then interviewed by a physician. All six of these people plus two additional staff members were then given ENT examinations by Dr. Raymond Strauss in Englewood. The exam consisted of pure tone audiograms, visual exams of the nose and throat, and catheterization/inflation of the eustachian tube.

B. Environmental

On May 1, 1982, industrial hygienists conducted air monitoring for carbon monoxide, formaldehyde, sulfur dioxide, nitrogen dioxide and volatile organics. The boilers were fired up to maximum heat and pressure prior to sampling. Carbon monoxide was sampled using an MSA Model 70 direct reading instrument. Sulfur dioxide, formaldehyde, and nitrogen dioxide samples were taken using a Draeger pump and detector tubes. Volatile organic area sampling was performed using Dupont pumps (Model P-4000) and charcoal tubes at a flow rate of approximately 0.6 liters/minute. Analysis was done by gas chromatography following desorption with carbon disulfide. Sampling sites included the area immediately adjacent to the boiler, the air handling plenum, and areas immediately next to the heating vents in four classrooms. A bulk sample of the fuel oil was also taken for GC analysis. In September, 1982, following reopening of the school after summer break, sampling for total particulates and volatile organics was performed.

Air flow measurements using an Alnor velometer and room size measurements were made in order to calculate air exchange levels before and after ventilation improvements.

Toxic Effects of Fuel Oil Combustion Products:

The combustion of any fuel oil is likely to produce certain amounts of carbon monoxide, sulfur dioxide and nitrogen oxides. Under proper conditions of heat and oxygen supply, aldehydes, ketones and carboxy-acids will also be formed. Partial combustion will result in the formation of straight chain (aliphatic) hydrocarbons of varying length. Fuel number 4 consists primarily of aliphatic hydrocarbons with 11 to 20 carbon atoms.

Except for carbon monoxide, the main effect of repeated low level exposure to these agents is primary irritation of tissues such as the eyes and respiratory tract lining. Exposure to carbon monoxide in such a manner would produce fatigue, headache, and dizziness as early symptoms. The NIOSH-recommended limit for exposure to carbon monoxide averaged over a work day is 35 parts per million.

The chronic effects of exposure to fuel oil combustion products have not been studied directly and are therefore not well understood. It is assumed that since strong odors and irritation were not experienced by most persons entering the classrooms, exposure levels to individual exhaust constituents were well below industrial health standards. Therefore these criteria were not applied to the interpretation of sampling results.

Ventilation Standards

The American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) is a national organization which publishes information and issues consensus standards on ventilation systems. Although ASHRAE considers these standards to be voluntary, many of these standards have been incorporated into building code requirements or contract specifications.

ASHRAE has issued a ventilation standard entitled "Ventilation for Acceptable Indoor Air Quality" which has been revised several times, and will continue to be revised as new information is developed.

School have been under evaluation, a revision of the standard has become available for use. An earlier version (#62-73) was used as a reference in the Interim Report. Although this standard suggested that room changes per hour could be used as a way to measure ventilation rates, greater emphasis was placed on cubic feet of fresh air per minute (CFM) per person which provides a better measure of individual comfort.

A more recent revision of the ventilation standard (#62-1981) has used CFM per person as the basic unit of measurement. Whereas the old standard (#62-73) specified two ventilation rates for each use of space, a minimum value and a recommended value, the new standard lists only one. Thus for classroom use, the old standard specified 10 CFM per person as a minimum rate, but 10 to 15 CFM per person was recommended. The new standard specifies 5 CFM per person. If smoking is permitted the required air supply is increased to 25 CFM per person. The new standard is 7 CFM per person for training shops and 10 CFM per person for laboratories. Although the rooms in question are essentially training shops, NIOSH suggests that the 10 CFM per person laboratory standard be applied since it provides a better margin of health and comfort.

The new standard permits energy conservation by specifying lower volumes of supply air. Throughout the ASHRAE ventilation standard, when amounts of air supply per person are specified, this refers to fresh outside air which has been heated or cooled as necessary, rather than recirculated air. This fresh outside air must not contain recognized contaminants above specific recommended levels. Since the proportion of fresh outside air being supplied could not be measured, it was not possible to determine precisely whether ASHRAE guidelines were being met. Certain assumptions about the proportion of fresh air could be made, however, which did allow presumptive evaluation relative to the ASHRAE criteria.

A. Medical

All of the eight individuals examined by the ENT specialist were diagnosed with eustachian salpingitis.

Table 1 summarizes the symptoms from these eight persons.

TABLE I

Reported Symptoms By Case
Upper School, Englewood Cliffs,
New Jersey

Case No.	Middle Ear Symptoms	Other Symptoms	ENT Diagnoses
1	ear pressure, dysequilibrium	lightheadedness, fatigue, cold extremities	eustachian salpingitis, allergic rhinitis
2	crackling in ears	dry mouth, lightheadedness, rash	eustachian salpingitis, TM joint malfunction
3	pain in ears, dysequilibrium, transient hearing loss	tearing, jaw clicks	eustachian salpingitis, TM joint malfunction, Mild presbycusis
4	sharp pain in ears, dysequilibrium	swollen eyelids, scotomata	eustachian salpingitis, deviated septum
5	sharp pain in ears, dysequilibrium	nasal congestion	eustachian salpingitis, allergic rhinitis
6	ear pressure, dysequilibrium	lightheadedness	eustachian salpingitis
7	ears blocked	lightheadedness, nausea, vomiting	eustachian salpingitis
8	dysequilibrium	sudden lightheadedness, nausea and vomiting	eustachian salpingitis, allergic rhinitis

Six of these people were teachers on staff from one particular wing of the building. A seventh person (Case No. 7) was a teacher whose classroom was elsewhere, but who had experienced blockage of the ears, lightheadedness, and nausea after perceiving an acrid oil-like odor in the affected wing.

Case No. 8 was a person who worked and experienced symptoms outside the affected wing and had a several-year history of allergic rhinitis. It is possible that any potential middle ear problems were due to the chronic allergy.

Audiograms were normal on all persons except case 3, who was found to have mild presbycusis.

B. Environmental

Air monitoring was performed in May 1982 with the boilers running at full capacity. These samples were analyzed for volatile organics and the results are summarized in Table 2. Detector tube sampling was also performed formaldehyde, sulfur dioxide and nitrogen oxides. These tests showed no detectable levels in either the boiler area or classrooms. Carbon monoxide levels in the boiler room during maximum firing were in the range of 1.3 parts per million (ppm). Carbon monoxide levels in all classrooms were below detectable limits.

The results of timed air sampling for particulates and total volatile organics conducted on September 16, 1982 when the school was reopened for the new year indicated that particulates were negligible and organics were beneath detection limits.

Analysis of the fuel oil determined it to be fuel oil number 4 with a slightly higher than normal sulphur content (0.35% as compared with a normal of 0.30% of less), and no evidence for unusual contaminants such as waste solvents.

TABLE 2

Air Sample Results for Volatile Organics
Upper School, Englewood Cliffs, New Jersey
May, 1982

Location	Volume Collected (Liters)	Chemicals Detected+ (Parts per million, ppm)
Art room	200.3	N-Hexane 0.007 ppm
Arts and Crafts	224.1	Below detectable limits (BDL)
Arts and Crafts*	297.6	BDL
Home Economics	192.8	N-Hexane 0.007 ppm
Industrial Arts	176.3	BDL
Boiler room, inside air handling unit	207.9	BDL
Boiler room, top of air handling unit	179.4	BDL
Boiler room, front of boiler	179.4	BDL

*This sample was taken from the center of the room, all other classroom samples were taken six inches away from forced hot air grilles.

+The limit of detection for hexane using a sample volume of 200 liters is 0.005 parts per million.

The filters from the air handling unit in the boiler room were visually inspected in February 1982. An oily black film was noted on the filters with increased deposit along the filter edge closest to the boiler. Similar oily residue was found on the heating grills through which heated air is discharged into the classrooms.

Table 3A shows the air flows into the four classrooms adjacent to the boiler room before ventilation improvements. The wood shop, home education and arts rooms have (at maximum) 1.3, 1.5 and 1.4 air exhanges per hour. These values were below the recommended value published by ASHRAE of 1.9 air changes per hour. If the recommendation of 10 CFM per person were to be met, it can be seen from Table 3A that fresh air proportions ranging from 31% to 59% would have to be used. Under normal operating conditions such high proportions of outside air would be prohibitively expensive from an energy cost perspective.

Table 3B shows air flows found in six classrooms located in a newer wing of the building. These six rooms are joined by a common ventilation system. Air from all six rooms is exhausted through a fan in the roof above the hallway. However unlike the rooms described in Table 3A, these rooms are linked to the exhaust fan by ductwork. This ventilation provides sufficient air so that all of these rooms were more likely to meet the ASHRAE guidelines for classroom use.

The results of the ventilation measurements after installation of the new system are shown in Table 4. The air supply has been increased in each room by a factor of at least 3.5. Table 5 gives the minimum percentage of outside fresh air required to meet the standard for the new ventilation system.

TABLE 3A

Ventilation Measurements in Four "Affected" Classrooms
Before Installation of New System, 1982

Name of Room	Duct Type (Supply or Exhaust)	Total Duct CFM	Room Volume (ft^3)	Usual # People in Room	Cubic Feet Air Per Hour	Room Changes Per Hour	Actual Cubic Feet Per minute Per Human Inhabitant	Percentage of Outside Air Required To Meet ASHRAE 62-1981 *
Wood Shop	Supply	253	11,340	15	15,180	1.3	17	10/17=59 %
Home Ed.	Supply	263	10,690	15	15,780	1.5	18	10/18=56 %
Art	Supply	250	10,410	15	15,000	1.4	17	10/17=!
Arts and Crafts	Supply	483	10,410	15	28,980	2.8	32	10/32=31 %

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) has issued standards for the amount of outdoor air required to ventilate various indoor environments. (ASHRAE Standard 62-1981 Table 3)

The recommended amount of outdoor air for laboratory areas in educational facilities is 10 cubic feet per minute per person.

TABLE 3B

Ventilation Measurements in Six "Unaffected" Classrooms, 1982

Name of Room	Direction of Flow (Supply or Exhaust)	Total Duct CFM	Room Volume	Usual # People in Room	Cubic Feet Per Hour	Room Changes Per Hour	CFM Human Inhabitant
10	Exhaust	363	7,490	20	21,780	2.9	18
11	Exhaust	322	7,490	20	19,320	2.6	16
12	Exhaust	490	7,490	20	29,400	3.9	24
13	Exhaust	406	7,490	20	24,360	3.2	20
14	Exhaust	468	7,490	20	28,080	3.7	23
15	Exhaust	474	7,490	20	28,440	3.8	24

TABLE 4

Ventilation Measurements Before and After Improvement at Englewood Cliffs, Upper School

Name of Room	Pre-Improvement Total Air Supply (cubic feet per minute)	Post-Improvement Total Air Supply (cubic feet per minute)	Ratio $\frac{\text{Post Air Supply}}{\text{Pre Air Supply}}$
Wood Shop	253	1,710	6.8
Home Education	263	2,000	7.6
Art	250	1,995	8.0
Arts and Crafts	483	1,690	3.5

TABLE 5

Minimum Outside Air Supply Currently Required
to Meet ASHRAE* Ventilation Standards

Name of Room	Number of People Using Room	Outside Air Supply Required To Achieve Compliance with ASHRAE 62-1981 of 10 CFM/person	Total Air Supply as of 1983 (Sum of Fresh and Recirculated Air)	Minimum Outside Air Percentage Required
Wood Shop	15	150 CFM	1,710	8.8 %
Home Education	15	150 CFM	2,000	7.6 %
Art	15	150 CFM	1,995	7.6 %
[illegible]ts and Crafts	15	150 CFM	1,695	8.8 %

*ASHRAE refers to the American Society of Heating Refrigerating and Air-Conditioning Engineers.

VII. DISCUSSION AND CONCLUSIONS

The medical results suggest, but do not conclusively prove, that an outbreak of middle ear disturbances due to recurrent inflammation of the eustachian tube orifice occurred amongst staff in a particular section of this school. Other symptoms may also have been related to exposure to agents in fuel oil exhaust. A logical explanation for this lies in the demonstrated leaks in the boiler room servicing that section. A definite cause and effect relationship could not be established, however, since adverse conditions such as the leaks in the boiler room could not be recreated in order to provoke symptoms or measure contaminants. The air sampling results indicate that after leaks in the boiler and air handling unit were sealed and after ventilation in the boiler room was improved, levels of fuel oil combustion products were well beneath hazardous levels. The detection of n-hexane in two rooms may be interpreted to be a result of contamination of the heating ducts with fuel exhaust, since hexane is an anticipated byproduct of this combustion. There were no other known sources of hexane in the vicinity.

The ventilation measurements of 1982 suggested that air supply levels in four rooms were beneath the optimum levels recommended for comfort by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Air supply to the classrooms in this affected wing was lower than air supply to six unaffected classrooms. Because materials such as wood, glue, solvents, and supplies for home economics and craft classes are used in the affected rooms, NIOSH considered the laboratory standard to be appropriate for determining recommended ventilation.

The data in Table 4 indicate that the air volume delivered to the four affected classrooms has been greatly increased. As Table 5 shows, in order to ensure that this increased air volume will be sufficient to improve the conditions in these classrooms, approximately 10 percent of this air supplied should be outside air rather than recirculated air. This should be very easy to achieve. The new system has two electronic controls which can be manipulated to control the proportion of outside to recirculated air. These controls, labelled "PTC 1" and "ECI" are located on the control panel for the roof fan. These controls should be set to provide at least 10% outside air at all times when the building is occupied.

The design of the boiler room was a distinct problem. The boilers were operated at positive pressure to maximize efficiency, but the boiler itself was not tightly sealed, and a unit pulling in fresh air to be heated was located very close by. Recent improvements in the boiler room have reduced the potential for exposure to fuel oil combustion products.

The newer wing of the School was not evaluated specifically, because few complaints were referred from that area, which has its own heating system. However, that heating system should be thoroughly checked by an engineer to ensure that similar problems do not occur in this area.

Although the association of illness with fuel exhaust cannot be totally confirmed with this report, improvements in the heating/ventilation system would be expected to prevent most problems if the association is correct. For the staff members who became ill, gradual recovery without long-term consequences is to be expected.

As in many outbreaks of illness related to indoor air problems, a considerable amount of anxiety resulted in amplification of some symptoms and potential inclusion of cases unrelated to exposure.

The finding of recurrent eustachian salpingitis in this episode may be of significance in other investigations of indoor air pollution. Often the constellation of symptoms is too non-specific or subjective to allow verification of a case. Middle ear disturbance due to low level irritation of the nasopharynx may then present a useful marker for "stuffy building syndrome". Alternative causes of middle ear disturbance must be considered. In this situation, two persons had allergic rhinitis, one had deviated septum, and two had tempero-mandibular joint problems which can cause pain referred to the ear. Nevertheless, the occurrence of seven cases in association within a single small workforce is notable.

VIII. RECOMMENDATIONS

The following recommendations have been made to correct the observed difficulties and to prevent any further outbreaks.

Recommendations #1-4 were presented to the Superintendent and Staff at a meeting at the Upper School in May, 1982.

1. The boilers, which are now temporarily sealed, will need to be permanently sealed during the summer.

2. Air flow into the boiler room should be increased by enlarging ventilation openings to the outside.

3. Air handling equipment in the boiler room should be maintained to insure an adequate seal; filters should be inspected frequently at first during the coming heating season, then less often to detect unusual.

4. All other boilers and air handling systems in the school should be evaluated with respect to the above design problems.

Recommendations #5-8 were presented in the Interim Report of June, 1982.

5. A full study of the building by a licensed ventilation engineer is recommended. Strategies for increasing air exchange by approximately 50% in the three classrooms should be considered. It may be necessary to construct additional exhaust ducts for these rooms. Until permanent modifications are made, use of windows and existing local exhaust fans to boost ventilation is recommended.

6. Surveillance of illnesses among staff members by the school nurse is recommended. Recommendations for setting up surveillance will be forwarded by NIOSH and the State Department of Health.

7. Repeat sampling of the air at the start of the next heating season is to be performed. New Jersey Department of Health personnel will conduct this sampling and follow-up the health status of the staff.

8. A joint committee of representatives from the faculty and administration should be formed to oversee resolution of this problem and consider future health and safety issues.

Recommendations 9 and 10 were presented in the final report of April 1984.

9. The outside air percentage in the affected classrooms should be maintained at no less than 10% of total air supply.

10. Maintenance staff should be instructed about the procedures necessary to maintain the outside air supply at 10% of the total air supply.

IX. AUTHORSHIP/ACKNOWLEDGEMENTS

Evaluation Conducted and Reported Prepared by:	Peter Gann, M.D. Chief, Occupational Medicine New Jersey State Department of Health
	Joseph Schirmer Industrial Hygienist New Jersey State Department of Health
Environmental Evaluation:	Joseph Rizzo Senior Field Representative New Jersey State Department of Health
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies, NIOSH Cincinnati, Ohio 45226

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
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