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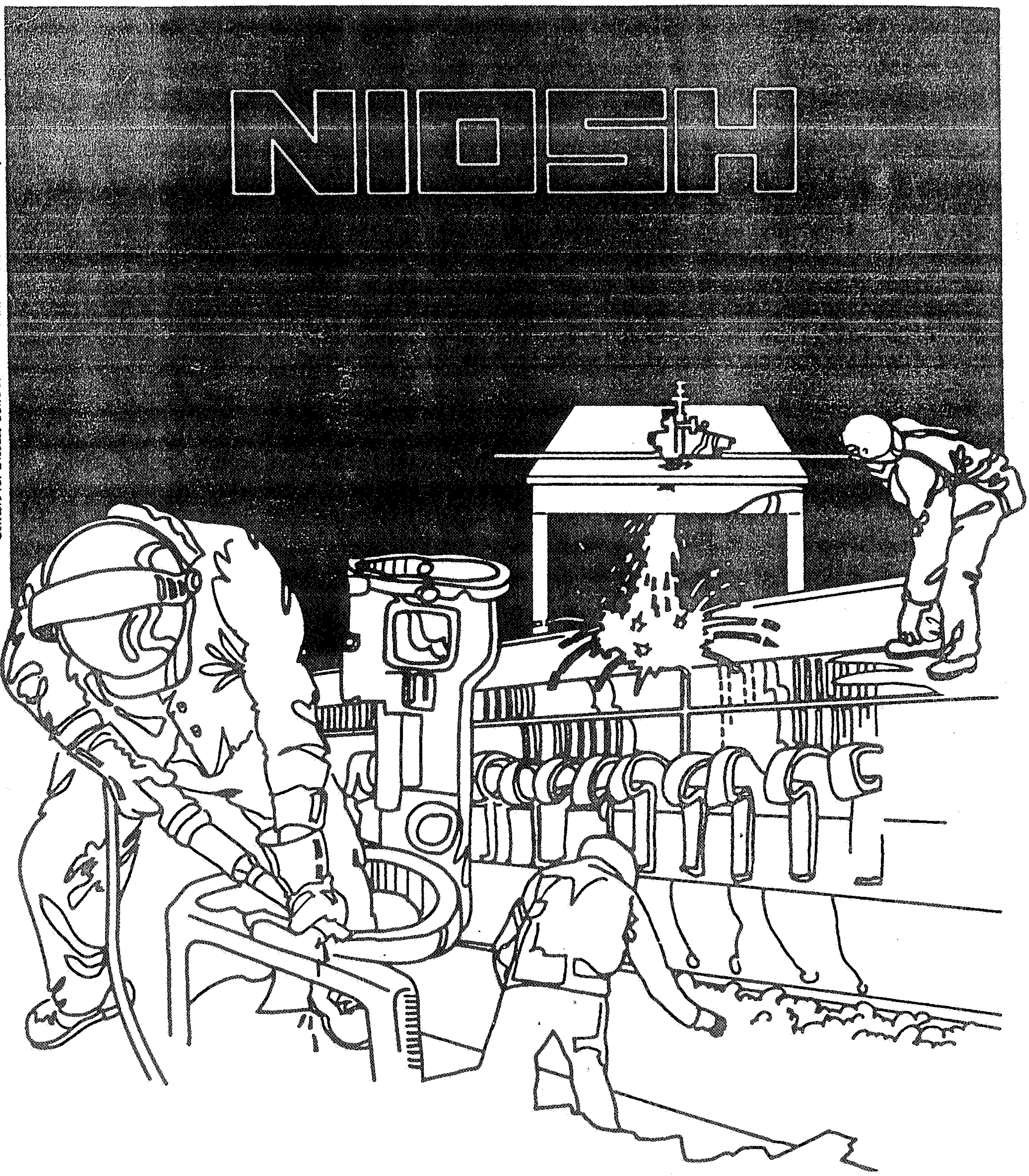

Health Hazard Evaluation Report

HETA 83-172-1409
WAPPINGERS CENTRAL SCHOOL DISTRICT
WAPPINGERS FALLS, NEW YORK

PREFACE

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

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

HETA 83-172-1409
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WAPPINGERS CENTRAL SCHOOL DISTRICT
WAPPINGERS FALLS, NEW YORK

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I. SUMMARY

On March 2, 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate an outbreak of illness at three schools in the Wappingers Central School District, Wappingers Falls, New York. Complaints of eye irritation, headaches, and skin rashes started in the first heating season after completion of an intensive energy conservation effort which included: 1) application of methylene bisphenyl isocyanate (MDI)-based polyurethane foam insulation on the roofs and in the exterior walls; 2) installation of inside storm windows; 3) sealing of fresh air intakes; and 4) installation of new water heaters. Air samples taken by a private contractor in January 1983 had suggested the presence of airborne MDI (2-42 ppb) in 6 of 24 air samples. This finding heightened concern among faculty, students, and parents that emissions from the foam insulation may have caused the outbreak of illness. Consequently, one of the schools, Van Wyck Junior High School (VW), did not re-open after the winter break (February 12-19, 1983).

NIOSH, in collaboration with the New York State Department of Health (NYSDH) and the Dutchess County Health Department (DCHD), conducted an initial environmental/medical survey during the week of March 7, 1983. Air samples were collected in all three schools and also in a fourth, control school during normal operating conditions to measure airborne concentrations of MDI, methylenedianiline (MDA, an hydrolysis product of MDI), aliphatic amines, organic vapors, formaldehyde and other aldehydes, and metals. There was no evidence of airborne MDI using a method specific for MDI and having a lower limit of detection of 0.05 ppb. Trace or background concentrations of formaldehyde, metals and organic vapors were detected, and all other air sampling results were negative.

NIOSH and NYSDH conducted a followup environmental survey on March 30-31, 1983 to evaluate boiler gas re-entry as a possible contributing cause for the reported health effects. Using sulfur dioxide as a marker for the boiler gas, air sampling at selected locations at VW confirmed that boiler gases were re-entering the school via an improperly connected water heater flue pipe and that these gases were distributed through the school via an underground utilities tunnel.

The DCHD conducted a questionnaire survey of teachers and students of the three affected schools. Compared to a junior high school not involved in the energy conservation program, VW teachers reported greater prevalences of eye irritation, sore throat, runny nose, headache, rash, and cough. Student questionnaires (completed by parents) showed similar symptoms, with VW having rates greater than the other junior high school and the high schools having intermediate rates.

Compared to previous years and to other schools, records showed no notable decrease in monthly attendance at the three affected schools, either at the time of installation of the foam insulation or during the winter of 1982-83. Also, there was no substantial increase in total daily health office visits at VW until the week of February 7, 1983 (when visits were solicited).

Excluding that week, the comparison junior high school had a median of 49% of the number of daily visits at VW, whereas 60% would have been expected on the basis of the schools' populations. Throughout January and early February, there were 8 to 24 cases of eye irritation among students and staff reported per week at VW. Then, following VW's closing in early February, clusters of cases occurred abruptly at the two high schools. In the vast majority of cases, there were, on ocular examination, either no objective findings or only slight conjunctival redness. Investigation of approximately 20 cases of illness thought related to environmental exposures at school failed to document objective medical evidence of such a relationship.

Van Wyck was reopened on April 25, 1983, following completion of repairs which corrected the boiler gas reentry problem. During the subsequent two weeks, there were 38 visits to the health office by 29 persons for eye irritation, a weekly rate comparable to those of January and early February. As of January 6, 1984, the next school year, school authorities reported that only a few students still complained of what they thought were building-related health problems. The DCHD was also contacted on January 6, 1984 and reported that its routine surveillance has not detected any recurrence of the previous school year's outbreak.

Based on information collected by NIOSH and other agencies, the outbreak of illness at Van Wyck was most likely initiated by the energy conservation measures which severely limited the fresh air in the building and resulted in a major problem with boiler gas re-entry at one school. The persistence of eye irritation after Van Wyck reopened in April 1983, and the occurrence of the outbreaks of eye irritation at the high schools following publicity about the outbreak at VW, indicate that environmental contamination was probably not the sole cause of the outbreaks at any of the three schools. Possible explanations are discussed in Section VII and recommendations in Section VIII.

KEYWORDS: SIC 8211 (Elementary and Secondary Schools), methylene bisphenyl isocyanate, indoor air quality, energy conservation,

II. INTRODUCTION

On March 2, 1983, NIOSH received a request from the Superintendent of Schools, Wappingers Central School District, Wappingers Falls, New York, for assistance in determining (a) the cause of an outbreak of illness in three of the district's schools, and (b) whether these schools were safe to occupy. The Dutchess County Health Department (DCHD), the New York State Health Department Of Health (NYSDH), and several private consulting firms had already evaluated the problem or were in the process of doing so.

In response to the request for assistance, NIOSH sent an industrial hygiene engineer and a medical officer to the school district on March 7-11, 1983 to conduct an initial survey. A followup environmental survey was conducted March 30-31, 1983.

The initial survey commenced with a meeting attended by the NIOSH team, DCHD representatives, NYSDH representatives, New York State Labor Department representatives, a representative from Congressman Hamilton Fish's office, Wappingers Central School District representatives, School Board members, representatives of a committee of concerned parents, and reporters from several newspapers. The purpose of the meeting was to discuss data already available, discuss the environmental and medical methods (detailed in Section IV) that would be used to evaluate the problem, and answer questions. For the next four days (March 8-11, 1983) NIOSH, in collaboration with the DCHD and NYSDH, conducted air sampling and collected medical information.

A follow-up environmental survey was conducted March 30-31, 1983 to evaluate the re-entry of boiler gases into the schools.

Results of the NIOSH environmental and medical evaluation were forwarded to the Superintendent of Schools by letter on April 8, 1983 and presented by the NIOSH investigators to the school board in a public forum on April 11, 1983.

III. BACKGROUND

Between August 1981 and September 1982, Wappingers Falls Central School District conducted an aggressive energy conservation program at three of its largest schools: Van Wyck Junior High School (VW) and John Jay (JJ) and Roy C. Ketcham (RCK) Senior High Schools. The schools have a combined student enrollment of around 4000, with a staff of several hundred. The most significant aspects of the energy program included:

1. application of polyurethane foam insulation, formed by the polymerization of the methylene bisphenyl isocyanate (MDI), on the roofs and in the exterior wall cavities.

2. installation of inside storm windows.

3. sealing of fresh air intakes in the unit ventilators

4. installation of new water heaters.

In January and Febuary 1983, the first heating season following completion of the major part of the 2.5 million dollar energy conservation program, outbreaks of illness characterized by complaints of eye irritation, metallic taste, headache, and skin rashes were reported to have occurred among the students and teachers at all three schools but to a greater extent at VW. Complaints were first reported to the School District in November and December 1982 and, as the number of complaints continued to increase, the Dutchess County Health Department initiated an investigation which included questionnaire surveys of illness among faculty (February 1983) and students (March 1983). Questionnaires were distributed to faculty members and parents of students at VW, Wappingers Junior High School (WJH), RCK, JJ, and Meyers Elementary school to be completed and returned by mail to the DCHD. In the meantime, the school district contracted with several consulting firms to conduct air sampling and thermography studies to determine if the insulation was properly installed and whether emissions from the insulation might be responsible for the health complaints. In mid-February 1983, one of the consultants reported airborne MDI in several locations at VW at concentrations of less than 1 ppb, except for one sample at 42 ppb where an interference was suspected.

Responding to the concerns of the parents that airborne MDI might be responsible for the health symptoms, the school board voted to close VW in late February 1983 until further studies were completed. Double classes were held at another school in the district to accomodate the students affected by the VW closing.

On February 10, 1983, the Dutchess County Health Department requested assistance from the New York State Health Department and both agencies conducted a joint, onsite investigation on February 28, 1983.

On February 24, 1983, the Superintendent of Schools contacted NIOSH officials by phone to request that NIOSH investigators also come to the school district to study the problem. Since numerous agencies were already involved our first response was to wait until more data became available for review. However, due to the increasing level of concern and the complexity of the situation NIOSH responded to a second telephone call (March 2, 1983) by sending two investigators to the school district on March 7, 1983.

IV. METHODS

A. Environmental

Air sampling was conducted on March 8-11, 1983 at all three foamed schools (VW, RCK, JJ) and one control, non-foamed school (Fishkill Elementary). Sampling equipment was placed in areas of the three school buildings (VW, RCK, JJ) based on the following rationale.

With the sampling equipment available, it was possible to set clusters of sampling pumps in five to six locations in each of the buildings. At least one sample set in each building was placed in a "worst-case" location which was in close proximity to an exposed foam surface. The other rooms were selected because of complaints and because there were two outside (foamed) walls.

Air samples were collected for the following substances:

Major components or by-products of the foam system - MDI, MDA, N,N-dimethylcyclohexylamine, trichlorofluoromethane.

Metals (because of reports of a metallic taste).

Formaldehyde and other aldehydes (to address irritant symptoms and concerns about possible off-gasing from urea-formaldehyde foam placed in a few wall areas of Fishkill Elementary School).

Organic vapors (to identify and quantitate the organic vapor contaminants within the buildings).

The following microscopic analyses were done: Air samples and surface swipe samples to determine the presence of synthetic foam particles (a possible source of eye irritation).

A bulk sample of a plaster-like substance from the Fishkill Elementary School (to determine if it contained asbestos).

The specific air sampling and analytical methods used are discussed in Appendix A.

The followup survey (March 30-31, 1983) was conducted with the specific purpose of evaluating the potential for boiler gases to re-enter the school buildings. Since sulfur dioxide is a common boiler gas emission (and a strong irritant), air sampling was conducted in various locations at VW using standard Drager® colorimetric detector tubes having a range of 1 to 15 ppm.

In addition to conducting air sampling, environmental data obtained by the other agencies was reviewed.

B. Medical

With the assistance of the DCHD we reviewed (1) the DCHD's faculty and parent questionnaire surveys, (2) school attendance data, and (3) school health office logs of patient visits and other health records. We interviewed numerous parents and school employees; the school nurses and physicians serving VW, RCK, and JJ; and several physicians who had seen students as private patients. In addition, because two of the physicians we interviewed thought that the seasonal increase in upper respiratory illness in the area was greater than usual that winter, the DCHD obtained information on patient visits to a group medical practice in the area.

The symptoms specifically asked on the initial teacher questionnaire were based on preliminary information from school health personnel and other reports to the DCHD. The symptoms asked on the parent questionnaire were based on this information plus the results of the teacher questionnaire.

V. EVALUATION CRITERIA

A. Building Related Illness Episodes

Building related illness episodes have been reported more frequently in recent years as buildings have been made more air-tight in order to conserve energy and to reduce aiur conditioning expenses. Modern high-rise office buildings are constructed primarily of steel, glass, and concrete, with large windows that cannot be opened, thus making the building totally dependent of mechanical systems for air conditioning. Contaminants may be present in make-up air or may be introduced from indoor activities, furnishings, building materials, surface coatings, and air handling systems. Symptoms often reported are eye, nose, and throat irritation, headache, fatigue, and sinus congestion. Occasionally, upper respiratory irritation and skin rashes are reported. In some cases, the cause of the symptoms has been ascribed to an airborne contaminant, such as formaldehyde, tobacco smoke, or insulation particles, but most commonly a single cause cannot be pinpointed.

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

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

1. Products of combustion

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

2. Formaldehyde

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

3. Sprayed-on insulation materials

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

4. Tobacco Smoke

Tobacco smoke contains several hundred toxic substances, the more important of which are: carbon monoxide, nitrogen dioxide, hydrogen cyanide, formaldehyde, hydrocarbons, ammonia, benzene, hydrogen sulfide, benzo(a)pyrene, tars, and nicotine. Tobacco smoke can irritate the respiratory system and, in allergic and asthmatic persons, often results in eye and nasal irritation, coughing, wheezing, sneezing, headache and other related sinus problems. People who wear contact lenses often complain of burning, itching, and tearing eyes when exposed to cigarette smoke. While cigarette smoking is the leading cause of lung cancer in the United States, currently available evidence is not sufficient to conclude that passive or involuntary smoking causes lung cancer in non-smokers.[7]

5. Microorganisms and allergens

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

6. Hydrocarbon vapors

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

B. Air Contamination Evaluation Criteria

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

The ASHRAE standards are general air quality standards for indoor environments, and are applicable for the general population exposed for up to a 24-hour day of continuous exposure without known toxic effects.

Neither NIOSH nor OSHA has developed ventilation criteria for general offices or schools. Criteria often used by design engineers are the guidelines published by the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE).

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

Subsequently, ASHRAE has revised its standard and has published the new standard, ASHRAE 62-1981, "Ventilation for Acceptable Indoor Air Quality." The new standard is based on an occupant density of 7 persons per 1000 ft^2 of floor area, and recommends higher ventilation rates for areas where smoking is permitted. The new ASHRAE standard states that indoor air quality for "General Offices" shall be considered acceptable if the supply of outdoor air is sufficient to reduce carbon dioxide to less than 2500 ppm and to control contaminants, such as various gases, vapors, microorganisms, smoke, and other particulate matter, so that concentrations known to impair health or cause discomfort to occupants are not exceeded. However, the threshold levels for health effects from these exposures are poorly documented. For "General Offices" where smoking is not permitted, the rate recommended under the new standard is 5 cfm of outdoor air per person. Higher ventilation rates are recommended for spaces where smoking is permitted because tobacco smoke is one of the most difficult contaminants to control at the source. When smoking is allowed, the amount of outdoor air provided should be 20 cfm per person. Areas that are nonsmoking areas may be supplied at the lower rate (5 cfm/person), provided that the air is not recirculated from, or otherwise enters from, the smoking areas.[8]

Table 3 of the new ASHRAE guide[8] contains specific recommendations on outdoor air requirements (cfm per person) for schools. They are as follows:

	Non-Smoking	Smoking
Classrooms	5	25
Laboratories	10	--
Training shops	7	35
Music rooms	7	35
Libraries	5	--

C. Polyurethane insulation

The polyurethane foam system used at the schools appear to be typical of those resin systems used for thermal insulation. Major components of these types of foam systems include:[1]

Isocyanates. One of the two major portions of a polyurethane foam formulation is an isocyanate. The two most widely used isocyanates are toluene diisocyanate (TDI) and methylene bisphenyl isocyanate (diphenylmethane diisocyanate, or MDI), with MDI being the main isocyanate used in thermal insulation.

Polyols. The other major portion of a polyurethane foam formulation is a polyol (a polyhydroxide compound). Since the variety of isocyanates is limited, polyols are the main constituents used for changing and adjusting foam properties. Some polyols are based on OH-terminated polyesters, amines, and highly halogenated substrates.

Surfactants. Most surfactants for polyurethane foams are based on silicone block copolymers of silicon tetrachloride. The major role of the surfactant is to make compatible the ingredients of the mixed blend, and to stabilize the cells by preventing drainage and collapse before the polymer growth has reached the gel stage. Some surfactants are additive (nonreactive), while others are reacted into the polymeric structure.

Catalysts. Most polyurethane foam catalysts are tertiary amines or organometallics. In rigid foams, organotin catalysts and some amine catalysts are used to promote maximum cross-linking by formation of biuret and allophanate. In flexible foams, the rate of reaction between water and isocyanate is controlled by tertiary amine catalysts.

Blowing Agents. The reaction of water with isocyanate results in an unstable intermediate carbamic acid which decomposes to an amine and carbon dioxide. The amine reacts further with isocyanate to form a urea linkage. With low-density foams, the blowing is frequently accomplished with fluorocarbons. These low-boiling liquids perform similarly to carbon dioxide except that they enhance firmness and insulation properties.

The resins used for thermal insulation contain one or more polyols, a silicone oil copolymer, one or more tertiary amine catalysts, an organotin catalyst, fluorotrichloromethane (used as a blowing agent), and alpha-methyl styrene (used as a stabilizer). A phosphate ester-based flame-retarding agent may be added.

Although there are no published data on measured exposures inside a building during the application of MDI foam insulation on the roof or in the walls, exposure data has been obtained for workers engaged in the manufacture and application of MDI insulation.[1] Exposure levels for components of the foam systems used were all well below applicable OSHA and NIOSH criteria except for MDI. MDI exposure levels reached 36 ppb (8-hour time-weighted average (TWA)) for a mechanic spraying MDI foam inside a room with no supplementary ventilation. This application would represent a worst-case exposure since spraying produces MDI-containing aerosols that add to the vapor exposure. A roof application or a wall application where the resin systems are poured into place would not be expected to produce quantities of aerosol comparable to spraying techniques. Therefore, the major isocyanate exposure would be vapors, and by using MDI instead of TDI this potential hazard is reduced because MDI has a vapor pressure far less than that of TDI. At 77°F MDI has a vapor pressure of 0.000005 mm Hg, compared to 0.011 mm Hg for TDI. Tests reported by one manufacturer of these foam insulation systems indicate that surface vapor concentrations of MDI in unventilated, open containers ranged from 15 ppb at 80°F to 40 ppb at 140°F.[2]

D. Methylene Bisphenyl Isocyanate[3,4]

Methylene bisphenyl isocyanate belongs to a group of compounds called diisocyanates (or isocyanates) that polymerize to form polyurethane. Occupational exposure to isocyanates has well-recognized adverse health effects. Isocyanates are irritants of the skin, eyes, and respiratory tract. Repeated exposure can lead to the development of allergic sensitization in some persons, resulting in asthma-like reactions (immediate, delayed, or both) at concentrations much lower than those producing irritation. Other chronic effects that have been reported include impairment of pulmonary function (one-second forced expiratory volume and forced vital capacity), shortness of breath, bronchitis, and hypersensitivity pneumonitis (another type of allergic lung disorder).[5,6] Although isocyanates are present in consumer products such as paints and floor finishes, we are not aware of any scientific reports of adverse health effects resulting from non-occupational exposure. NIOSH recommends that exposure to MDI not exceed a 10-hour time-weighted average concentration of 5 parts per billion (ppb) or a 10-minute ceiling concentration of 20 ppb. The OSHA standard is a ceiling concentration of 20 ppb

E. Other substances

Exposure criteria for the substances evaluated during this survey are included in the tables of results where applicable.

VI. RESULTS AND DISCUSSION

A. Foam Application

The foam systems used were obtained in 55-gallon drums as part A and part B. Since the mixture cannot be seen as it is poured into the wall spaces, safeguards and controls must be used to insure a proper mix. The control systems used by the applicator at the Wappingers Falls schools monitored temperature and pressure parameters as part A and B were mixed in a heated hose, and sent through an electronically controlled mixing gun into the top of the wall void space. Excessive differences in temperatures and pressures at various points in the delivery system should have automatically shut the system down. In addition to insuring a proper mixture, this monitoring system helps to prevent costly delays due to hose clogging.

The foam systems were applied as froth on the roof and in the walls and were sprayed onto interior walls above the false ceiling along the intersection of the wall and roof. Frothing (pouring) offers less of an exposure potential than spraying because the vapors and aerosols generated during spraying can travel substantial distances from the point of application. During frothing, isocyanate vapors represent the most significant exposure; aerosols are a minor consideration. Spraying was supposed to have been done after school hours, but there are reports that frothing was done, in some cases, while school was in session.

B. NIOSH Survey Conducted March 7-11, 1983

The ventilation systems in all of the schools evaluated were operating, and the metal panels that had been added to seal the fresh air intakes on the unit ventilators had been removed.

Using a sampling/analytical method specific for MDI which had a lower detection limit of 0.05 ppb, there was no evidence of airborne MDI in any of the schools (Table 1). Similarly, no detectable amounts of N,N-dimethylcyclohexylamine or any other aliphatic amine were found with a sampling/analytical detection limit of 5 ppb (Table 2).

The compound 4,4'-methylenedianiline (MDA), an hydrolysis product of MDI, was not detected (lower detectable limit of 5 ppb).

Formaldehyde concentrations ranged from 0.01 to 0.06 ppm (Table 3). The current ASHRAE indoor air criterion for formaldehyde is 0.1 ppm. NIOSH recommends that exposure be controlled to the lowest feasible level . No other aldehydes were detected (Table 4).

Eight metals were detected at a number of sampling points (Table 5). None of the levels found would be expected to be of any health significance.

All concentrations of organic vapors found would be considered trace amounts (Table 6). In general, they were typical of indoor, non-industrial environments.

The microscopic analyses of the air and surface swipe samples did not detect any evidence of synthetic foam particles. All contained dust and soil characterized by common minerals such as clay, quartz, and calcite, and evidence of organic soot. The plaster-like material from Fishkill Elementary School did not contain asbestos. It was a plaster matrix material with a mineral wool/fibrous glass binder.

Temperature and humidity data are presented in Table 7. Dry bulb temperature ranged from 66°F to 77°F in the classrooms. Relative humidity ranged from 24% to 47%. Outside temperature during the survey was 42°F to 48°F, with a humidity range of 70% to 77%.

C. NIOSH Survey Conducted March 30-31, 1983

The second NIOSH survey evaluated boiler gas re-entry at VW as a possible source of some of the reported health effects. A malfunction of the pneumatic system at VW caused all three boilers to start up. The business manager for the school district noticed the backup of boiler gases in the boiler room when he responded to the incident and alerted the New York State Department of Health and NIOSH. Both agencies evaluated the problem.

We created a worst-case condition, by manually overiding the automatic controls and causing all three boilers to operate. After a very short time (less than five minutes), the boiler room environment was unbearable. Eye and throat irritation were the prominent symptoms. The boiler gases were coming back into the boiler room via a newly installed hot water flue that was connected to the end of the chimney breech near the point where the #1 boiler riser emptied into the breech (Figure 1). The high negative pressure in the building, most likely due to the hallway exhaust fans, caused the gases to be drawn into a utility tunnel which ran around the perimeter of a major part of the building beneath the unit ventilators (Figure 2). Sulfur dioxide measurements taken in Room 109 confirmed that the gases were being circulated through the tunnel system and entered 109 through a hole in the floor beneath the unit ventilator. Sulfur dioxide (SO_2) readings in the boiler room were as high as 15 ppm. Readings at the hole in the floor in Room 109 were as high as 10 ppm. Measurements taken at the supply grills in the girls' locker room (5 ppm) and cafeteria (10 ppm) confirmed that the boiler gases were also entering the negative-pressure side of the air handling units (AHU's) servicing these areas (Figure 2). These two AHU's were suspended from the ceiling in the boiler room. This situation did not exist at RCK or JJ, primarily because the new water heaters flues were connected to the breech at a different point.

Draw-down on the incinerator side of the split chimney was allowing boiler gases to re-enter the buildings in all three schools through the incinerator doors. This mode of re-entry, although important, was a minor problem compared to the re-entry at VW via the water heater flue stack.

D. Environmental Data From Other Agencies and Consultants

1. Consultant A

Consultant A reported finding airborne concentrations of MDI ranging from 0.4 to 42 ppb in six of 20 air samples taken on February 9, 17 and 18, 1983, and no detectable MDI in all 8 samples taken on March 2, 1983. Their report said that the 42 ppb sample result may have been due to a possible interference from a washing solution being used to clean floors outside the room. Of the five remaining positive samples, two were 0.4 ppb, one 0.7 ppb, one 0.8 ppb and one 2.0 ppb. The lowest detectable limit was reported as 0.4 ppb.

The sampling/analytical method used by Consultant A was NIOSH Method No. P&CAM 142[9]. Although this method, sometimes referred to as the Marcali method, has been used for a number of years in industrial settings, it is subject to interference from any free aromatic amine, other isocyanates such as TDI, and methylene dianiline (MDA), which is an hydrolysis product of MDI. MDI, when exposed to the atmosphere, is converted to MDA. Therefore, sampling results obtained using this method can be difficult to interpret, especially in the ppb range.

To explore the possibility that floor maintenance procedures may have generated emissions causing a positive interference in the IHI tests, NYSHD conducted air sampling using the Mercali method during floor stripping, waxing and cleaning. Also, bulk samples of the materials used (Knoxout, Seal-o-Tile, Parade and Fill Clean) were analyzed. None of the testing was able to confirm an interference.

One important possible interference was confirmed by both NIOSH and NYSHD testing. Substances in side-stream cigarette smoke cause a positive interference in the Marcali MDI method. Further testing by NIOSH revealed that there was no actual MDI in cigarette smoke; rather the effect on the test was an analytical interference mechanism.

A study was set up in NIOSH offices to further evaluate the likelihood that cigarette smoke may have been responsible for the Consultant A's finding of MDI. Air sampling was conducted in five offices where employees smoked cigarettes and five where no one smoked. None of these samples were positive for MDI. However, when air was drawn from the neck of the Erlyrmeyer flask containing a lighted cigarette, a strong positive interference was noted. This implies that cigarette smoke does affect the test but, for an interference to occur, the samples would have to be very near a lighted cigarette or in the plume of an exhaled stream of cigarette smoke. Individuals were reportedly smoking while Consultant A's samples were being taken, but we could not establish with certainty that this was the cause of the positive MDI sampling.

NIOSH also conducted air sampling in the boiler room to determine if boiler gases re-entering the building contained substances that may cause a positive interference in the Marcali method. These results were negative, indicating that boiler gases were not responsible for the positive MDI findings.

Consultant A conducted other testing for formaldehyde, hydrocarbons, relative humidity and nitrogen dioxide. These test results were all well below levels expected to cause adverse health effects.

2. Consultant B

Consultant B collected one air sample in one room at VW to be analyzed for MDI, 3 polyurethane insulation samples from VW and 1 foam sample from the manufacturer. They reported an MDI air concentration of 5 ppb using a method not subject to the problems with the Marcali method previously discussed, but qualified their finding with the comment that there was a co-eluting peak. The fact that only one sample was taken and the presence of a co-eluting peak, make it difficult to interpret this finding. Their infrared analysis of the foam samples indicated that there was no significant difference between the foam from the school and the sample from the manufacturer.

3. Consultant C

This company used infrared heat scanning techniques to identify potential heat loss locations in the outside walls of VW, RCK, and JJ. This testing was conducted on February 25, 26, and 27, 1983, which was after the polyurethane insulation was applied in the walls. They identified a few void areas and a number of areas having a varying thermal pattern, the cause of which was not determined but could be due to construction design of the interior wall, thermal indications of the heating system, or improper installation of the insulation.

4. Consultant D

Twenty-four core samples (eight from each of the three schools insulated) were analyzed by gas chromatographic/mass spectrometry (GC/MS) for MDI, tertiary amines and trichlorofluoromethane (Refrigerant 11), a blowing agent used to cause the foam to expand to fill the void into which it was poured. Most samples were taken from within the cavity in the outside walls. Some were taken from inside the buildings above the false ceiling.

No MDI or tertiary amine was detected in any of the samples. Less than 1 ppm Refrigerant 11 was found in all the samples. There were indications of the presence of siloxanes from the surfactant additive used as a cell-forming agent. The chemical makeup of the core samples was the same as two samples from the manufacturer.

B. Medical

Participation in the teacher questionnaire survey ranged from 69% to 97% (Table 8). Compared to WJH, VW teachers reported a substantially greater prevalance of all symptoms except appetite loss and fever. RCK teachers reported a greater prevalence of most symptoms than JJ teachers and, except for rash, a similar or greater prevalence than VW teachers. Meyers teachers had a greater prevalence of sore throat, runny nose, headache, cough, and fever than WJH teachers. (These symptoms, especially fever, are suggestive of upper respiratory infection rather than an allergic reaction or exposure to an irritant, and might be explained by Meyers being an elementary school, symptomatic upper respiratory infections being more common in younger children). With the exception of some reports of a metallic taste, very few participants reported symptoms not specifically asked, although the questionnaire provided space for "other" symptoms.

Overall, parents completed questionnaires for approximately 60% of the students at VW, WJH, RCK, and JJ (Table 9). VW had the highest prevalence of all symptoms asked. Except for "butterflies in stomach", a symptom of anxiety, RCK had higher symptom prevalences than JJ. WJH had the lowest prevalences of the various symptoms. VW, RCK, and JJ student symptoms were far more likely than those at WJH to be temporally associated with being in school. VW students were the most likely to have been seen by a doctor; WJH students were the most likely to have other family members ill and the least likely to have been seen by a doctor. Since most symptom questions had a substantial number of non-responses, the prevalence at all schools are probably inflated (since a non-response more likely means the absence of the symptom), but calculating the prevalences assuming that non-responses are negative answers does not substantially change the relative differences in prevalences.

VW had no notable decrease in its monthly attendance, either at the time of the installation of the polyurethane foam (January-April 1982) or during the winter of 1982-83; rates tended to be similar for any given month over the years and tended to parallel those at WJH (Table 10). Compared to previous years RCK showed no notable decrease during the winter of 1982-83 nor at the time of foam installation (December 1981 - March 1982). JJ showed an apparent decrease in attendance in February and possibly March 1983 compared to previous years, but none in January 1983 or December 1982. There is no prior year data for two of the three months of foam installation (March - May 1982), but the attendance rates weresimilar to those at RCK.

The VW health office log of patient visits showed no substantial increase in total daily visits until the week of February 7, 1983 (Figure 3). On two days that week students and staff with symptoms thought possibly related to being in the building were solicited, via the public address system, to come to the health office to be evaluated by the school physician. Excluding the week of February 7, WJH, with 60% of the population of VW, had between 37% and 73% (median 49%) of the number of daily health office visits that VW had. Data assembled by the DCHD for the period February 21-24, 1982, showed that RCK and JJ had rates of visits to the health office no greater than two other high schools in the county (Table 11).

The patient visit data from the group medical practice showed an increase in both total patient visits and visits for upper respiratory infection (URI) during the winter of 1982-83 compared to the previous winter, although the monthly numerical increases in URI visits do not seem large enough to account for the increases in total visits (Table 12). (Perhaps the increase in total visits could be explained by upper respiratory illnesses with diagnoses more specific than URI, but we don't have the data to test this hypothesis). An increase in total patient visits among children 1-12 years old (an age group presumably including no RCK or JJ students and only a minority of VW students) was not seen in February 1983, and the December 1982 and January 1983 increases were proportionally less than among the 13-18 year-olds. These data could be interpreted either as evidence of an increased prevalence or severity of respiratory illness among teenagers or as evidence that there was an increase in some illness among teenagers in addition to the all-ages increase in URI visits.

According to school health personnel, the symptoms commonly reported as being related to a putative environmental chemical exposure at school were eye irritation, headache, irritated or runny nose, and throat discomfort. Since these symptoms are typically associated with upper respiratory infection and common allergies, it was not readily apparent how we could define a "case" of building-related illness. That is, there was no satisfactory way to distinguish epidemiologically symptoms due to irritation from an environmental chemical contaminant from those due to the other causes. We therefore chose to use eye irritation as an indicator symptom. We counted as a case of eye irritation any eye complaint other than a foreign body or trauma. At VW there were several cases per week throughout January and early February, with a larger number February 8-11 (Figure 3). The clustering of cases at RCK and JJ followed the closing of VW (Figure 4).

In the vast majority of cases of eye irritation, according to the school nurses and physicians, there were either no physical findings or only slight redness. They neither recorded nor recalled any instance of conjunctival discharge, photophobia, or markedly inflamed conjunctivae. In all cases where the cause was thought possibly to be an environmental chemical exposure at the school, the attribution was based on the patient's (or parent's) statement that the symptoms were temporarily related to being at school or in a particular room.

We investigated approximately 20 reports of students with respiratory, gastrointestinal, and/or general systemic symptoms thought by parents or others to be due to environmental exposures at school.

In some cases these symptoms seemed to represent continuing manifestations or exacerbations of medical conditions present prior to the installation of the insulation. In other cases the reported length or severity of illness and/or the etiologic diagnosis were not substantiated by the patient's physician. In about a third of the cases a physician considered an environmental chemical a plausible cause of the illness, but the attribution was based on the patient's report of symptoms being temporally related to being in the school (or a certain part of it) and on the assumption that reports of environmental contaminants were valid.

A local physician obtained serum antibody tests on 56 persons, all apparently students or staff from VW, RCK, or JJ. The tests were done using an enzyme-linked immunosorbent assay. One of the 56, a JJ student had IgG antibody, but the titer was relatively low. Five others (two VW students, one VW employee, one RCK student, and one JJ student) had IgG titers ranging from 1:5 to 1:80 (a laboratory control serum specimen from an isocyanate worker had a titer of 1:320). We interviewed the VW employee and parents of all five students. Three of the six had a history of allergies, including asthma in two of the three. Four of the six (including two of the three with an allergy history) reported school-related illness in the past year that included respiratory symptoms, but in only one case were the respiratory symptoms the primary problem and in only one was there eye or upper respiratory tract irritation at the time of the foam installation. One of the six was not attending any of the three schools at the time of foam installation. Two reported being in a classroom when foam was being poured from the outside; in one of these cases the windows were said to have been left open. One person had past exposures at home to polyurethane floor finish; this person was the one whose illness was primarily respiratory and was one of the two who came from a home in which nobody smoked tobacco.

Van Wyck reopened April 25 following repairs to the ventilation system. (Measurements made by the NYSDH verified the lack of re-entry of boiler gases). A physician was present during school hours, volunteer parent observers were in the building, and students and staff were encouraged to report any symptoms. During the first two weeks of school there were, respectively, 18 and 20 health office visits by 29 persons for eye irritation.

VII. CONCLUSIONS

Our investigation leads us to conclude that the outbreak of illness at Van Wyck during the winter of 1982-83 consisted mostly of a non-disabling syndrome that included irritation of eyes, nose, throat, and possibly skin; headache; and possibly an abnormal taste. These symptoms can be manifestations of common minor illnesses or of exposure to a wide variety of chemicals, including sulfur oxides and other constituents of boiler exhaust. There has been some speculation that they may also be manifestations of excessive environmental temperature and a lack of fresh air, but the evidence for this is mainly anecdotal. Such symptoms may occur from exposure to high levels of isocyanates, but would not be expected in a substantial number of persons at air concentrations of less than 20 ppb. While they are symptoms of a certain type of allergy (hayfever, for example), they are not the typical symptoms of hypersensitivity to isocyanates.

The energy conservation measures-which severely limited the amount of fresh air in the building, caused wide temperature fluctuations, and resulted in re-entry of boiler gases-were likely responsible for some of the symptoms among students and staff at Van Wyck, but the persistence of eye irritation after the school reopened in April following correction of the ventilation problem suggests that environmental contamination was not the sole cause of the outbreak. While the effects on temperature and fresh air volume resulting from the energy conservation measures may have contributed to some of the symptoms reported by students and staff at RCK and JJ, the publicity about the outbreak at VW undoubtedly led to a heightened awareness and increased reporting and concern about common discomforts and chronic health problems at all three schools.

VIII. RECOMMENDATIONS

These recommendations were included in a letter sent to the Superintendent of Schools April 8, 1983, and presented to the School Board at a public meeting April 11, 1983.

1. Re-evaluate the ventilation system and take corrective action that ensures, as a minimum, that the ASHRAE guidelines for outdoor air presented in Section IV this report are met.

2. Re-evaluate the purpose and effect of the hallway exhaust systems. At the time of our surveys they appeared to be developing excessive negative pressure in the buildings.

3. Continue working on the heating systems with the goal of maintaining temperature and humidity levels within comfortable ranges. Before any type of humidification system is installed, temperature and relative humidity data should be obtained in classrooms during normal sessions using a continuously recording instrument.

4. Correct boiler system deficiencies that have resulted in emissions re-entering the buildings, particularly at VW.

   a) Seal incinerators at top and bottom.

b) Temporarily block off the new water heater flues with long range plans of a more permanent solution, i.e., extend the flue out the ceiling at VW instead of hooking it into the breech.

IX. Epilogue

Recommendation 4 has been completed and recommendations 1 through 3 are in progress. As of January 9, 1984 the School Superintendant reported that only a few students still complained of what they thought were building-related health problems. The Dutchess County Health Department was also contacted on January 6, 1984 and reported that its routine surveillance has not detected any recurrence of the previous school year's outbreak.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. Superintendent, Wappingers Central School District
2. NIOSH, Region II
3. OSHA, Region II
4. New York State Department of Health
5. Dutchess County Health Department

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 2

N,N-dimethylcyclohexylamine and Other Aliphatic Amines

Wappingers Central School District
Wappingers Falls, New York
HE 83-172
March 8-11, 1983

School	Sample Location[1]	Sampling Time	Concentration (ppb)
Van Wyck	109	1431 - 1900	N.D.[2]
Van Wyck	118	1434 - 1910	N.D.
Van Wyck	204	1437 - 1915	N.D.
Van Wyck	211	1556 - 1920	N.D.
Van Wyck	214	1439 - 1923	N.D.
Van Wyck	223	1444 - 1930	N.D.
Van Wyck	Outside (dock)	1450 - 1846	N.D.
Roy C. Ketcham	286	1705 - 2020	N.D.
Roy C. Ketcham	345	1705 - 2030	N.D.
Roy C. Ketcham	217	1645 - 2005	N.D.
Roy C. Ketcham	233	1650 - 2010	N.D.
Roy C. Ketcham	Library	1655 - 1955	N.D.
Roy C. Ketcham	Outside (302)	1715 - 2040	N.D.
John Jay	211	1512 - 1800	N.D.
John Jay	253	1516 - 1807	N.D.
John Jay	134	1527 - 1817	N.D.
John Jay	106	1526 - 1823	N.D.
John Jay	167	1534 - 1825	N.D.
John Jay	Outside (302)	1508 - 1748	N.D.
Fishkill Elementary	121	0815 - 1100	N.D.
Fishkill Elementary	123	0815 - 1115	N.D.
Fishkill Elementary	126	0815 - 1120	N.D.
OSHA Standard			None
NIOSH Recommended Standard			None

Note (1): Air samples obtained on a student's desk or on the teacher's desk.

Note (2): N.D. means not detected. With an analytical sensitivity of 6 ug/sample and a sample volume of 250 liters, the overall detection limit for the method was 5 ppb.

Table 3

Formaldehyde

Wappingers Central School District
Wappingers Falls, New York
HE 83-172
March 8-11, 1983

School	Sample Location(1)	Sampling Period	Formaldehyde (ppm)
Van Wyck	109	1431 - 1900	0.01
Van Wyck	223	1444 - 1930	0.06
Roy C. Ketcham	286	1705 - 2020	0.01
Roy C. Ketcham	217	1657 - 2005	0.01
John Jay	106	1526 - 1823	0.01
John Jay	167	1534 - 1825	0.01
John Jay	211	1512 - 1800	0.02
Fishkill Elementary	121	0815 - 1100	0.04(2)
Fishkill Elementary	123	0815 - 1115	0.02
Fishkill Elementary	126	0815 - 1120	0.03
OSHA Standard:			3.0
NIOSH Recommended Standard			lowest feasible level
ASHRAE Indoor Criterion			0.1

Note (1): Air samples were collected on a student's desk or the teacher's desk

(2): An individual walked into the room on three occassions during the sampling period smoking a cigarette.

Table 4

Aldehyde Scan

Wappingers Central School District
Wappingers Falls, New York
HE 83-172
March 8-11, 1982

Each of the samples that were collected for formaldehyde determination (see Table 3) were also analyzed for:

Acetaldehyde
Propionaldehyde
n-butyaldehyde
n-valeraldehyde

No detectable concentrations were found at an analytical detection limit of 0.02 mg/sample for all but acetaldehyde for which the limit was 0.10 mg/sample due to interference from water peak. The analytical detection limit was based on a 10 ml impinger volume. The air sampling volume was about 250 liters for all of the air samples.

Table 5

Metals Scan

Wappingers Central School District
Wappingers Falls, New York
HE 83-172
March 8-11, 1983

An air sample for metals analysis was obtained at each of the following locations:

Van Wyck :	Rooms 109, 223
Roy C. Ketcham:	Rooms 286, 217, 233, outside
John Jay :	Rooms 211, 106, 167
Fishkill :	Rooms 121, 123, 126

Each sample was screened for the following 31 metals:

1. Al	6. P	11. Ba	16. La	21. Ni	26. Sr	31. Zr
2. Ca	7. Ti	12. Be	17. Li	22. Pb	27. Te	
3. Cr	8. Zn	13. Cd	18. Mg	23. Pt	28. Tl	
4. Fe	9. Ag	14. Co	19. Mn	24. Sb	29. V	
5. Na	10. As	15. Cu	20. Mo	25. Se	30. Y	

Metals #9 thru 31 were not detected at an analytical detectable limit of .001 mg/sample.

Metals #1 thru 8 were detected at concentrations ranging from .004 to 0.1 mg/m^3 except for Rooms 223 at VW and 286 at RCK, where concentrations of iron were 0.3 and 0.4 mg/m^3. Most of the metals detected were at typical background levels, and none would be expected to be of any health significance at the concentrations found.

Table 6

Organics Scan

Wappingers Central School District
Wappingers Falls, New York
HE 83-172
March 8-11, 1983

Twenty-five charcoal tubes were analyzed for organic vapors. Ten samples had no detectale quantities of organics. Nine had detectable but not quantifiable amounts (less than 0.02 ppm). The following 4 samples had quantifiable amounts of one or more of the organic vapors listed below:

VW - Room 223
RCK - Room 233
RCK - Library
JJ - Room 167

Organic Vapor	Concentration Range (ppm)
Total alkanes (C_3-C_{10})	N.D.[1] - 0.60
n-hexane	N.D. - 0.05
Toluene	N.D. - 0.03
Xylene	N.D. - 0.04
Other aromatics (C_9-C_{12})	N.D. - 0.04
Ethanol[2]	N.D. - 0.08
Acetone[2]	N.D. - 0.08
Trichloroethylene[2]	N.D. - 0.02

All levels of organics found would be considered trace amounts.

Note (1): N.D. means not detectable. For the sampling and analytical methods used the lower detectable limit was 0.02 ppm.

Note (2): These vapors were only found in Room 223, which was a science lab closet.

Table 7

Temperature/Humidity Data

Wappingers Central School District
Wappingers Falls, New York
HE 83-172
March 8-11, 1983

School	Location	Time	Temperature(°F)	Relative Humidity(%)
Van Wyck (3-8-83)	109	1725	72	28
	118	1730	75	25
	204	1735	71	28
	211	1745	72	26
	214	1747	70	28
	223 (Storage Room)	1755	80	24
	Outside	1645	42	77
Roy C. Ketcham (3-9-83)	286	1850	67	38
	345	1855	66	38
	217	1845	70	34
	233	1835	67	38
	Library	1830	74	27
	Outside	1900	44	70
John Jay (3-10-83)	211	1630	77	32
	253	1640	75	32
	134	1658	69	47
	106	1653	73	39
	167	1700	68	42
	Outside	1615	48	75
Fishkill Elementary (3-11-83)	121	1000	72	42
	123	1005	67	42
	126	1010	69	36

Table 8

Results of the Dutchess County Health Department's
Faculty Questionnaire Survey

Wappingers Central School District
Wappingers Falls, New York
HE 83-172
February 1982

	School*				
	JJ	RCK	VW	WJH	Meyers
Questionnaires distributed	191	115	180	90	116
Questionnaires received					
Number	132	109	135	78	112
% of Distributed	69%	95%	75%	87%	97%
Symptoms: number and (%) positive responses					
Eye Irritation	36 (27%)	54 (50%)	47 (35%)	9 (12%)	12 (11%)
Sore Throat	39 (30%)	45 (41%)	53 (39%)	14 (18%)	28 (25%)
Loss of Appetite	2 (2%)	4 (4%)	3 (2%)	2 (3%)	2 (2%)
Runny nose	29 (22%)	24 (22%)	28 (21%)	11 (14%)	26 (23%)
Headache	55 (42%)	55 (50%)	28 (21%)	19 (24%)	37 (33%)
Rash	3 (2%)	1 (1%)	10 (7%)	0	3 (3%)
Cough	26 (20%)	34 (31%)	30 (22%)	8 (10%)	22 (20%)
Fever	2 (2%)	6 (6%)	7 (5%)	3 (4%)	13 (12%)

*See text for abbreviations

Table 9

Results[1] of the Dutchess County Health Department's Parent Questionnaire Survey of Student Illness

Wappingers Central School District
Wappingers Falls, New York
HE 83-172
March 1982

	School[2]			
	VW	WJH	RCK	JJ
Questionnaires distributed	1486	812	1465	1460
Questionnaires received				
Number	1075	418	883	786
% of Distributed	72%	51%	60%	54%
History of allergy	256 (24%)[3]	114 (28%)	210 (26%)	191 (24%)
Symptoms:				
Eye Irritation	384 (42%)	46 (12%)	244 (35%)	203 (31%)
Sore Throat	477 (52%)	99 (26%)	309 (45%)	258 (39%)
Headache	612 (62%)	113 (30%)	420 (57%)	366 (50%)
Rash	104 (13%)	22 (6%)	70 (11%)	44 (7%)
Butterflies in stomach	167 (21%)	22 (6%)	98 (16%)	103 (17%)
Runny nose	318 (38%)	98 (27%)	213 (33%)	183 (29%)
Cough	411 (46%)	99 (26%)	234 (35%)	194 (30%)
Fever	186 (24%)	50 (9%)	79 (13%)	59 (10%)
Symptoms disappear on weekends	447 (72%)	44 (28%)	275 (64%)	214 (64%)
Symptoms recur upon returning to school	519 (76%)	45 (27%)	352 (43%)	320 (78%)
Seen by a doctor	246 (28%)	42 (18%)	123 (20%)	120 (22%)
Other family members ill	120 (13%)	67 (28%)	78 (12%)	55 (10%)

1 - Does not include approximately 40 questionnaires received after March 11, 1983.
2 - See Text for abbreviations.
3 - Percentages for this and all subsequent survey questions refer to the ratio of positive responses to total number of responses; most symptom

Table 10

School Attendance[1]

Wappingers Central School District
Wappingers Falls, New York
HE 83-172
1979-1983

School[2]	School Year	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
VW	1979-80	N/A[3]	N/A	N/A	N/A	0.92	0.93	N/A	N/A	N/A	N/A
	1980-81	N/A	N/A	N/A	0.93	0.92	0.94	0.94	N/A	N/A	0.98
	1981-82	0.97	0.95	0.95	0.94	0.94	0.95	0.94	0.92[4]	0.94	0.97
	1982-83	0.98	0.96	0.95	0.93	0.93	0.92*				
WJH	1979-80	N/A	N/A	N/A	N/A	0.92	0.89	N/A	N/A	N/A	N/A
	1980-81	N/A	N/A	N/A	0.89	0.93	0.92	0.93	N/A	N/A	0.97
	1981-82	0.96	0.94	0.92	0.91	0.91	0.92	0.92	0.88	0.91	0.95
	1982-83	0.96	0.95	0.93	0.92	0.93	N/A	N/A			
RCK	1979-80	N/A	N/A	N/A	N/A	0.91	0.92	N/A	N/A	N/A	N/A
	1980-81	N/A	N/A	N/A	0.92	0.92	0.93	0.94	N/A	N/A	0.98
	1981-82	0.97	0.94	0.93	0.94	0.93	0.93	0.93	0.90	0.93	0.97
	1982-83	0.96	0.94	0.93	0.92	0.93	0.93	0.93			
JJ	1979-80	N/A	N/A	N/A	N/A	0.94	0.91	N/A	N/A	N/A	N/A
	1980-81	N/A	N/A	N/A	0.92	0.94	0.92	0.94	N/A	N/A	0.96
	1981-82	0.97	0.94	0.94	0.91	0.93	0.93	0.93	0.90	0.93	0.95
	1982-83	0.97	0.93	0.92	0.92	0.94	0.89	0.92			

1 - Attendance = Actual aggregate days of attendance/potential aggregate days of attendance.
Aggregate Attendance: Number of students present per day for period.
Possible Aggregate Attendance: If all registered students attended school daily.

2 - See Text for abbreviations.

3 - N/A = data not available.

Table 11

Visits to Four High School Health Offices

Dutchess County, New York
HE 83-172
February 21-24, 1983

School	Population	Date			
		Feb. 21	Feb. 22	Feb. 23	Feb. 24
Roy C. Ketcham	1696	12 (0.7%)[a]	4 (0.2%)	17 (1.0%)[b]	28 (1/7%)
John Jay	1690	20 (1.2%)	32 (1.9%)	43 (2.5%)[b]	28 (1.7%)
Poughkeepsie	1075	20 (1.9%)	21 (2.0%)	25 (2.3%)	23 (2.1%)
Roosevelt	1053	28 (2.7%)	18 (1.7%)	24 (2.3%)	11 (1.0%)

a - Number of visits and (percent of school population).
b - School physician present; students and staff with suspected building-related symptoms encouraged to visit health office.

Table 12

Patient Visits to a Group Medical Practice

Dutchess County, New York
HE 83-172
Winter 1981-82 and 1982-83

	Winter 1981-82	Winter 1982-83	% Change
All Visits			
Ages 1-12			
December	546	674	+23%
January	527	778	+48%
February	710	701	- 1%
Ages 13-18			
December	58	80	+38%
January	57	131	+130%
February	48	86	+79%
Visits with diagnosis of upper respiratory infection, all ages			
December	24	27	+13%
January	19	48	+153%
February	21	46	+119%

Figure 1
Van Wyck School
HETA 83-172
March 30, 1983

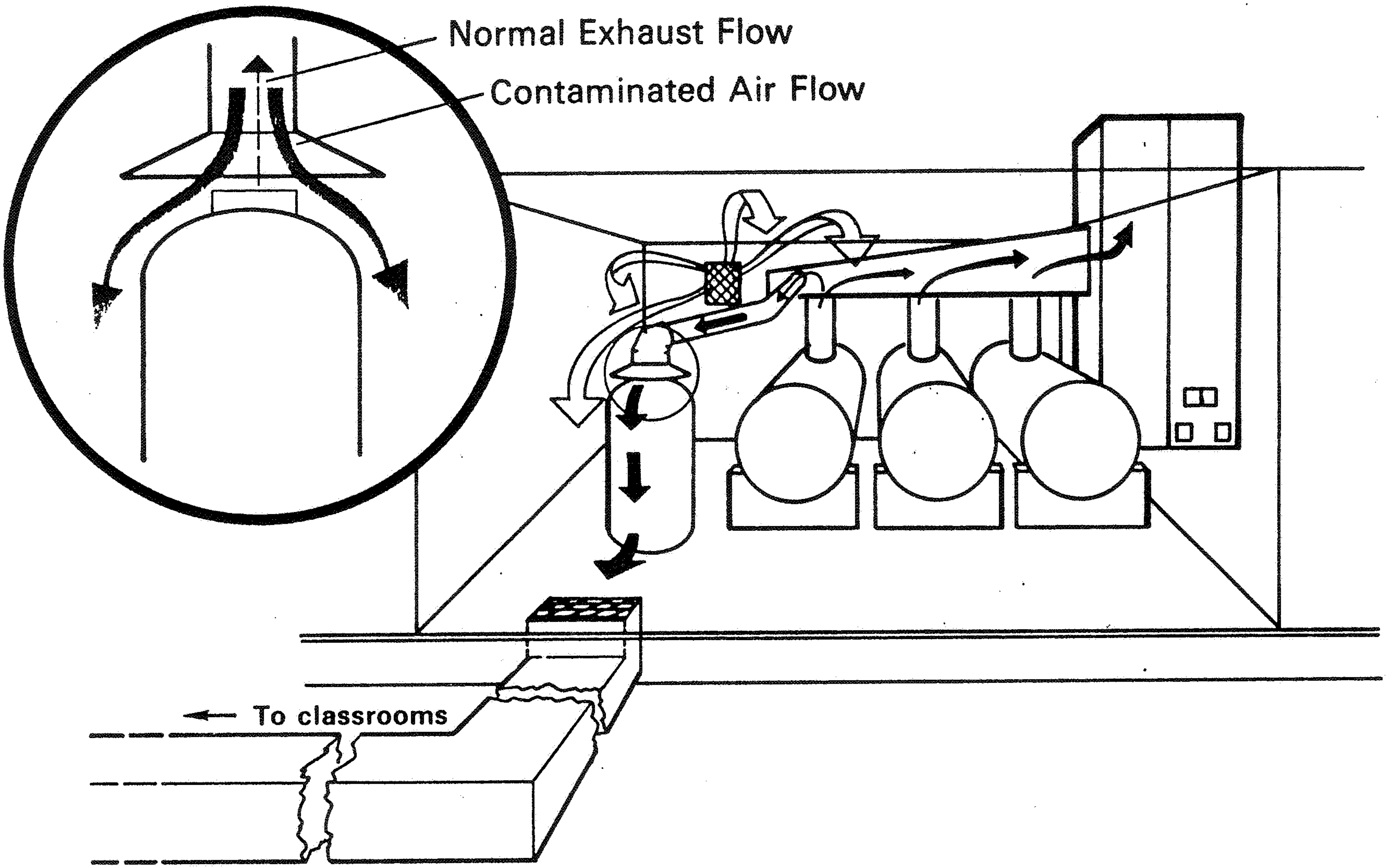


Figure 2

Van Wyck School
HETA 83-172
March 30, 1983

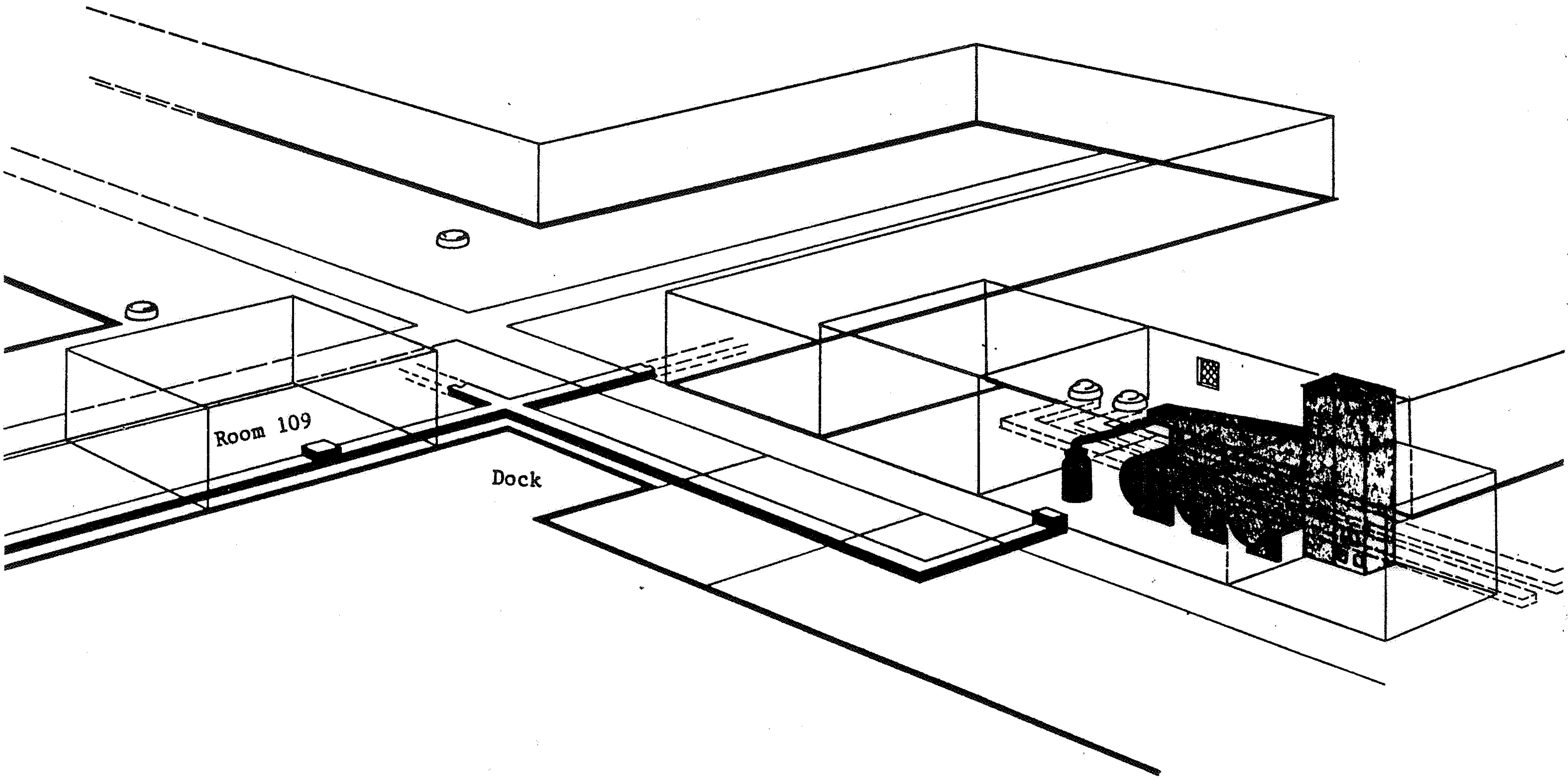


Figure 3

School Health Office Visits at Two Junior High Schools, Wappingers Central School District
Dutchess County, New York
January-February 1983
HETA 83-172

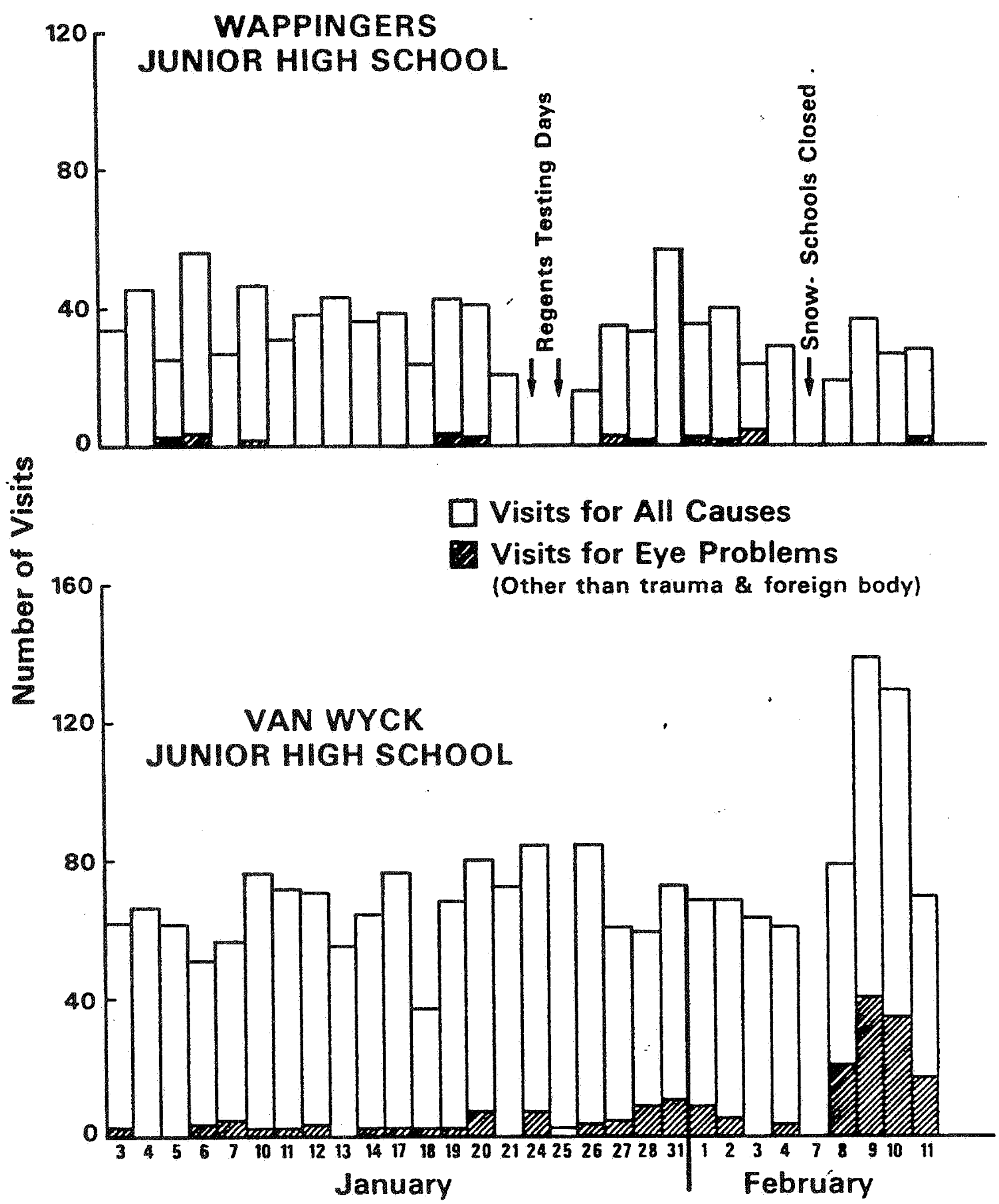
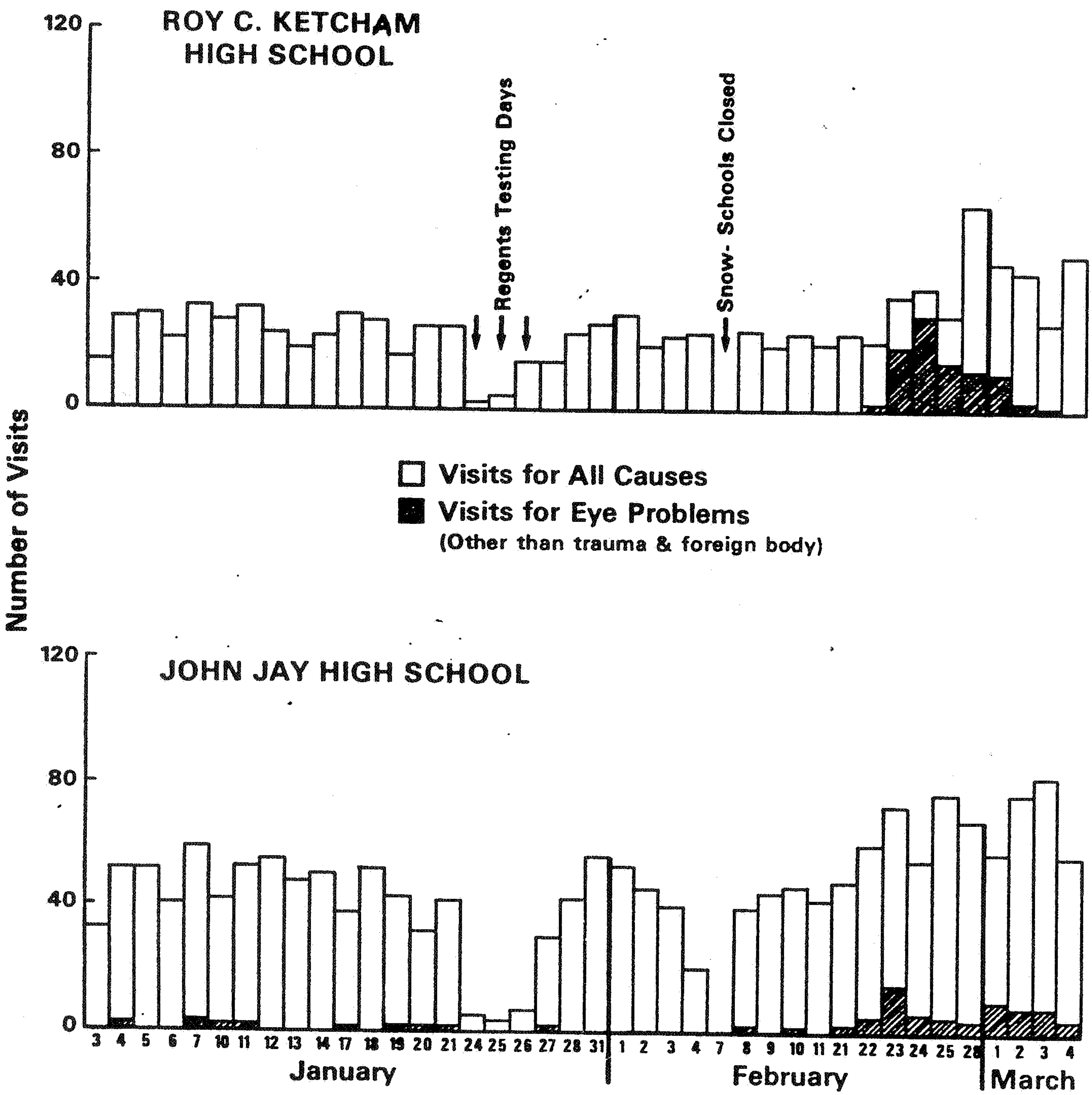


Figure 4
School Health Office Visits at Two Senior
High Schools, Wappingers Central School District
Dutchess County, New York
January-February 1983
HETA 83-172



Appendix A

Air Sampling/Analytical Methods
HE 83-172

Methylene Bisphenyl Isocyanate (MDI)

Air samples were collected using battery-powered sampling pumps connected to 13 mm, nitro-impregnated, glass fiber filters operating at a flow rate of 1 lpm.

The filters were prepared for analysis by disorbing each filter in 1 ml of methanol and filtering each resulting solution through a 0.5 um Teflon filter prior to injection into a high-pressure liquid chromatography system under the following conditions:

Column	:	Supelcosil LC-18, 250 x 4.6 mm, 5 micron packing
Mobile Phase	:	acetonitrile/water buffered with triethylamine and phosphoric acid
Flow Rate	:	1.8 mL/minute
Elution	:	isocratic
Detection Wave-length	:	254 nm at 0.02 AUFS
Instrumentation	:	Sp-8700 pump module, Perkin-Elmer LC-75 UV Detector with Autocontrol, Waters Intelligent Sample Processor

The limit of detection for MDI was 0.1 ug/sample.

Methylene Dianiline (MDA)

Air samples were collected on glass fiber filters at 1 lpm.

The filters were desorbed with 1.0 mL of toluene, 30 uL of HFBA a derivatizing reagent, and 5 uL of triethylamine was added. The addition of heptafluorobutyric anhydride (HFBA) forms the corresponding amide derivative. The sample was heated for 30 minutes at 55°C, then the excess HFBA was removed by shaking the sample with 1 mL of a phosphate buffer solution of pH 7. The toluene solution of the heptafluorobutyryl amide was then analyzed by gas chromatography using an electron-capture detector (ECD) and a 6 ft., 3% OV-225 on Chromosorb WHP (100/120 mesh) glass column. Spiked filters were run at the same time under the same conditions.

The limit of detection was about 25 ng/sample.

Aliphatic Amines

Air samples were collected using 150 mg silica gel tubes at 1 lpm.

The samples and blanks were analyzed according to NIOSH P&CAM 221, the general method for aliphatic amine analysis. Each sample was desorbed for 2 hours in a sonic bath with 2 mL of 1N H_2SO_4. A 0.5 mL portion was then made basic with the addition of 0.5 mL of 1.1N NaOH solution. The basic solution was then analyzed using a gas chromatograph equipped with a nitrogen-phosphorus detector and a 30-meter DB-5 fused silica capillary column. The nitrogen-phosphorus detector was used because it is more sensitive to nitrogen-containing compounds than an FID.

The limit of detection was about 6 ug/sample.

Formaldehyde

Air samples were collected using 1% sodium bisulfite solution in impingers and analyzed by NIOSH Method P&CAM 125.

The limit of detection was 0.1 ug/ml.

Other Aldehydes

The impinger solutions used to evaluate formadehyde exposures were also used to determine if other aldehydes such as acetaldehyde, propionaldehyde, n-butyraldehyde and n-valesaldehyde were present.

Air aliquot from each impinger solution was analyzed using NIOSH Method P&CAM 127 with the following modifications:

Gas Chromatograph	:	Hewlett-Packard Model 5731 equipped with a flame ionization detector
Column	:	6' x 1/8" stainless steel packed with 3% Carbowax 20mm and 0.5% H_3PO_4 on 60/80 Carbopack B
Oven Conditions	:	2 minutes at 100°C programmed at 8°C/minute to 170°C for an additional 8 minutes
Other	:	Helium was used as the carrier gas

The detection limits for the requested analytes are listed below.

Analyte	mg/Sample (assuming a 10 mL volume)
Acetaldehyde	0.10
Propionaldehyde	0.02
n-Butyraldehyde	0.02
n-Valeraldehyde	0.02

Trace Metals

Air samples were collected on AA filters at 1 lpm and analyzed using a ICP-AES technique.

The limit of detection was 1.0 ug/sample for each of the 39 metals included in the analysis.

Organic Vapors

Air samples were collected on standard 150 mg charcoal tubes at 1 lpm.

All samples were desorbed with 1 mL carbon disulfide spiked with n-hexadecane as an internal standard. Samples with analyzed by gas chromatography (FID) using a 30 meter DB-1 bonded phase fused silica capillary column (splitless mode). Four of the samples were further analyzed by GC/MS.

Microscopic Analysis

Whatman filter tabs were used to collect wipe samples of selected horizontal surfaces.

The samples were scanned under the stereo microscope to determine whether urethane foam particles were present.