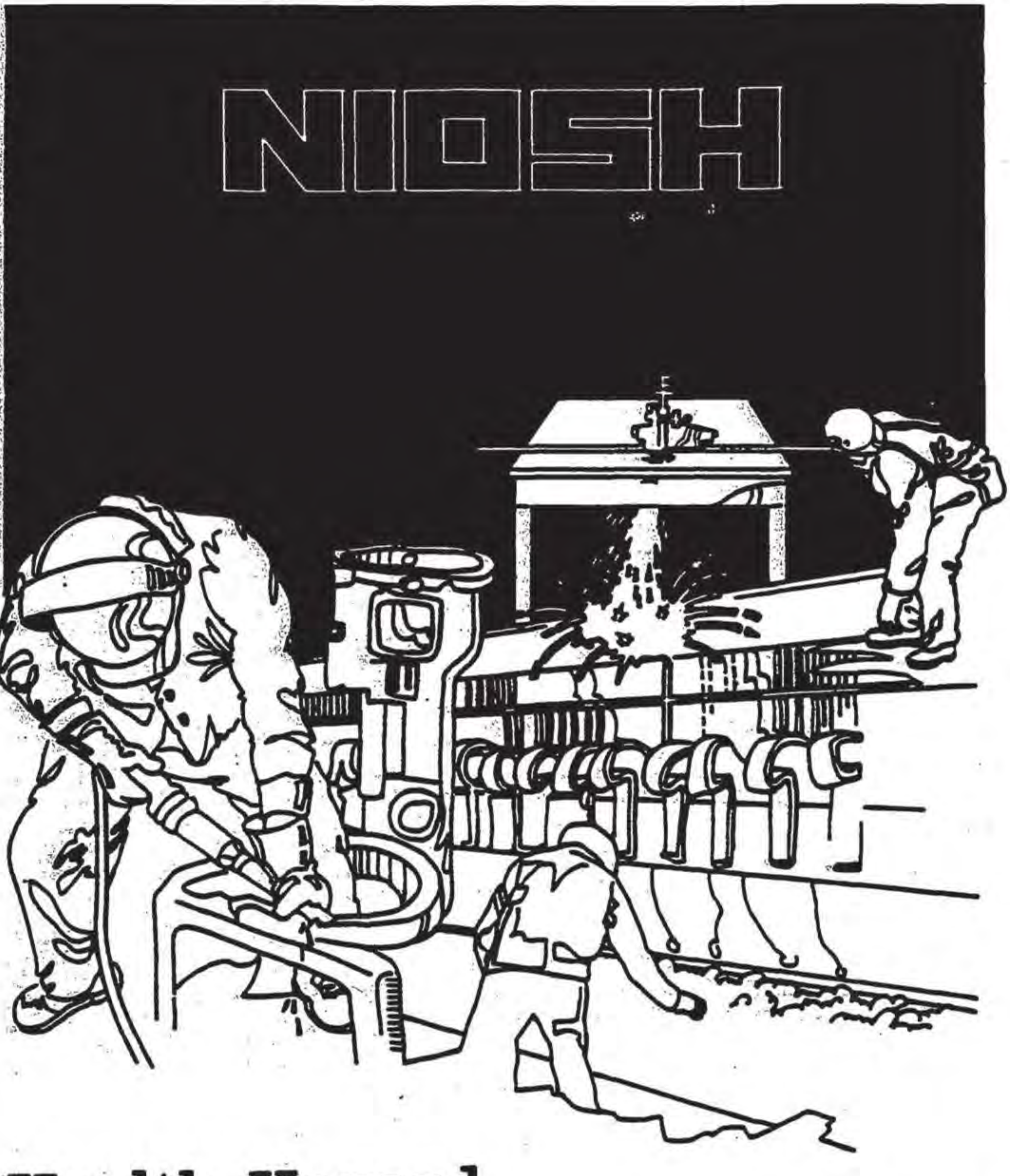
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
Centers for Disease Control • National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 84-248-1694
WASSON ELEMENTARY SCHOOL
DUBOIS, PENNSYLVANIA

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 84-248-1694
MAY 1986
WASSON ELEMENTARY SCHOOL
DUBOIS, PENNSYLVANIA

NIOSH INVESTIGATORS:
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I. SUMMARY

In March 1984, the National Institute for Occupational Safety and Health (NIOSH) was requested by the DuBois area school district, DuBois, Pennsylvania to investigate complaints of bloody noses, dry eyes, upper respiratory irritation, and headaches among students and faculty at Wasson Elementary School.

A NIOSH industrial hygienist and a medical officer visited the school on April 11-12, 1984, to collect information related to the physical layout of the building, potential emission sources, heating/cooling system and previous investigations. A questionnaire that focused on medical histories and symptoms related to working in the school was administered to all 24 teachers. A followup environmental survey was conducted on April 25-26, 1984, during which time air samples were collected in five locations for organic vapors, formaldehyde, isocyanates (the school community was concerned that isocyanate vapors were being released from the coating on the multipurpose room floor), and carbon dioxide. The heating/cooling system was more thoroughly evaluated, and temperature and humidity data was obtained in several locations.

Trace concentrations (less than 0.1 ppm) of organic vapors, primarily toluene and C_9-C_{12} hydrocarbons, were detected. All are commonly found in indoor air and do not cause adverse health effects for most people at the concentrations detected. Formaldehyde was not detected using a method having a lower limit of detection (LLD) of 0.04 ppm. No isocyanates were detected (LLD=0.3 ppb). Carbon dioxide (CO_2) levels measured 200 ppm outside and up to 800 ppm inside, which suggested that the quantity of fresh air introduced into the building was not adequate. The distribution of air in the building was also determined to be inadequate. There were several major deficiencies noted in the heating/cooling system which were related to design, installation, and maintenance. The unit ventilators were operating at an average of 64% of design air flow. Dry bulb temperatures fluctuated from 69 to 80°F within the building; relative humidities averaged about 28% (outside was 32%).

Twenty-two of the 24 teachers interviewed reported symptoms they felt were associated with working in the building. The most common symptoms reported were eye irritation (83%), throat irritation (75%), stuffy or dry nose (63%), excessive thirst (57%), throat irritation (58%), headaches (54%), lightheadedness (50%) and dryness of the skin (46%). Twenty teachers reported three or more of these symptoms.

Improvements in the ventilation system, which were recommended in April and May 1984, were made in the summer of 1984, and the winter of 1984 was used to evaluate their effectiveness. The school principal, in February 1985, reported greater than 98% reduction in complaints (924 down to 25) through February 5, 1985 compared to the same time period the previous school year.

Based on evaluation of the collected data, the health complaints were determined to be related to poor indoor air quality caused by deficiencies in the ventilation system. The recommendations which help to resolve the problem are provided in Section VIII of this report.

KEYWORDS: SIC 8211 (Elementary and Secondary Schools), indoor air quality, formaldehyde, isocyanates, ventilation

II. INTRODUCTION

On March 21, 1984, the Superintendent of the DuBois area schools asked NIOSH to evaluate complaints of bloody noses, dry eyes and headaches among students and teachers at Wasson Elementary School, DuBois, Pennsylvania. The school district had commissioned several agencies to evaluate the problem during the time span from January 1977 through March 1984. Various solutions were tried but complaints persisted causing the overall level of concern in the school community to reach the point where parents were reluctant to send their children to school.

A NIOSH industrial hygiene engineer and a medical officer were assigned on March 27, 1984. An initial and followup field survey were conducted in April 1984. Initial evaluation of the symptoms and the heating/cooling system tended to suggest that poor indoor air quality in general may be responsible for the symptoms. Further evaluation of the heating/cooling system and the lack of any significant findings from air sampling supported this initial theory. Specific recommendations, related to the heating and cooling system, were forwarded in April and May 1984. Contact was maintained with the school district throughout the summer of 1984. The remainder of the NIOSH results were reported via letters by November 1984. In December 1984 and February 1985 NIOSH received letters from school officials indicating that the corrective actions were effective.

III. BACKGROUND

Wasson Elementary School was completed in December 1976 and occupied in January 1977. It is a one story, steel frame (masonary fill between columns) building constructed on a concrete slab. Other construction features are provided in Appendix A. Except for plumbing, all utilities are between the false ceiling and roof deck. A floor plan is shown in Figure I.

Soon after occupancy, teachers and students began complaining of headaches and eye, nose and throat irritation. Several agencies had evaluated the problem between 1977 and 1984, and some provided recommendations. At several points, the problem had seemed to be resolved. Unfortunately, in each case this turned out to be a false assumption. School administration officials felt that teachers and parents had simply stopped reporting symptoms to the school office. Pressures from the school community continued to build. In the spring of 1984, several parents considered transferring their children to another school. Some kept their children home for a week or more at a time. Parents reported that the children felt fine after being away from the school a day or more.

IV. METHODS

A. Environmental

1. Results from earlier investigations were reviewed.

2. The ventilation system was evaluated with respect to its design and performance. A complete set of HVAC drawings used during construction of the school was available. Temperature and relative humidity measurements were made to evaluate the overall comfort level at different areas of the school. Carbon dioxide (CO_2) measurements were taken to evaluate the adequacy of fresh air ventilation.

3. Air samples were collected at five locations: classroom 109, classroom 117, classroom 110, cafeteria, and outside the building. At each of these locations airborne concentrations of organic vapors, formaldehyde and isocyanates were evaluated. The air samples for isocyanates were taken because of concern in the school community that the synthetic floor covering "Versaturf", installed in the multipurpose room during the original construction, may be emitting isocyanate vapors, and that these vapors may be causing or be partially responsible for the symptoms. All air samples were taken during normal class activities.

   a. Organic Vapors

   Air samples for organic vapors were obtained on standard 150-milligram charcoal tubes at a sampling rate of 200 cubic centimeters per minute (cc/min) for a period of 8 hours. Analysis utilized gas chromatography (flame ionization detector) and mass spectrometry techniques. The lower analytical limit of detection was 5 ug/sample which, for a commonly-found organic vapor such as toluene, translate to an overall method sensitivity of less than 0.05 ppm.

b. Formaldehyde

Air samples for formaldehyde, a common substance found in many indoor environments, were obtained on sorbent tubes (chromosorb 102 coated with n-benzylethanolamine) at a flow rate of 80 cc/min for a period of 8 hours. Analysis involved desorption with isooctane and capillary gas chromatography - FID detection in accordance with the procedures outlined in NIOSH Method P&CAM 354. The lower analytical detection limit was 2 ug/sample, which translated to an overall method sensitivity of 0.04 ppm for this survey.

c. Isocyanate

The synthetic floor covering was a methylene bisphenyl diisocyanate (MDI)-based urethane system. Air samples for MDI were obtained using Nitro-impregnated, glass fiber filters at a sampling rate of 200 cc/min for 8 hours and analyzed by high pressure liquid chromatography in accordance with NIOSH Method P&CAM 347. The analytical limit of detection was 0.3 ug/sample which, considering the sample volumes, resulted in an overall method sensitivity of 0.6 parts per billion (ppb).

B. Medical

A standardized questionnaire was administered to all 24 teachers at the school. The questionnaire focused on medical history and symptoms experienced in relation to working in the school building. Some parents and other staff members were also interviewed.

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 air conditioning expenses. Modern high-rise office buildings are constructed primarily of steel, glass, and concrete, with large windows that cannot be opened, thus making the building totally dependent on mechanical systems for air conditioning. Contaminants may be present in make-up air or may be introduced from indoor activities, furnishings, building materials, surface coatings, and air handling systems and treatment components. Symptoms most 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 ventilation 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 a 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 considered to be 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 normally considered to be 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 or asthmatic persons, often results in eye and nasal irritation, coughing, wheezing, sneezing, headache, and other related sinus problems. People who wear contact lenses often complain of burning, itching, and tearing eyes when exposed to cigarette smoke. Of the 15 studies published to date which have examined the link between passive smoking and cancer, only three have not shown a statistically significant positive correlation between the two[A]. Active cigarette smoking remains the leading cause of lung cancer in the United States.

5. Microorganisms and allergens

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

6. Hydrocarbon vapors

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

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

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

Several examples of common contaminants found in both industrial and non-industrial (indoor air) environments are shown below with their relevant environmental exposure criteria:

	Concentration/Exposure Period		
Contaminant	8-Hour TWA	Continuous	Source
Carbon monoxide (ppm)	50	---	OSHA/ACGIH
	35 (200[C])	---	NIOSH
	---	9	ASHRAE
Formaldehyde (ppm)	3	---	OSHA
	CA	---	NIOSH
	---	0.1	ASHRAE
Total particulates (mg/m^3)	15	---	OSHA
	10	---	ACGIH
	---	0.26 (24-hr[C]) or 0.075 (1-yr mean)	ASHRAE
Asbestos (fibers/cc)	2	---	OSHA
	0.5--2	---	ACGIH
	0.1, CA	---	NIOSH
	---	CA	ASHRAE

NOTE: ppm = parts of contaminant (gas or vapor) per million parts of air, by volume
mg/m^3 = milligrams of contaminant per cubic meter of air
CA = lowest feasible level (suspect or confirmed carcinogen), use best control technology
C = short-term (15-30 min) or ceiling limit

Other contaminants may be identified or suspect, dependent upon the particular situation and processes existing, and thus warrant further consideration.

C. Ventilation

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

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

Subsequently, ASHRAE has revised its standard and has published the new standard, ASHRAE 62-1981, "Ventilation for Acceptable Indoor Air Quality." The new standard is based on an occupant density of 7 persons per 1000 ft^2 of floor area, and recommends higher ventilation rates for areas where smoking is permitted. The new ASHRAE standard states that indoor air quality for "General Offices" shall be considered acceptable if the supply of outdoor air is sufficient to reduce 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].

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

VI. RESULTS AND DISCUSSION

A. Environmental

1. Previous Investigations

Previous investigations were conducted in March 1978, January 1983, October 1983, December 1983, February 1984, and March 1984. Substances evaluated during one or more of these surveys included: formaldehyde, carbon monoxide (CO), carbon dioxide (CO_2), oxygen (O_2), dust, and moisture content.

In February 1984 formaldehyde was measured in the art room at 0.31 ppm. There was no apparent explanation for this level which was 10 times the levels found in the rest of the school. Re-sampling efforts a month later did not detect formaldehyde in the art room (LLD=0.02 ppm).

There were no significant organic vapors detected in a survey conducted in December 1983. The moisture content in the air was reported as "low" in this same survey. Nothing significant was found in the dust samples analyzed using phase contrast microscopy.

Oxygen levels and CO levels were reported as within normal limits in January and October 1983.

None of these investigations included a thorough evaluation of the ventilation system.

2. Evaluation of Heating/Cooling System

A complete set of architectural drawings were available; this aided in understanding the design and, therefore, in evaluating the performance of the system.

The heating, ventilation, and air conditioning (HVAC) system is primarily a zonal system with each zone consisting of a number of ceiling unit ventilators (Nesbitt Horizontal Symcretizer®) suspended above the false ceiling and a relief damper system designed to limit pressurizing the building when fresh air is brought in via the unit ventilators. Each unit ventilator delivers air through two ceiling diffusers near the outside wall; air is returned to the unit via two ceiling return grills on the inside wall. An outside temperature sensor regulates a damper in each unit ventilator that determines the mix of return air and fresh air. Fresh air enters through a vertical duct directly above each unit. In order for this type of system to work effectively, room air must have a pathway to the relief dampers, which were typically located outside of the classrooms in the corridors.

The performance of a heating and air conditioning system, with respect to maintaining a comfortable environment, can be evaluated on a general basis through measurement of temperature, relative humidity, overall air flow and distribution, and fresh air ventilation.

Dry bulb temperatures and relative humidity ranged from 69 to 80^{o}F and 21 to 36%, respectively, in the classrooms on April 26, 1984. The outside temperature at the time was 77^{o}F, and the relative humidity was 32%. The temperature range inside, which was 11 degrees, is larger than desirable. The relative humidity, which was below the comfort range of 40-60%, is not unusual for a building in the heating season if no humidification is provided. On the day of this survey, the outside conditions were mild. Under colder weather conditions, such as those expected in January and February, relative humidity levels in the school would more than likely be below 20%. As the relative humidity drops below 40% complaints of upper respiratory irritation, and throat and eye irritation will be more frequent and directly related to how far the relative humidity drops with respect to 40%. Very low relative humidity can cause bloody noses. The membranes of the nose tend to dry out and become "coated" with nasal secretions. As nasal passages are cleared, small blood vessels near the surface can be ruptured causing the bleeding.

As more and more homes are equipped with humidification systems, the lower humidities encountered at work and school are more noticeable and cause more symptoms in more people.

Measurement of carbon dioxide (CO_2) is often used as a screening tool to evaluate the overall ventilation of building. CO_2 is ubiquitous and present in the atmosphere at concentrations ranging from 150 to 400 ppm. In rural areas, such as the location of Wasson Elementary School, the ambient CO_2 level is usually on the low end of the scale and, in fact, was measured at 200 ppm. Since people expire CO_2 during the normal breathing cycle, if adequate outside air ventilation is not provided, the CO_2 levels in a building can rise. The higher the level above the outdoor level, the more evidence that the HVAC systems is not introducing and/or mixing adequate amounts of fresh air. The CO_2 is not usually suspected of causing symptoms, since concentrations up to 2500 ppm can be easily tolerated. As the CO_2 level builds up, however, so do other air contaminants, which tend to have an cummulative effect of causing symptoms such as eye, nose, and throat irritation, headaches, malaise and lethargy.

As shown in Table 1, the CO_2 levels ranged from 2 to 4 times the outdoor level. It should be noted that the day of the survey was a mild day with temperatures reaching 77°F. The outside temperature sensor would have caused all outside air vents to be open to the maximum setting under these conditions which suggests that under more severe weather conditions, i.e., temperatures below freezing, when dampers close to the minimum position, the build up of contaminants in classroom atmospheres could be greater. Also, CO_2 levels in the lower half of classrooms, measured at 3 ft above the floor and in the center of the room, were higher than CO_2 levels near the ceiling, which were measured at the 7 ft level. In three classrooms monitored, the CO_2 level was about 200 ppm higher in the lower half of the room. This indicates that the fresh air being introduced via the ceiling unit ventilators (CUV) was not effectively mixed in the room and therefore not beneficial to the students whose breathing zone was 3 to 4 ft above floor level at their desks.

Since the original design drawings were available, it was possible to determine the amount of air, in cubic foot per minute (CFM), each CUV was supposed to be delivering. The total flow of the CUV's in each of the 24 classrooms was measured and compared to the original design specifications. In addition to the poor mixing of outside air, which is a problem inherent with ceiling HVAC systems, the output of the CUV's varied from 33 to 84% of design, with an average of 64%. Figure 2 presents the data from each of the 24 classrooms. The air filter from room 115, a room where the total air flow was less than 40% of design, was removed and found to be heavily loaded. The unit was turned on without the filter, and the output increased to 94% of design. This suggested that partially clogged filters were probably responsible for the flow deficits in all of the CUV's.

Further investigation revealed a problem that would make it difficult for the HVAC system in the building to balance itself. The backdraft dampers on the pressure relief grills were not connected with the primary relief dampers via the intended linkage system. As a result, even though the first set of primary dampers opened to relieve pressure the backdraft dampers, being in the closed position, would not allow this part of the overall HVAC system to function efficiently. Also, the classroom doors did not have grills in them, so there was no pathway for the buildup of pressure resulting from the introduction of fresh air in the classrooms to relieve itself via the pressure relief system. This also caused a "layering" effect in the classrooms, with the better quality air being in the top half of the room as illustrated in Figure 3. The higher CO_2 levels in the lower half of the room, as discussed earlier, provided evidence of the phenomenon.

3. NIOSH Air Sampling

The following reports the results from air samples obtained in rooms 109, 110, 117, the multipurpose rooms and outside. Air samplers were placed on desk tops in the center of each classroom evaluated and on the floor in a corner of the multipurpose room.

a. Organic Vapors

There were no significant amounts of organic vapors detected. Considering the analytical detection limit of 5 ug/sample and a sample volume of approximately 50 liters, any organic vapor, if present, was at concentrations of less than 0.1 ppm (using toluene as an example) and would not, at these levels, be expected to cause significant health effects for most people.

b. Formaldehyde

Formaldehyde was not detected using a method having a lower detectable level equivalent to 0.04 ppm. There are methods more sensitive; however, this method was chosen because it is very specific and because other methods had been used at the school. Some of the more sensitive methods are subject to interferences. Formaldehyde is a common airborne contaminant, and trace quantities are frequently found in indoor air environments. Air concentrations below 0.04 ppm would not be expected to cause adverse health effects except in someone sensitized to this substance. Adequate ventilation helps minimize the buildup of formaldehyde and other air contaminants.

c. Isocyanates

The multipurpose room floor was covered with a methylene diisocyanate (MDI)-based material at the time of construction. It is unlikely that isocyanate vapors would be released once the curing process is completed, which generally takes a matter of minutes. If mixed improperly at the time of application, isocyanate vapors could continue to evolve, but this would more than likely have been discovered shortly after installation since such an area would not cure properly and tend to remain soft.

No MDI was detected in any of the air samples. The lower detectable limit for the method used was 0.005 ppb.

B. Medical

There were 47 staff members at Wasson Elementary School. This included the principal, a nurse, 24 teachers, and 21 others (secretarial staff, school psychologists, custodians, cafeteria staff, and aides). The 24 teachers included 22 white females and two white males; they ranged in age from 27 to 57 years ($\bar{x}$ = 35 years). They are assigned to specific rooms throughout the school building. Their duration of employment in this building ranged from under a year to seven years ($\bar{x}$ = 5.7 years). They worked in their present classrooms for an average of 5.4 years.

Twenty-two of the 24 teachers (92%) have experienced symptoms in the school building. The most common symptoms reported are eye irritation (20/24; 83%); throat irritation (18/24; 75%); stuffy or dry nose (15/24; 63%); excessive thirst (14/24; 58%); headaches (13/24; 54%); lightheadedness (12/24; 50%); and dryness of the skin (11/24; 46%). Twenty of the 24 teachers (83%) reported three or more of these symptoms. A review of the data collected by the school principal indicated similar symptoms among the students. These data also suggest that there was a greater prevalence of symptoms among pupils using rooms 104 to 112 (the nine rooms at one end of the building) than among pupils in rooms 116 to 112 (the nine rooms at the other end of the building). Our interview data indicated a similar experience among the teachers. Seven out of nine (78%) teachers in rooms 104 to 112 perceived the air circulation in their rooms to be poor, compared to one out of nine (11%) teachers in rooms 116 to 122 ($p = 0.01$, Fisher's exact test). Among all 24 teachers interviewed, 10 perceived the air circulation in their rooms to be poor (42%), and 14 felt the air circulation to be adequate or good (58%). There was a higher frequency of reporting of each of the seven commonest symptoms among teachers who perceived the air circulation to be poor than among those who said that it was adequate or good (Table 2). There was no significant difference in seniority, age, or smoking status between the groups (Table 2).

With regards to other aspects of the environment in the school building, 22 of the 24 teachers (92%) perceived the lighting in their rooms to be adequate, one felt it to be poor, and one other felt that there was too much glare. Twenty-two teachers (92%) also perceived the humidity to be very low. The air temperature was felt by only three individuals (13%) to be comfortable. Four teachers (17%) thought the temperature too high, nine (38%) felt that it was too cold, and eight (33%) said that the air temperature tended to vary between the two extremes.

Eleven of the 24 teachers (46%) had noticed peculiar odors while working in the school building. These odors were infrequent (less than 2-3 times a year), not seasonal, and were noticed by different individuals on different occasions. The most common descriptions of the odors were a 'burning smell' (25% of teachers), and a 'smell of gasoline' (25% of teachers). Other descriptions were a 'paint smell', 'bug spray', 'spoiled milk', and a 'smell of cafeteria food'. Of the 11 teachers who noticed odors, the mean number of symptoms experienced was 4.8 out of the eight commonest symptoms. Among the 13 teachers who did not notice any peculiar odors, the mean number of symptoms was 4.5. There was no significant difference between those who perceived odors and those who did not, in terms of prevalence of symptoms reported (t test; p more than 0.05).

VII. CONCLUSIONS

Based on the environmental and medical data obtained during the course of this investigation, there is evidence that problems with the ventilation system resulted in poor indoor air quality in general and that the majority of complaints were attributable to these deficiencies.

VIII. RECOMMENDATIONS

The following recommendations were provided in letters dated April 24, May 7, and November 26, 1984.

1. The air filters in all the CUV units should be removed and thoroughly cleaned. They should be checked every three months and cleaned as necessary.

2. The backdraft dampers on the pressure relief ducts should either be wired open or fitted with linkage that opens them in unison with the primary dampers.

3. All classroom doors should be left open until they can be modified with the proper grills.

4. The outside air dampers should be adjusted to introduce a minimum of 250 CFM per classroom during any occupied cycle. Assuming a student occupancy of 25 per room, this would allow for a ventilation rate of 10 CFM/student.

5. Promote more effective mixing of outside air by using either an oscillating or ceiling fan (52" blade). The ceiling fans, if chosen, should be mounted in the center of the room and have variable speed and reverse flow capability. If oscillating fans are used, care should be taken to avoid directing them at students. They should be set on the lowest speed and directed upward at a 45^{o} angle.

6. It is generally preferable to set all thermostats at the same setting, i.e., 72^{o}F, and ask that students wear or not wear sweaters to satisfy their own comfort requirements. Local or regional school authorities should be consulted for further guidelines related to thermostat settings.

7. Since there is no central humidification system, some consideration may be given regarding humidification of the air. It should be noted that humidification of a building can cause more problems than it solves; and, since the extreme cold weather conditions occur for a relatively short period of the year, humidification should be given a lower priority among these recommendations.

   In the use of any of the portable type humidifiers, such as those placed in several locations at the school, care should be taken to maintain and service the units according to manufacturers' recommendations. This would avoid future health problems arising as a result of mold or fungal growth in the water reservoirs. Anti-bacteria agents, which are used in some humidifiers, may also cause ill health effects such as upper respiratory irritation.

   A certain amount of complaints of eye, nose and throat irritation would be expected in any school that is not humidified during the heating season. Similar complaints would be expected in a home that was not humidified.

IX. EPILOGUE

Correspondence from the school received in February 1985 reported that corrective actions (recommendations one through six above) were effective. The number of complaints decreased by more than 98% (924 down to 25) from September, 1984 through February 5, 1985 compared to the same time period the previous school year.

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

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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, Publications Dissemination Section, 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, DuBois Area Schools
2. Principal, Wasson Elementary School
3. NIOSH, Region III
4. OSHA, Region III

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 1

Carbon Dioxide (PPM)

Wasson Elementary School
DuBois, Pennsylvania
HETA 84-248

April 12, 1984

	8:00 AM	11:30 AM
Room 106	400	600
Room 117	400	500
Room 110	400	600
Multipurpose Room	800	500
Outside	200	200

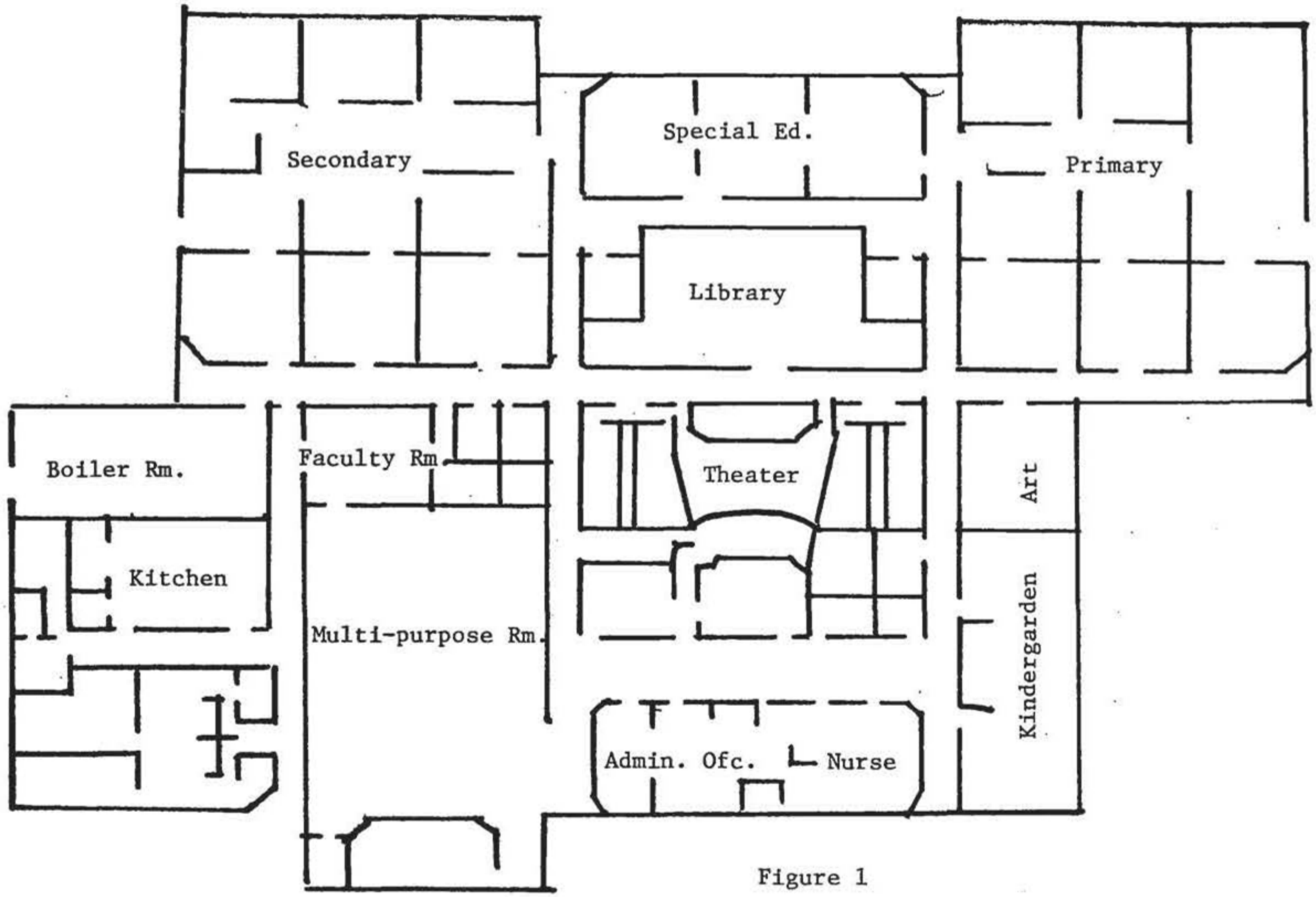


Figure 1

School Floor Plan
HETA 84-248
April, 1984

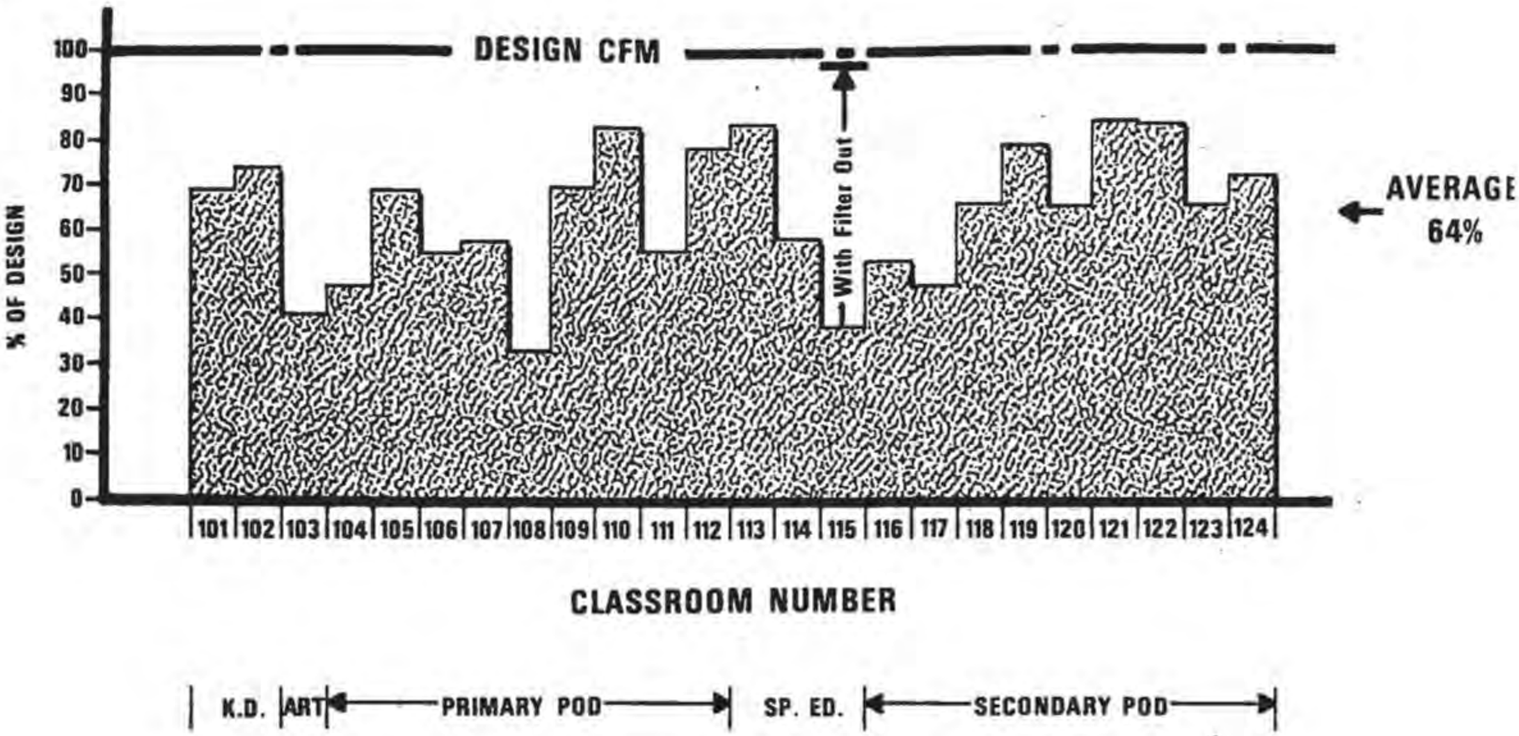
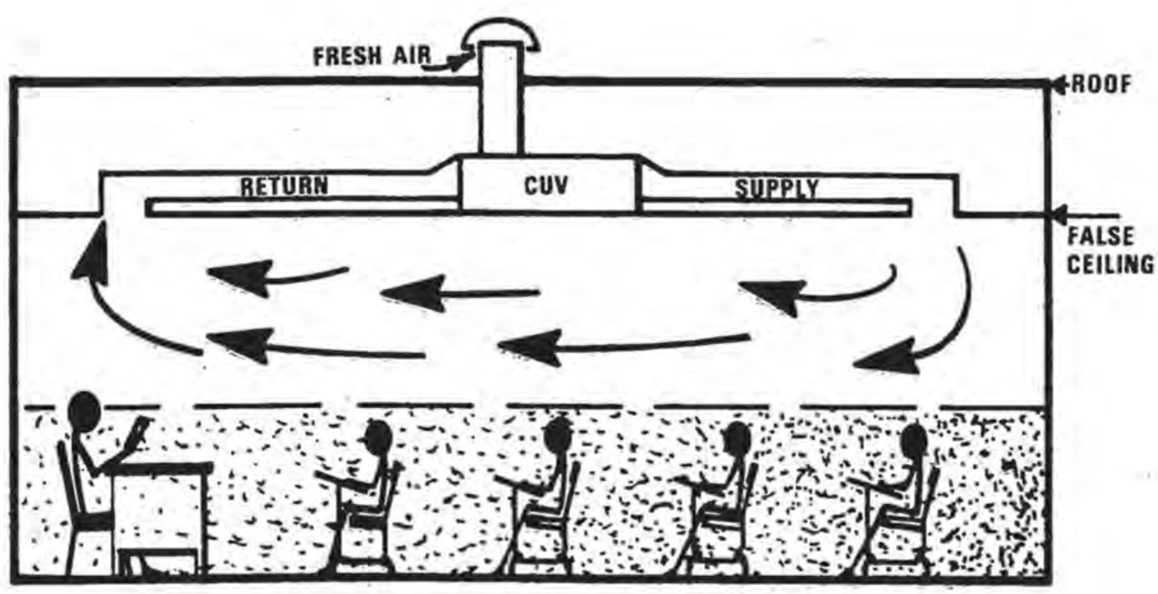


Figure 2
Measured Air Flow vs Design
HETA 84-248
April, 1984



TYPICAL CLASSROM CROSSECTION

Figure 3
"Layering" Effect
HETA 84-248
April, 1984

Table 2

Symptoms Experienced by Teachers

Wasson Elementary School
DuBois, Pennsylvania
HETA 84-248

Symptoms	Teachers who perceived the air circulation to be: Poor	Adequate or Good
Eye irritation	10/10 (100%)	10/14 (71%)
Throat irritation	8/10 (80%)	10/14 (71%)
Stuffy or dry nose	8/10 (80%)	7/14 (50%)
Excessive thirst	7/10 (70%)	7/14 (50%)
Headaches	6/10 (60%)	7/14 (50%)
Lightheadedness	6/10 (60%)	6/14 (43%)
Dry skin	5/10 (50%)	6/14 (43%)

Table 3

Length of Employment, Age, and Smoking Status in Teachers

Wasson Elementary School

	Teachers who perceived the air circulation to be: Poor	Adequate or Good
Seniority of employment	Mean = 6.6 years	Mean = 5.0 years
Age	Mean = 39 years	Mean = 35 years
Smoking Status	2 smokers	2 smokers
	6 non-smokers	9 non-smokers
	2 ex-smokers	3 ex-smokers
TOTAL	10 teachers	14 teachers

Appendix A

Wasson Elementary School
DuBois, Pennsylvania
HETA 84-248

Basic Structure:	1 story, on slab Steel frame with masonary fill between columns
Walls:	Face brick Rigid foam visualization Concrete block interior layer
Roof:	Flat built-up roof composed of - 1/2" steel deck - 3" rigid foam panels - 3-ply roof - hot-moped asphalt with pea gravel cover
Ceiling:	Dropped 5'-11' from roof Acoustical tile (3/4"x2'x4') mineral base
Windows:	Aluminum with operable bottom pane
Lighting:	Mostly fluorescent and recessed
Flooring:	Rugs over concrete slab floor Versaturf® in multipurpose room (MDI-based urethane floor coating material)

Except for plumbing all utilities run above the dropped ceiling