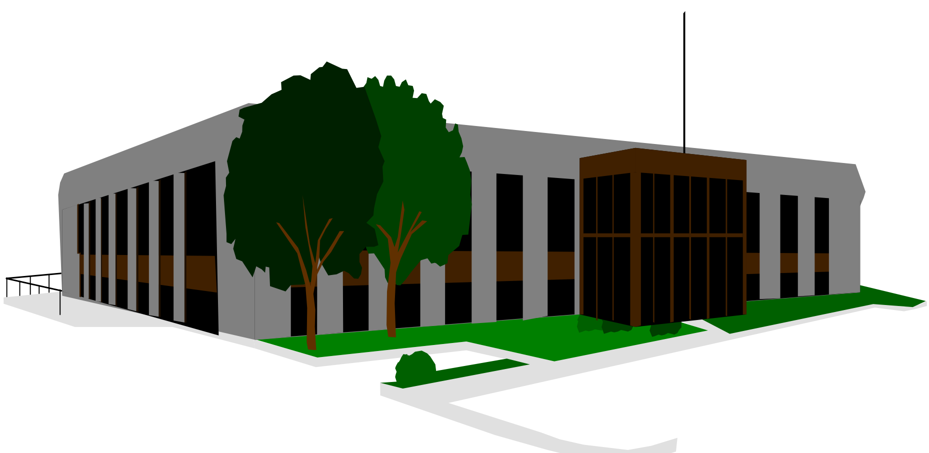
INDOOR AIR QUALITY ASSESSMENT

Powder Mill Middle School
94 Powder Mill Road
Southwick, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Paul Petit, Business Manager of the Southwick/Tolland Regional School District, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality issues and health concerns at the Powder Mill Middle School, 94 Powder Mill Road, Southwick, Massachusetts. On April 7, 2000, a visit was made to this school by Mike Feeney, Chief of Emergency Response/Indoor Air Quality, BEHA.

The school consists of two distinct sections. The original building, constructed in 1954, is a single story red brick structure. A two-story red brick addition was added in 1959. The school contains general classrooms, the main administrative office, library, cafeteria, gymnasium, art room, music room, home economics room and chemical storeroom. Windows are openable. The roof is covered with a rubber membrane.

Methods

Air tests for carbon dioxide were taken with the Telaire, Carbon Dioxide Monitor and tests for temperature and relative humidity were taken with the PTH Pen 8708 Thermo-hygrometer.

Results

This school has a student population of over 575 and a staff of approximately 50. The tests were taken during normal operations at the school. Test results appear in Tables 1-4.

Discussion

Ventilation

Carbon dioxide levels were above 800 parts per million of air (ppm) in twenty-five out of thirty-seven areas surveyed, which is indicative of an overall ventilation problem in the school. It is important to note that a number of areas were sparsely populated or had open windows, which can greatly reduce carbon dioxide levels. Classrooms 8, 101 and 109 had carbon dioxide levels over 800 ppm with windows open.

Classrooms have fresh air supplied by a unit ventilator (univent) system. A univent draws fresh air from a vent on the exterior of the building and air from the classroom (called return air) through a vent in the base of its case (see Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were deactivated in several classrooms. Obstructions to airflow, such as boxes and tables blocking univents were seen in a number of classrooms. In order for univents to provide fresh air as designed, fresh air diffusers and univent returns must be unblocked and remain free of obstructions.

The school has two different types of exhaust ventilation systems. In the older section of the building, exhaust ventilation is provided by ungrated holes (see Picture 1) connected to rooftop exhaust vents (see Picture 2) by ductwork. Airflow is controlled by a flue, which is opened by a draw chain-pulley system. The flue is set at a desired angle by setting the draw chain in a locking mechanism. The interior of several of these vents appears to be sealed with fiberglass. These vents need to be free of obstructions in order to function as designed.

In the 1959 addition, exhaust ventilation is provided by a mechanical, ducted ventilation system. Exhaust vents are located in the ceiling of each classroom closet (see

Picture 3). Classroom air is drawn into the coat closet via a grate mounted on the front face of the closet. This design allows for these vents to be easily blocked by stored materials (see Picture 4). When blocked, exhaust air is drawn through the space between the closet door and doorframe. Confirming this condition is the heavy accumulation of dust along the closet door edge (see Picture 5). In order to function properly, these vents must be cleared and remain free of obstructions. Each classroom exhaust vent is connected to a rooftop motor. One third of the exhaust vent motors were deactivated (see Tables 5 and 6). Without active exhaust ventilation, normally occurring environmental pollutants can build up in the indoor environment.

A rooftop air-handling unit (AHU) provides ventilation in the library. The fresh air intake is located on the roof (see Picture 6). This AHU is connected by ductwork to fresh air diffusers located in the ceiling of the library. Return air is drawn into a ceiling plenum through grates in the ceiling back to the rooftop AHU. The ceiling was missing one ceiling tile. In order to have the exhaust ventilation system function as designed, all ceiling tiles must remain intact in order to draw air through the ceiling tile system.

In order to have proper ventilation with a univent and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing of these systems could not be identified.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings recorded during the assessment were in a range of 72 ^{o}F to 78^{o}F, which is within the BEHA's recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range between 70 ^{o}F to 78 ^{o}F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 12 to 31 percent, which was below BEHA guidelines. The BEHA recommends that indoor air relative humidity be maintained in a range of 40 to 60 percent for comfort purposes. Of note however, is that 31 areas had relative humidity measurements 1-16 percent higher than the relative humidity measured outdoors (15%) on the day of the assessment. The increase of relative humidity in these rooms can be attributed to lack of exhaust ventilation. Without airflow created by the mechanical ventilation system, water vapor resulting from classroom occupancy can build up, as demonstrated by these relative humidity measurements. Please note that most of these areas also had carbon dioxide levels in excess of 800 ppm, which also indicates poor air exchange. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several areas had water stained ceiling tiles, which is evidence of historic and/or current roof or plumbing leaks. Ceiling tiles can provide a source of mold and mildew and should be repaired/replaced after a water leak is discovered.

Caulking around windows appears to be missing, damaged or crumbling in a number of areas (see Pictures 7 and 8). Moss was observed growing on the seam of a window frame (see Picture 9). Moss growth can indicate substantial moisture exposure to these window frames. Moss growth can lead to damage to the frame seal. Windows should be properly sealed and broken windows should be replaced to prevent water intrusion and subsequent mold growth.

Shrubbery in direct contact with the exterior wall brick was noted in several areas around the building (see Picture 10). Shrubbery can serve as a possible source of water impingement on the exterior curtain wall due to the location of plants growing directly against the building. Plants retain water and in some cases can work their way into mortar and brickwork causing cracks and fissures, which may subsequently lead to water penetration and possible mold growth.

Several classrooms had a number of plants. In some classrooms, flowering plants were observed on univent air diffusers. Several classrooms contained plants in window planters without drip pans. Window planters are designed to be mounted on the outside of windows and usually do not have drip pans. The lack of drip pans can lead to water pooling and mold growth on windowsills when used indoors. Moistened plant soil, drip pans and standing water can serve as a source of mold growth. Plants should be equipped with drip pans and over-watering should be avoided. In addition, plants should be located away from univents to prevent aerosolization of dirt, pollen or mold.

The home economics room contained several water-damaged sink cabinets. Improper drainage or overflow could lead to water penetration of countertop wood and potential damage to the cabinet interior as well as materials stored therein. Water-damaged wood and standing water may also be potential sources of mold growth.

Other Concerns

Several other conditions that can potentially affect indoor air quality were identified. Of note are the chemicals found in the science storeroom. Several other conditions of improperly stored materials were also found in this storeroom. The storage cabinet contains several acidic materials. This material is extremely corrosive. The storage caps on acid containing bottles have not been secured, as evidenced by corrosion to the shelf supports in this cabinet (see Picture 11). Corrosion of the metal can undermine the integrity of the shelf supports and lead to shelf failure. Of note is the storage of plumbing torches stored beneath the acids. Welding torches should be stored in a separate storage area that is in compliance with state and local fire ordinances. It is highly recommended that a thorough inventory of chemicals in the science department be done to assess chemical storage and disposal in an appropriate manner consistent with Massachusetts' hazardous waste laws.

Accumulated chalk dust was noted in several classrooms (see Picture 10). Chalk dust is a fine particulate, which can become easily aerosolized and serve as an eye and respiratory irritant. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Missing and ajar ceiling tiles, as well as spaces and holes in the interior walls of classrooms were also observed. Since wall cavities are unconditioned space and would be expected to have a lower temperature than heated classrooms, drafts of air moving from the wall interiors into the classroom may occur. Particulates can move with airflow from the interior of the wall cavity into the classroom.

Some univent fresh air intakes are located at ground level (see Picture 12). These vents can be prone to drawing dust, dirt and pollen into univents as well as blockage with accumulated snow. In addition, grass cutting during school hours can introduce plant matter, dirt, dust and pollen into univent fresh air intakes.

Classrooms 109 and 112 have sinks, several of which are not in use (see Picture 23). This condition can lead to drain traps drying out, subsequently leading to sewer gas odors penetrating the room through the unsealed trap. Sewer gas odors can be irritating to the eyes, nose and throat.

The rooftop AHU is installed with air filters that do not fit flush with their racks. Filters should be one piece that fits flush with the filter rack. If two filters are to be used, the filter rack must have the appropriate equipment to make each filter fit flush. Air drawn into the AHU will bypass filters through spaces between filters and racks. This can result in dust, dirt and other debris to be distributed by the ventilation system. Univents and AHUs are installed with filters that provide minimal filtration of respirable particulates. Both univents and AHUs are equipped with filters that strain particulates from airflow. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced through increased resistance. Prior to any increase of filtration, each piece of air handling equipment should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made:

1. Repair exhaust vent motors.
2. Examine exhaust vents in the original building for blockages. Restore the airflow controls for the exhaust ventilation system.
3. Remove blockages of the univents.

4. Examine univents throughout the school for function. Survey classrooms for air diffuser and exhaust vent function to ascertain if an adequate air supply exists for each room. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
5. Obtain spacers for between air filters in the library AHU.
6. Ensure that the ceiling tile system in the library remains intact in order for the exhaust plenum ventilation system to work as designed.
7. Ensure that ground level fresh air intakes remain clear of blockages, particularly snow in winter. Avoid grass cutting during school hours.
8. Examine the filters in the univents and AHUs and change filters as recommended by the manufacturer or more frequently if needed. Consider increasing the dust spot efficiency of filters to increase the removal of particulates from the environment.
9. Once fresh air supply and exhaust systems are functioning, the ventilation system should be balanced by a ventilation engineer.
10. Repair/replace any water-stained ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
11. Remove water damaged wood from the home economics sink cabinets. Examine the floor below the water-damaged wood for mold growth. If mold is present, disinfect the non-porous surfaces with an appropriate antimicrobial agent and subsequently clean with soap and water.
12. Replace damaged window caulking.
13. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, implementation of scrupulous cleaning practices

should be implemented. This will minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Use of vacuum cleaning equipment outfitted with a high efficiency particulate arrestance filter (HEPA) is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

14. Reduce/trim or remove plants that are growing against the exterior brick curtain wall.

15. Seal abandoned drains or wet dry drain traps regularly to prevent odor migration into classrooms.

16. Have a chemical inventory done in all storage areas and classrooms. Properly store flammable materials in a manner consistent with the local fire code. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Follow proper procedures for storing and securing hazardous materials. Obtain Material Safety Data Sheets (MSDS) for chemicals from manufacturers or suppliers. Maintain these MSDS' and train individuals in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F. (MGL. 1983).

17. Consider obtaining an acid resistant storage cabinet for the chemical storeroom.

18. Clean chalkboards and chalk trays regularly to prevent the build-up of excessive chalk dust.

References

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

BOCA. , 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

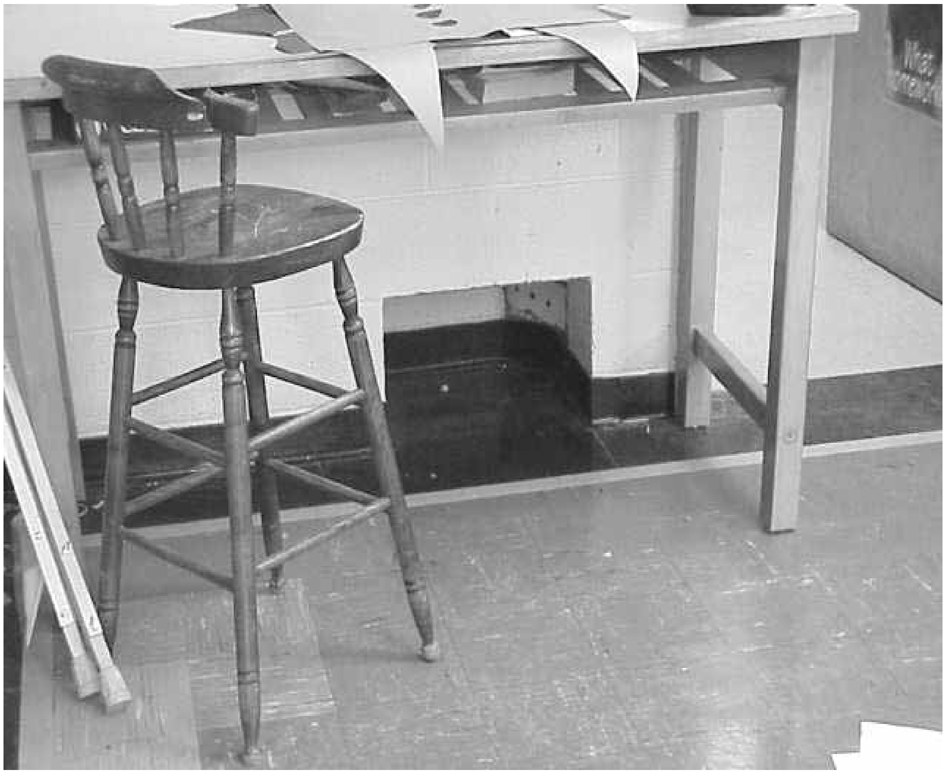
OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Thornburg, D. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

Picture 1

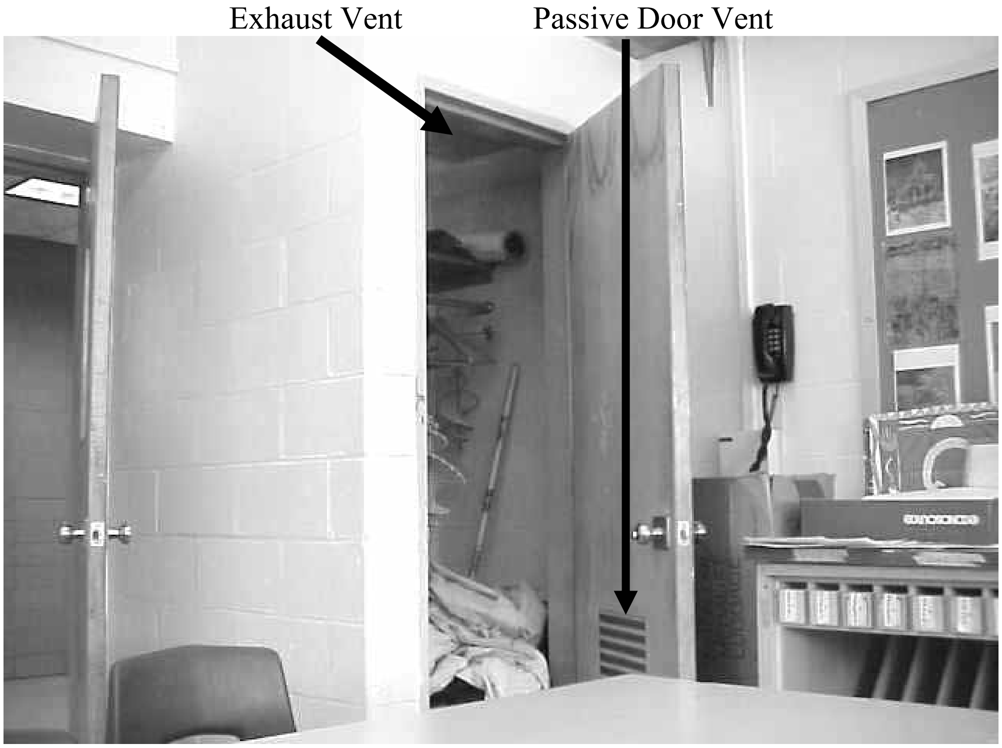


Exhaust Vent in the Original Building

Picture 2

Rooftop Exhaust Vents

Picture 3

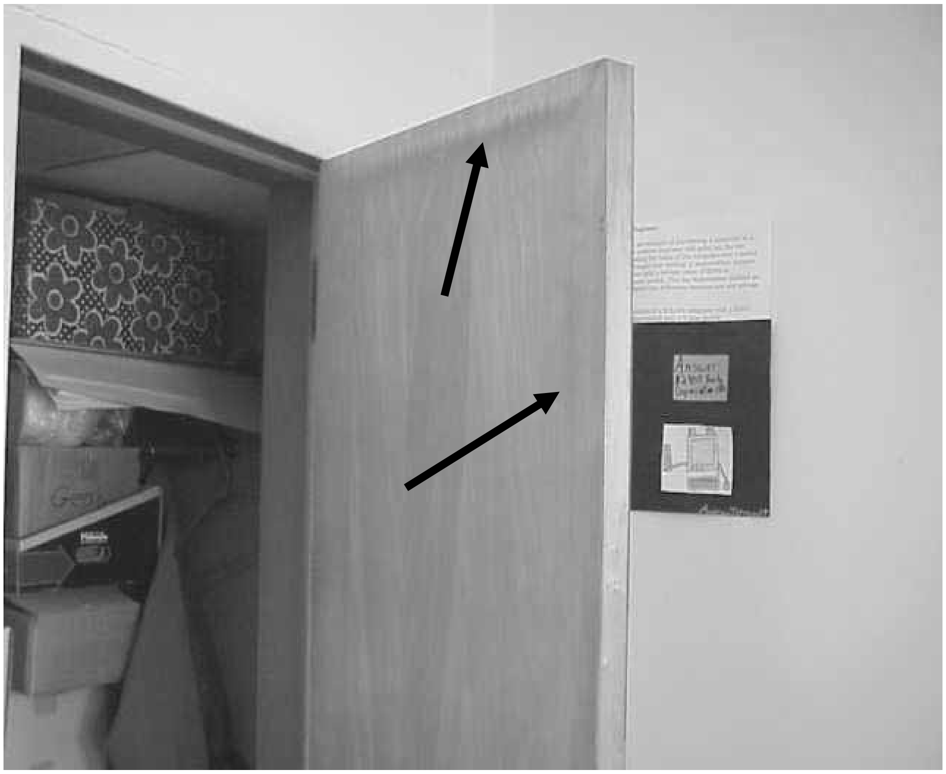


Exhaust Ventilation System in the 1959 Addition

Picture 4

Piled Materials Blocking Closet Passive Door Vent

Picture 5



Collected Dust on Edge of Classroom Door

Picture 6

Library AHU

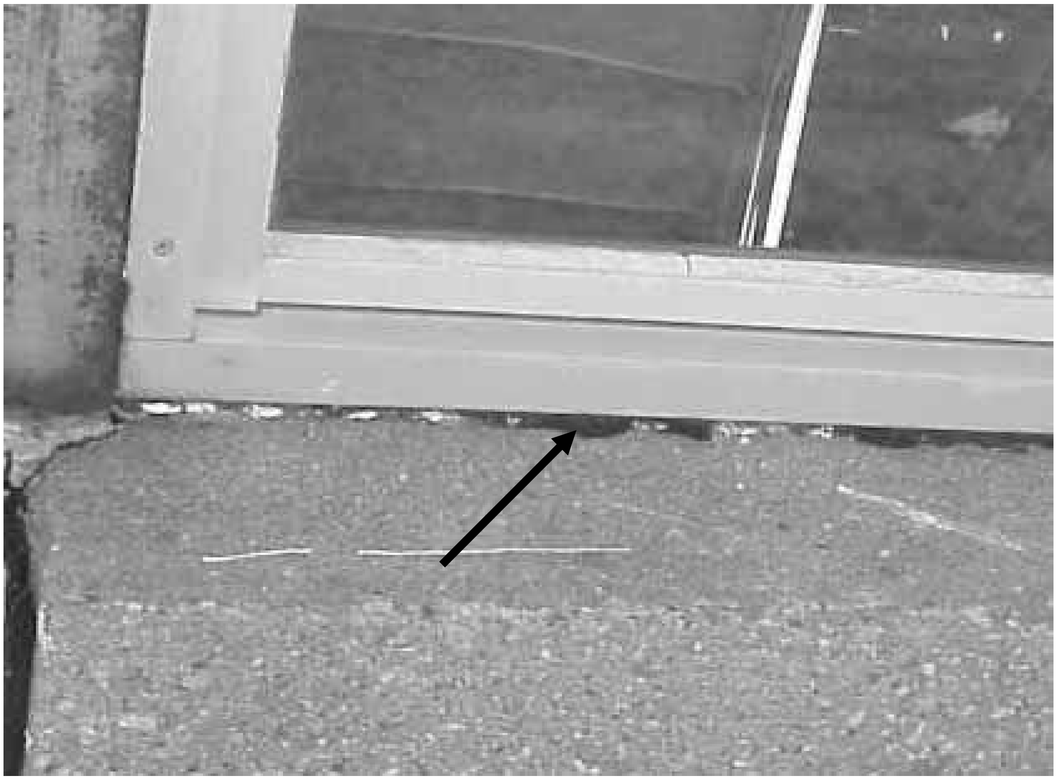
Picture 7

Eroded Window Caulking

Picture 8

Missing and Damaged Window Caulking

Picture 9



Moss Growing in Window Frame Seam

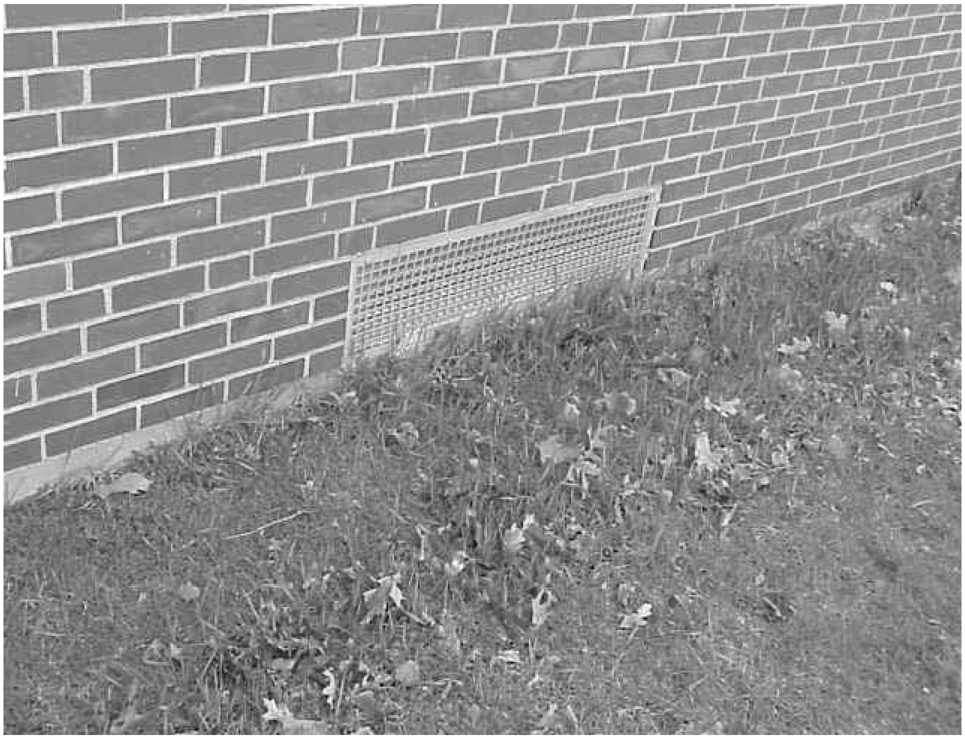
Picture 10

Shrubbery Growing against the School Exterior Wall

Picture 11

Corrosion of Shelf Support from Exposure to Stored Acids

Picture 12



Univent Fresh Air Intake Note Lawn Growth against Air Intake

TABLE 1

Indoor Air Test Results –Powder Mill Middle School, Southwick, MA – April 7, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	395	71	15					
Cafeteria	1235	75	24	50+	yes	yes (4)	yes	2 out of 4 univents on, exhaust off, 2 missing ceiling tiles, 1 CT, door open
Home Ec. Room	705	78	16	9	yes	yes	yes	univent off, accumulated dust on exhaust, 6 CT, water damaged sink 4-5, door open,
Arts & Crafts	525	73	17	2	yes	yes	yes	univent off-blocked by boxes, exhaust off-blocked, window and door open, 5 CT
Room 113	523	72	12	6	yes	yes	yes	univent blocked by plants/boxes, exhaust off, window and door open, chalk dust
Room 111	866	73	22	20	yes	yes	yes	broken exhaust grille, univent off-blocked, 10+ CT
Chemical Storage					yes	no	no	isopropyl denatured alcohol
Room 112	1132	74	23	23	yes	yes	yes	abandoned sink
Room 110	848	73	22	8	yes	yes	yes	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results –Powder Mill Middle School, Southwick, MA – April 7, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 109	919	74	22	16	yes	yes	yes	window open, chalk dust, 3 traps-abandoned sinks
Room 108	1030	74	22	17	yes	yes	yes	chalk dust
Room 107-Computer Room	854	75	21	20	yes	yes	yes	39 computers, Expo wipes, 2 ceiling tiles ajar
Room 104-Nurse's Office	823	72	21	2	yes	no	no	door open
Room 103	758	72	21	0	yes	yes	yes	univent blocked by table, exhaust off, door open
Room 101	1060	76	25	23	yes	yes	no	univent blocked by box, window open, wall crack
Library	489	74	14	3	no	yes	yes	ceiling plenum exhaust, 1 missing ceiling tile, 11 computers
Music Room	675	74	18	19	yes	yes (2)	yes	door vent exhaust, window and door open, wall crack
Room 1	742	73	17	18	yes	yes	no	window and door open, fiberglass, 1 ceiling tile ajar, chalk dust
Room 8 – 2nd Floor Lab	1484	74	25	21	yes	yes	no	chalk dust
Room 8	1189	74	25	21	yes	yes	yes	univent blocked by box/rack, exhaust blocked by cabinet, window open

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results –Powder Mill Middle School, Southwick, MA – April 7, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Team Room	1056	72	20	0	yes	no	no	blocked door vent
Room 4	1170	72	23	0	yes	yes	yes	univent off
Room 9	715	72	21	21	yes	yes	yes	univent and exhaust off, window and door open
Room 5	957	72	21	25	yes	yes	yes	exhaust off, 2 missing ceiling tiles, door open
Room 6	1681	72	27	20	yes	yes	yes	exhaust off-blocked by shelf, dry erase board, door open
Room 11	1202	72	25	27	yes	yes	yes	exhaust off, door open
Room 7	1185	72	24	15	yes	yes	yes	exhaust off-blocked by board, door open
Room 12A	1091	73	22	6	yes	no	no	door open
Gym	1128	72	31	40+	no	yes	yes	supply and exhaust off, ceiling fans
Room 211	963	75	23	19	yes	yes	yes	supply and exhaust off, plants near exhaust,
Room 209	804	75	20	1	yes	yes	yes	exhaust off

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results –Powder Mill Middle School, Southwick, MA – April 7, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 210	1466	76	23	23	yes	yes	yes	
Room 207	691	74	16	15	yes	yes	yes	window open, 1 ceiling tile ajar
Room 206	929	76	19	16	yes	yes	yes	univent off
Room 205	733	74	12	1	yes	yes	yes	exhaust blocked by boxes, window open
Room 203	881	74	19	11	yes	yes	yes	1 CT, chalk dust
Room 204	880	75	20	21	yes	yes	yes	water damaged windowframe, door open
Room 202	786	75	18	0	yes	yes	yes	
Main Office	563	74	15	2	yes	no	no	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

Table 5 **Operating Exhaust Vent Rooftop Motors**

Exhaust Vent Motor Activated (by number)
1
2
4
5
7
9
10
11
13
14
15
17
21
22
24
25
26
29

Table 6 **Non-Operating Exhaust Vent Rooftop Motors**

Exhaust Vent Motor Deactivated (by number)
3
6
8
12
16
18
19
20
26
27
28