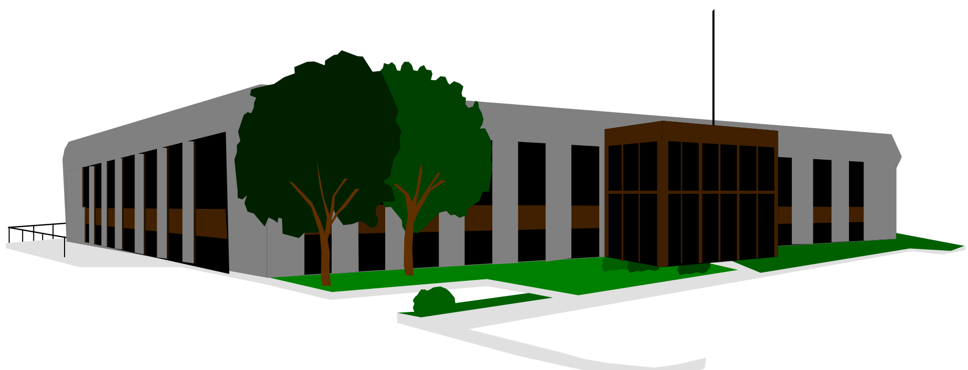
INDOOR AIR QUALITY REASSESSMENT

Wilbraham Middle School
Hampden-Wilbraham School District
Stony Hill Road
Wilbraham, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
March, 2000

Background/Introduction

At the request of the Wilbraham School Department, the Bureau of Environmental Health Assessment (BEHA) provided follow-up assistance and consultation regarding indoor air quality issues and health concerns at the Wilbraham Middle School (the school).

On January 7, 2000, a visit was made to this school by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Michael Messier, Wilbraham School Department Maintenance Supervisor. Accompanying Mr. Feeney for parts of the assessment were Jim Bisnette, Wilbraham Middle School Head Custodian, Lance Trevallion, Wilbraham Building Inspector, Deidre Barbeau, a parent representative from the school's indoor air quality committee, and Roy Brown, architect.

The school is a multilevel brick building constructed in 1968. The building is constructed on the side of a hill and consists of two sections: the front section and the back wing. The front section of the building, located on the uphill side, contains the school offices, wood shop, cafeteria, art room, auditorium, music room and gymnasium. The back wing second floor contains classrooms 1 through 12. The back wing first floor contains classrooms 13 through 26, including science rooms 18 and 19. Classrooms have openable windows.

Actions on Short Term Recommendations

BEHA previously made 18 recommendations to improve indoor air quality at the school (MDPH, 1999). School officials reported that they have acted on all of these recommendations that are in control of school department personnel. The following is a status report of action(s) on BEHA recommendations based on reports from school officials, documents, photographs and BEHA staff observations.

1. All univents were repaired and functioning.
2. Most exhaust vents in the building were functioning.
3. Blockages of airflow to univents (see Picture 1 for an example) and univent exhaust vents (see Picture 2 for an example) continue to exist in classrooms.
4. A concrete pad and drain system was installed beneath the concrete platforms and around the perimeter of the building to draw pooling water away from the base of the building (see Pictures 3 and 3A).
5. Work orders to rebuild the thresholds of the fire escape were commissioned. A caulking material was installed along the concrete slab and exterior wall junction (see Picture 4). A waterproofing compound was applied to the exterior of the brick wall.
6. Ceiling tiles were replaced above the first floor exits of the back wing.
7. The fiberglass insulation was removed from the window frame in classroom 9 (formerly classroom 19). The univent in this room was replaced.
8. The exterior of window systems throughout the school was sealed with a sealing compound (see Pictures 5 and 6).
9. Front hallway windows were repaired.
10. Moss was removed from window gaskets.
11. Pooled oil in the boiler room was removed and the oil leak was repaired. Weather stripping was installed on the boiler room doorframe to render the door airtight.

12. The interior wall/roof-decking joint above the art room ceiling was sealed with a foam material to prevent migration of odors from the boiler room (see Picture 7).
13. Shrubbery was removed from the fresh air intake for classroom 6 (formerly classroom 15) (see Picture 8). The vanes of the fresh air intake need to be cleaned with an appropriate antimicrobial.
14. The thermostat controlling the main room of the library was moved from the back office to the main room. Occupants report improved temperature control in the main room of the library.
15. Plants remain above univents in a number of classrooms. These plants should be removed from the close proximity of univents to prevent the aerosolization of particulates.
16. Chemicals were removed from the school.
17. No flammable materials were noted stored outside flameproof cabinets.

In addition to the implementing of recommendations, renovations also provided a new thermostat system installed throughout the school. As noted in the library, it appears that temperature control over the univents has been achieved.

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 Mannix, TH Pen PTH8708 Thermo-Hygrometer. Air tests for carbon monoxide were taken with the Responder Multigas Detector. Classrooms were renumbered subsequent to the previous indoor air quality assessment. Room numbers listed in Tables reflect the current numbering scheme of classrooms. Where possible, conditions noted in the previous indoor air quality assessment under the old numbering system will be matched to the new room numbering system.

Results

The school has a student population of approximately 650 and a staff of approximately 55. Tests were taken during normal operations at the school. Test results appear in Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million (ppm) in all occupied classrooms surveyed as well as the cafeteria and gymnasiums, which is indicative of an overall ventilation problem in the school. Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Figure 1). These univents were functioning in all classrooms. Obstructions to airflow, such as books, easels and plants stored on univents were seen in a number of classrooms.

The mechanical exhaust system in each classroom consists of unit exhaust ventilators installed in the exterior of classrooms. Several areas (such as science classrooms, cafeteria, library and gymnasiums) have ducted, grated wall vents. Small offices in the back wing have ceiling mounted exhaust vents. The exhaust systems were operating throughout the building with some exceptions (see Tables). Of note is that the unit exhaust ventilators were drawing minimal amounts of air. In order to remove stale air and environmental pollutants from classrooms, the draw of air by exhaust vents should be increased.

As reported by Wilbraham School Department officials, the exhaust vent for the large gymnasium is inoperable. The exterior casing of the exhaust vent appears to be heavily vandalized (see Picture 9). The exhaust vent is located on the gymnasium's exterior wall, over twenty feet off the ground. It is planned to have this vent repaired.

Of note is the configuration of the univents to the unit exhaust ventilators in classrooms. Both the univent and unit exhaust ventilator are located in the exterior wall in opposite corners (see Figure 2). This design requires the univent to propel air from the window towards the classroom hallway wall. The unit exhaust ventilator draws exhaust air. Both the univent and unit exhaust ventilator must propel/draw air with sufficient velocity to create airflow in parts of the classroom furthest from these vents. If impeded by obstructions, the ability of the HVAC system to create airflow throughout the classroom can be impeded (see Figure 3). In addition to increasing the airflow of this equipment, obstructions to airflow within the classroom should be minimized.

In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air. The purpose of balancing is to match the airflow produced by the fresh air supply (univents) with the amount of air drawn by the exhaust system in each room. Balancing of univents involves measuring the airflow into fresh air intakes as well as measuring the amount of air expelled by the fresh air diffuser. The date of the last balancing of these systems was not available at the time of the assessment.

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 (BOCA, 1993, SBBRS, 1997). 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 occurs 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 measurements were in a range of 69^{o} F to 73^{o} F, which were within the BEHA recommended comfort range in most areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° 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. Prior to this evaluation, a new thermostat system was installed in the building to better control temperature in classrooms. School officials report difficulty in heating classrooms with univent fresh air dampers set at 20 percent open. School maintenance staff has decreased fresh air intake to improve the ability of the univents to provide heat. This restriction of airflow will reduce the amount of fresh air distributed into classrooms, which in combination with the limited function of the unit exhaust ventilators, can lead to the elevated carbon dioxide levels measured in the building.

As reported by school officials, a number of building occupants report cold temperatures. Of note in a number of classrooms is the positioning of teachers' desks in the air stream created by univents and exhaust ventilators. Univents have vents in the base of the casing which draw air (called return air) from the classroom. Exhaust ventilators draw classroom air through vents located approximately 3 feet above the floor. In both cases, the placing of desks in front of these vents places the individual in the air stream, which can influence the person's perception of overall temperature. Removing desks from the air stream of this equipment can improve comfort issues related to temperature in classrooms.

The relative humidity in the building was within a range of twenty to twenty-seven percent, which is below the BEHA recommended comfort range in all areas sampled. The BEHA recommends a comfort range of forty to sixty percent for indoor air relative humidity. Relative humidity levels in the school would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Mold odors noted in the lower classroom in the previous assessment were not present during this assessment. The installation of the drain system around the perimeter of the back wing, repair of seals on window systems and replacement of the univent in classroom 9 (formerly classroom 19) have served to reduce or eliminate the penetration of water into the interior of the building. With the restriction of water into the building, mold growth will be inhibited.

Water damaged ceiling tiles were noted in classrooms that are immediately adjacent to the cement platforms at each end of the back wing. Each of these platforms are supported by steel I-beams that project from the interior of the building through the exterior wall. The corrosion of steel on these beams indicates that water is penetrating to the interior of the building along these beams (see Picture 10). As water moves along beams, water droplets form, which moisten the ceiling tiles. Water also appears to be penetrating through the door threshold at the cement slab. Steel joists beneath the threshold were also corroded, indicating water penetration.

Efflorescence (i.e., mineral deposits) was observed on the brickwork on the interior of exterior walls of classrooms 16 and 17 (formerly classrooms 24 and 25). Efflorescence is a characteristic sign of water intrusion, but it is not mold growth. As moisture penetrates and works its way through mortar around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As this solution moves to the surface of the brick or mortar, the water evaporates, leaving behind white, powdery mineral deposits. With the application of waterproofing compound to the exterior of this wall and the installation of the drainage system, the amount of water working its way into these classrooms should be reduced. These mineral deposits may be a sign of water trapped in brick or mortar after the water sealing of the exterior wall. Of note is the elimination of the musty odor noted in these classrooms, which indicates that this water penetration through this wall has been reduced or eliminated.

Some classrooms continue to have plants located over univent fresh air diffusers or over heating registers (see Picture 11). Airflow created by the ventilation/heating system can result in the aerosolization of pollen, dust, dirt, spores or other particulates. Moistened plant soil and drip pans can serve as a source of mold growth. A mold odor was traced to carpet squares and cloth beanbags in the corner of a classroom (see Picture 12). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials (e.g., carpeting) be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth.

Classroom 20 (formerly classroom 2) has an animal cage containing a rabbit placed on the carpeted floor. While the rabbit cage is well maintained, wood shavings from the cage were found on the carpet outside the cage (see Picture 13). Carpeting can absorb animal wastes and can be a reservoir for mold and bacterial growth. Animal dander, fur and wastes can all be sources of respiratory irritants.

Other Concerns

As recommended, shrubbery around the fresh air intake of classroom 6 (formerly 15) was removed. In order to ascertain the condition of fresh air intakes, the fresh air intake grille (see Picture 14) was removed. The interior of this vent contained leaves, dirt and other normal outdoor debris (see Picture 15). No unusual contamination was noted on the inside of this univent. Univents 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 in univents. 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 dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (ASHRAE, 1989). Note that increased filtration can reduce airflow produced by the univent by increasing resistance. Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer as to whether the univent can maintain function with more efficient filters.

Concerns about exhaust odors/products of combustion penetrating into occupied areas of the building were expressed by building occupants. The combustion of fossil fuels produces a number of pollutants, including carbon monoxide. Air testing to determine if carbon monoxide was present in the school was conducted throughout the building. Carbon monoxide levels were measured in the audio-visual room fifteen minutes prior to dismissal in order to ascertain if vehicle exhaust was being entrained by the fresh air intake of this classroom. Carbon monoxide was not detected in any room in the building, including during student bus pickup in the afternoon. Please note that Chapter 90 section 16A of the General Laws of Massachusetts prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (M.G.L., 1986).

Concerns were raised by building occupants about the presence of asbestos in classroom dividers. Requests were made to school officials to drill samples to determine if asbestos is in the core of these dividers. Intact asbestos-containing materials do not pose a health hazard. If damaged, asbestos-containing materials can be rendered friable and become aerosolized. Friable asbestos is a chronic (long-term) health hazard, but will not produce acute (short-term) health effects (e.g., respiratory symptoms, headaches, etc.) that are associated with buildings that are believed to have indoor air quality problems. Pursuant to the Asbestos Hazard Emergency Response Act (AHERA), school systems are required to examine asbestos containing materials on a three-year cycle for signs of friable dust or damage (US EPA, 1988). Where asbestos-containing materials are found damaged, these materials should be removed in a manner consistent with Massachusetts asbestos remediation laws (MDLI, 1993). Sampling of these dividers using a drill is not advisable since this method can result in the aerosolization of asbestos if present. To determine if these dividers contain asbestos, a review of the school's AHERA plan, blueprints, purchase orders or contacting the manufacturer is recommended. School officials reported that removal of old carpeting is planned. It was also reported that floor tiles may contain asbestos. As noted previously, materials containing asbestos do not pose a health threat if intact (in a non-friable state). Please note that carpet cannot be readily removed if glued to asbestos-containing tile. If asbestos-containing tile exists under the old carpeting, all relevant precautions to prevent the aerosolization of asbestos from the floor tiles must be taken.

A number of the science classrooms have aquarium-like equipment attached to drains with traps (see Picture 16). It is likely that these drains have dry traps, which can allow for sewer gas to back up into classrooms. A sewer gas vent pipe located on the roof was found in close proximity to a fresh air intake. Sewer gas vent pipes should be located away from or extended above air handlers to avoid entrainment of sewer gas odors into fresh air intakes. The building code requires that exhaust vents be located at a minimum 10 feet away from or 2 feet above a fresh air intake (SBBRS, 1997; BOCA, 1993). Sewer gas can be an eye, nose and respiratory irritant.

The wood shop contains a number of wood dust generating machines that are connected by ductwork to a wood dust collection system. Flexible hose connecting this local exhaust system was partially disconnected, which can result in aerosolization of wood dust. Wood dust can be an irritant to the eyes, nose and throat. Welding equipment was also found in this area. Welding produces metal fumes, which should be exhausted from the interior of the building with local exhaust ventilation. Welding fumes have occupational limits. OSHA has established Permissible Exposure Limits (PELs) (OSHA, 1997) and ACGIH has established Threshold Limit Values (TLVs) (ACGIH, 1999) for various metal fumes. An evaluation of the contents of the material producing fumes must be done in order to ascertain which PEL or TLV applies in this situation.

Conclusions/Recommendations

BEHA staff confirmed that the Wilbraham School Department implemented a number of the recommendations made in our previous report. The renovations conducted by the Wilbraham school department to seal window systems, remove water damaged materials and improve drainage around the perimeter of the building have reduced/eliminated water penetration into the interior of the building. These actions have eliminated detectable musty odors that were noted by BEHA staff during the previous assessment. In addition, the sealing of the interior wall/roof decking space between the art room and boiler; the installation of weather stripping of the boiler room door; cleaning and repair of the boiler oil leak; and replacement of ceiling tiles have eliminated the migration of boiler room odors into occupied space. The installation of a new temperature control system was necessary to gain control of the operation of the HVAC system. Each of these actions has improved the overall indoor air quality at the school.

As indicated by air testing and BEHA staff observations, a number of additional steps can be taken to further improve indoor air quality at the school. In view of the findings at the time of the visit, the following additional recommendations are made:

1. The draw of fresh air by univents should be increased. As noted previously, the percentage of fresh air to return air in univents has been gradually decreased in order to provide sufficient heat to classrooms. In order to increase fresh air to classrooms, an increase in the temperature of the heating coils may be necessary. Consideration should be given to consulting an HVAC consultant to increase the ability of heating coils to warm univent air.

2. The draw of classroom air by exhaust vents needs to be increased to provide adequate airflow in classrooms. The amount of air drawn by the exhaust vents should roughly be equal to the amount of air produced by the univent.
3. As noted in our previous report, all blockages from univents and exhaust ventilators must be removed to ensure adequate airflow.
4. In order to increase thermal comfort, move teachers' desks away from the air stream of HVAC equipment.
5. Examine methods to eliminate water penetration through exterior walls along steel I-beams and the door threshold of the cement platforms. Examine the paper material adhered to the floor decking above the ceiling beneath the cement platform door threshold. Remove moldy materials. Examine nonporous materials beneath the paper material and disinfect with an antimicrobial agent. Replace water damaged ceiling tiles.
6. As suggested by Mr. Trevallion, consider installing a canopy over the cement platform to direct rainwater away from the base of the platform.
7. Clean the efflorescence in classrooms 15 and 16 (formerly 24 and 25) from brickwork. Monitor this wall after rainstorms for the development of new deposits of efflorescence.
8. Remove debris from the interior of univent fresh air intakes. Each of these vents should be examined periodically and cleaned of debris. Clean vanes of fresh air intake for classroom 6 with an appropriate antimicrobial.
9. Continue with plans to repair the large gymnasium exhaust vent.
10. Seal abandoned drains in science classrooms.

11. Move the rabbit cage to a room with a water impermeable surface that can be easily cleaned.
12. Extend the height of the sewer vent pipe on the roof to prevent odor entrainment.
13. Move plants away from univents and heat registers in classrooms. Examine drip pans for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants in certain areas.
14. Reconnect flexible hose in woodshop to the wood dust collection system.
15. Provide adequate mechanical local exhaust ventilation for welding. This system should be designed in a manner in conformance with the recommendations of the ACGIH for adequate ventilation for welding operations (ACGIH, 1998).
16. Examine the classroom dividers as part of the required AHERA three-year inspection. If asbestos is in a friable state, remove the damaged material in a manner consistent with Massachusetts asbestos remediation and hazardous waste disposal laws.
17. Prior to removal, determine if classroom carpets are adhered to asbestos-containing floor tile. If found to contain asbestos, carpet removal must be done in a manner consistent with Massachusetts asbestos remediation and hazardous waste disposal laws.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ACGIH. 1999. Guide to Occupational Exposure Values-1999. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

MDPH. 1999. Indoor Air Quality Assessment Wilbraham Middle School, Wilbraham, MA. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA.

MDLI. 1993. Regulation of the Removal, Containment or Encapsulation of Asbestos, Appendix 2. 453 CMR 6,92(I)(i).

MGL. 1986. Stopped motor vehicles; Operation of Engine; Time Limit; Penalty. Massachusetts General Laws. M.G.L. c. 90:16A.

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.

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

US EPA. 1988. Asbestos-In-Schools: A Guide to New Federal Requirements for Local Education Agencies. US Environmental Protection Agency, Office of Toxic Substances, Washington, DC.

Figure 2 **Design of Airflow in Classroom**

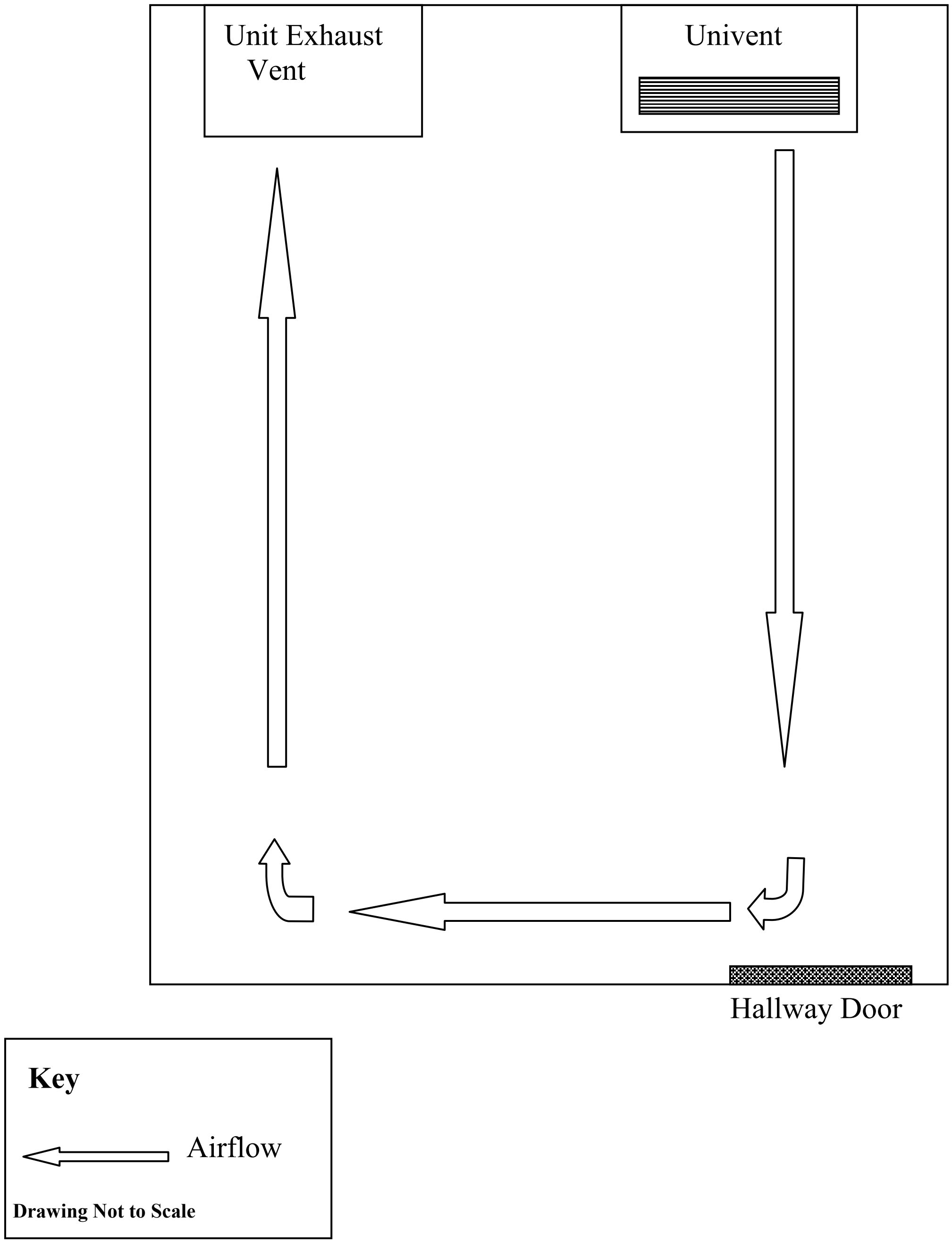
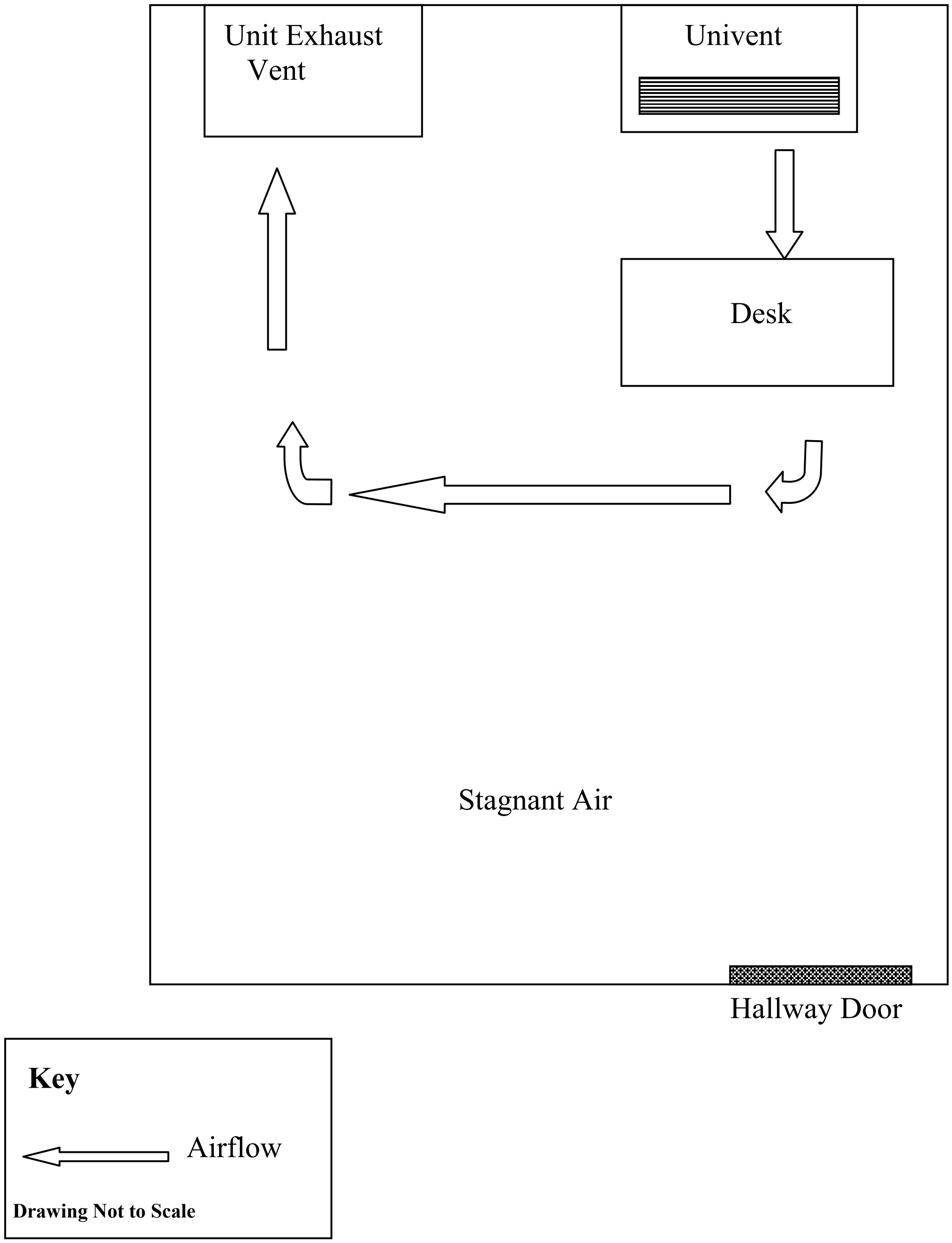


Figure 3 **Design of Airflow in Classroom**



Picture 1

Univent Blocked with Free-Standing Bulletin Board

Picture 2

Return Vent of Unit Exhaust Ventilator Blocked with Student Desk

Picture 3

Concrete Pad

Concrete Pad Installed around the Perimeter of the Lower Wing

Picture 3A

Concrete Pad Installed beneath the Concrete Platform

Picture 4

Sealant Applied To Door Threshold, Concrete Slab and Exterior Wall Junction

Picture 5

Caulking

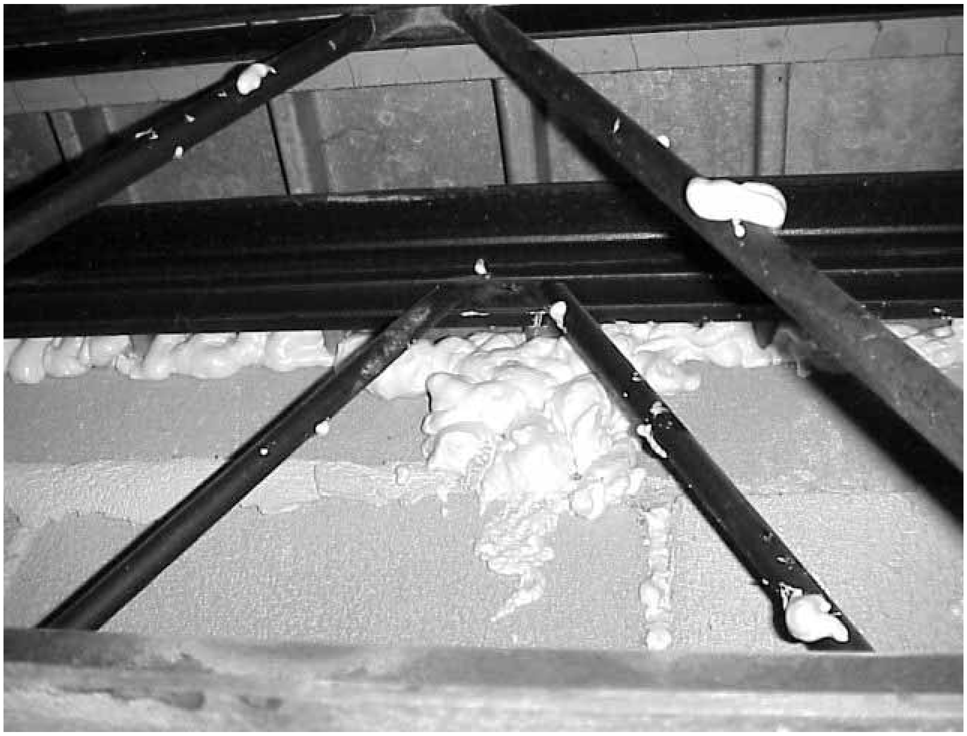
Example of Caulking Applied to Exterior Wall/Window Frame Seam

Picture 6

Caulking

Example of Caulking Applied to Interior Wall/Window Frame Seam

Picture 7



Foam Sealant Applied to Roof Decking/Wall Junction of Shared Wall of Art Room and Boiler Room

Picture 8

Shrubbery Was Removed From The Fresh Air Intake For Classroom 6 (Formerly Classroom 15)

Picture 9

Vandalized Gymnasium Exhaust Vent Cover

Picture 10

Corrosion of Steel Beams from Water Penetration through Seams around Concrete Platforms

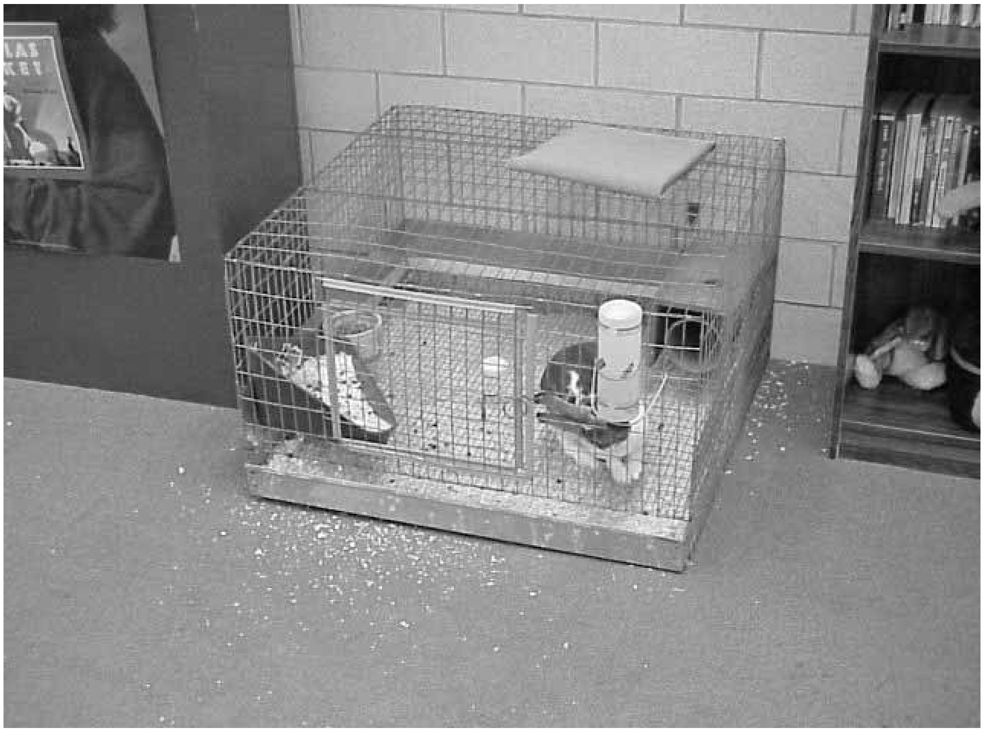
Picture 11

Plants Over Univent Air Diffuser

Picture 12

Carpet Squares and Bean Bags With Musty Odor

Picture 13



Shavings from Rabbit Cage on Carpeting

Picture 14

The Fresh Air Intake Grille (See Picture 14) Was Removed From Exterior Of Classroom 6 (Formerly Classroom 15)

Picture 15

Leaves, Dirt and Other Normal Outdoor Debris behind Fresh Air Intake Louver Of Classroom 6 (Formerly Classroom 15)

Picture 16

Aquarium-Like Equipment Attached To Drains with Traps

TABLE 1

Indoor Air Test Results –Wilbraham Middle School, Wilbraham, MA – January 7, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	425	46	41					
Food Lab	1060	72	20	13	yes	yes	yes	3 CT, 2 gas stoves
Room 27	1958	71	27	24	yes	yes	yes	univent blocked by books
Room 28	1603	70	25	23	yes	yes	yes	door open
Room 29	1486	72	25	17	yes	yes	yes	exhaust off, door open
Room 30	1475	71	25	18	yes	yes	yes	univent blocked, exhaust off, door open
Room 31	1061	69	24	20	yes	yes	yes	window open
LC 7	1112	70	22	5	yes	yes	yes	door open
Room 26	1270	70	24	20	yes	yes	yes	1 CT, dead plant, door open,
Room 25	1380	71	22	22	yes	yes	yes	exhaust off-no draw, door open
Room 24		72	23	19	yes	yes	yes	univent & unit exhaust ventilator blocked by desk, window & door 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 2

Indoor Air Test Results –Wilbraham Middle School, Wilbraham, MA – January 7, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 23	1394	72	27		yes	yes	yes	exhaust blocked by desk, door open
Room 20	1509	72	21	12	yes	yes	yes	unit exhaust blocked, rabbit
Room 10	882	73	21	25	yes	yes	yes	new univent, exhaust off, plant – fiberglass, door open
Room 10 Storeroom								dry drain
Room 9	1019	72	21	20	yes	yes	yes	univent blocked by easel-HEPA filter, plant, door open,
Room 8	1294	71	24	20	yes	yes	yes	HEPA filter
Room 7	1328	71	25	19	yes	yes	yes	1 CT
Room 6	1547	72	26	20	yes	yes	yes	
Room 5	1111	71	22	20	yes	yes	yes	door open
Cafeteria	1075	72	22	200+	yes	yes	yes	
Woodshop	692	70	18	12	yes	yes	yes	exhaust-open duct, door open

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TABLE 3

Indoor Air Test Results –Wilbraham Middle School, Wilbraham, MA – January 7, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
FOCUS	1085	70	22	21	yes	yes	yes	
Computer Room	821	73	19	21	yes	yes	yes	plant on univent, door open
Library	561	73	14	1	no	yes	yes	
Room 17	1209	71	24	21	yes	yes	yes	
Room 16	1334	70	24	19	yes	yes	yes	1 CT-mold, efflorescence
Room 15	1486	73	24	25	yes	yes	yes	
Room 14	1431	72	24	19	yes	yes	yes	
Room 13	1418	72	25	19	yes	yes	yes	
Room 12	1431	71	24	20	yes	yes	yes	univent blocked by box, open pipe
Room 11	781	69	20	16	yes	yes	yes	new univent, holes in floor, door open
Room 19	899	69	23	0	yes	yes	yes	door open

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TABLE 4

Indoor Air Test Results –Wilbraham Middle School, Wilbraham, MA – January 7, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Band Room	1138	71	25	23	yes	yes	yes	
Room 3	1168	71	23	22	yes	yes	yes	
Small Gym	686	72	16	19	no	yes	yes	
Large Gym	925	72	20	17	no	yes	yes	
Room 1	893	72	18	6	no	yes	no	
Professional Library 1	749	73	17	5	no	yes	yes	
Professional Library 2	713	72	16	0	no	yes	yes	
Room 18	1167	72	21	16	yes	yes	yes	
Art Room	1212	72	22	18	yes	yes	yes	
Boiler Room								pooling oil

*** ppm = parts per million parts of air**
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