INDOOR AIR QUALITY ASSESSMENT

John Greenleaf Whittier School
256 Concord St
Haverhill, MA 01830

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
May 2005

Background/Introduction

At the request of Jeffrey Dill, Supervisor of Maintenance and Energy Management, Haverhill Public Schools (HPS), the Massachusetts Department of Public Health (MDPH)'s Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at the John Greenleaf Whittier Middle School (WMS), 256 Concord Street, Haverhill, Massachusetts. On December 17, 2004, a visit to conduct an indoor air quality assessment was made to this school by Sharon Lee, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program.

The WMS is a single-story brick building constructed in 1957. The school consists of classrooms, offices, a gymnasium, an art room, a library, a cafeteria, a music room and a computer lab. Windows throughout the window are openable.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). MDPH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 425 sixth through eighth grade students and approximately 40 staff members. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) of air in 20 of 30 areas surveyed, indicating inadequate air exchange in the majority of areas surveyed. It is important to note that some areas were empty or sparsely populated at the time of assessment, which can greatly reduce carbon dioxide levels. In addition, mechanical ventilation components were not operating in many classrooms.

Fresh air in classrooms is mechanically provided by unit ventilator (univent) systems (Picture 1). A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building (Picture 2) and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents were not operating in many classrooms at the time of the assessment. Obstructions to airflow, such as desks and other items located on or in front of univents, were also observed. To function as designed, univents must be allowed to operate and remain free of obstructions.

Exhaust ventilation is provided by wall- or cabinet-mounted exhaust vents (Picture 3), which are ducted to motorized fan units. Exhaust vents were off, drawing weakly, back-drafting and/or blocked with materials in a number of classrooms surveyed (Picture 4). As with the univents, exhaust vents must be allowed to operate and remain free of obstructions. In addition, the location of some exhaust vents near hallway doors can limit exhaust efficiency (Picture 5). When classroom doors are open, exhaust vents will tend to draw air from both the hallway and the classroom reducing the effectiveness of the exhaust vent to remove common environmental pollutants.

To maximize air exchange, the MDPH recommends that ventilation equipment operate continuously during periods of school occupancy. 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 from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last servicing and balancing was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (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 MDPH 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. For more information concerning carbon dioxide, please see Appendix A.

The temperature measurements ranged from 72^{o} F to 81^{o} F, which were within or slightly above the MDPH recommended comfort guidelines (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 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. In addition, temperature control is often difficult without operating the ventilation systems as designed (e.g., univents/exhaust vents deactivated/obstructed).

The relative humidity measurements ranged from 13 to 36 percent, which were below the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. The sensation of dryness and irritation is common in a low relative humidity environment. Relative humidity levels in the building would be expected to drop during the winter months due to heating. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of rooms had water-stained ceiling tiles (Picture 6). An active leak was observed in the hallway outside of the nurse's office, where a plastic trash bag was being used to divert water into a trash barrel (Picture 7). Water damaged wood was also observed around skylights. WMS staff indicated leaks are primarily related to roof damage. Water-damaged ceiling tiles can provide a source of mold growth and should be replaced after a water leak is discovered and repaired. Appropriate measures should also be taken to minimize the aerosolization of particulates from tile removal/replacement.

The American Conference of Governmental Industrial Hygienists (ACGIH) and United States Environmental Protection Agency (US EPA) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If items are not dried within this time frame, mold growth may occur. The application of a mildewcide to mold colonized porous materials is not recommended.

Condensation was noted on windows in classroom 5 (Pictures 8 and 9). These windows consist of single panels of glass framed with metal. One window in this classroom was slightly ajar. As a result, cold air was infiltrating the heated classroom. Since the room is heated by a univent that is located below the metal framed window system, heat generated by the univent is conducted throughout the window system by the metal frame. In addition, sunlight hitting the window also warms the metal frame. When the outdoor air comes in contact with the window, condensation forms. Overtime, chronic condensation formation and subsequent moistening has resulted in damage to the exterior window frame (Picture 10). Materials placed close to such windows were also observed to be water damaged (Picture 11). Water damaged materials should be removed and discarded. Occupants should also refrain from placing porous materials near these windows.

A number of other conditions observed along the building exterior may be conducive to water penetration through the building envelope. Spaces were noted around window frames (Picture 12). These breaches can allow moisture to penetrate the building. Such spaces should be sealed to prevent water damage to the interior of the building.

Clinging plant growth was observed on some exterior walls (Picture 13). Clinging plants can cause damage to brickwork through the insertion of tendrils into brick and mortar. Water can penetrate into the brick along the tendrils, which can subsequently freeze and thaw during the winter. This freezing/thawing action can weaken bricks and mortar, resulting in damage. This type of plant growth on brickwork is not recommended.

Shrubbery and other plants were also observed to be growing in cracks and crevices in close proximity to the foundation walls (Picture 14). The growth of roots against the exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Plants were noted in several classrooms. Plants should be properly maintained and equipped with drip pans. Some plants were placed near ventilation sources (Picture 15), while others were placed on carpeting (Picture 16). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should not be placed directly on carpeting and be located away from univent air diffusers to prevent the aerosolization of dirt, pollen or mold.

Other Concerns

Indoor air quality can also be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

The US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, the US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 19 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors were in a range of 4 to 36 $\mu g/m^3$. Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can also generate particulates during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system; cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products. While no TVOC levels measured exceeded background levels, materials containing VOCs were present in the school. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

A floral odor was detected upon entering library. MDPH staff observed potpourri and ornamental lights in a glass container. Excess heat produced by the lights is likely magnifying the potpourri scent. These odors may be irritating to sensitive individuals. More importantly, placing such lights with potpourri may be a fire hazard. Occupants should refrain from this practice. Also of concern are unlabelled bottles and containers of which the contents were unclear. Products should be kept in their original containers and be clearly labeled for identification purposes, especially in the event of an emergency.

Several other conditions that can affect indoor air quality were noted during the assessment. Crawlspaces function as chaseways for pipes to traverse a building. At the time of the assessment, occupants from the music/drama room reported odors from the crawlspace below. A crawlspace access door with an opening was observed in the room (Picture 17). This opening can allow for crawlspace odors to migrate to occupied areas. MDPH staff randomly examined some univents, since pipes running through the crawlspace connect the boiler to classroom univents. Spaces and holes were observed around pipes and within the air handling cabinet (Picture 18). Breaches were also noted around other pipes that also run into the crawlspace (Picture 19). Heated air from HVAC system pipes can create drafts that rise from the crawlspace into classrooms. These drafts can also draw crawlspace-associated odors and particles into occupied areas.

A number of exhaust/return vents, univent supply vents and personal fans were noted with accumulated dust (Picture 3). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles. Re-activated univents and fans can also aerosolize dust accumulated on vents/fan blades. Excessive chalk dust was also noted in chalk trays of some classrooms. Chalk can become easily aerosolized and serve as an eye and respiratory irritant. To prevent dust aerosolization, a wet cloth should be used to clean the chalk trays regular.

Several window-mounted air conditioners (ACs) were installed in offices. These units are normally equipped with filters, which should be cleaned or changed as per the manufacturer's instructions. MDPH staff removed the covers of several ACs to examine the interior of the units and found filters and the cooling fins occluded with dust and debris (Picture 20). In order to prevent the equipment from serving as a source of aerosolized particulates, MDPH staff recommended changing/installing filters and cleaning the air handling sections of the ACs *prior to re-activation*.

Lastly, a bird's nest was noted near a column supporting the entryway roof (Picture 21). Signs of bird roosting was also noted in recessed areas around the exterior of the building. Birds can be a source of disease, and bird wastes and feathers can contain mold, which can be irritating to the respiratory system. Certain molds are associated with bird waste and are of concern for immune-compromised individuals. Other diseases of the respiratory tract may also result from chronic exposure to bird waste. Exposure to bird wastes is thought to be associated with the development of hypersensitivity pneumonitis in some individuals. Psittacosis (bird fancier's disease) is another condition closely associated with exposure to bird wastes in either the occupational or bird rearing setting. While immune-compromised individuals have an increased risk of health impacts following exposure to the materials in bird wastes, these impacts may also occur in healthy individuals exposed to these materials.

The methods employed for cleaning of a bird waste problem depend on the amount of waste and the types of materials contaminated. The MDPH has been involved in several indoor air investigations where bird waste has accumulated within ventilation ductwork (MDPH, 1999). Accumulation of bird wastes have required the clean up of such buildings by a professional cleaning contractor. In less severe cases, the cleaning of the contaminated material with a solution of sodium hypochlorite has been an effective disinfectant (CDC, 1998). Disinfection of non-porous materials can be readily accomplished with this material. Porous materials contaminated with bird waste should be examined by a professional restoration contractor to determine whether the material is salvageable. Where a porous material has been colonized with mold, it is recommended that the material be discarded (ACGIH, 1989).

Conclusions/Recommendations

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

1. Examine each univent for function. Operate univents while classrooms are occupied. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
2. Examine exhaust vents for function and make repairs as necessary.
3. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.
4. Remove all obstructions from univents and exhaust vents to facilitate airflow. Close classroom doors to improve air exchange.
5. Remove debris and dust accumulated on the ventilation grilles.
6. Consult a ventilation engineer concerning re-balancing of the ventilation systems and the calibration of univent fresh air control dampers throughout the school. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).

7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
8. Identify and repair sources of water leaks. Replace water-damaged ceiling tiles. These ceiling tiles can be a source of microbial growth. Examine the non-porous surface beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial. Appropriate measures should also be taken to minimize the aerosolization of particulates from tile removal/replacement.
9. Ensure windows are closed during cooler months to prevent condensation generation on windows. Remove porous materials placed near windows to prevent water damage to these items. Discard water-damaged porous materials (e.g. paper).
10. Examine plants in classrooms for mold growth in water catch basins. Disinfect water catch basins if necessary. Remove plants from ventilation sources and carpeted areas.
11. Remove plants growing against building and its foundation to prevent water intrusion through brickwork.
12. Consider repointing or recaulking around windows.
13. Ensure doors leading crawlspace remain closed to prevent the movement of odors and materials into occupied areas. Consider using a rubber stopper to plug the hole in the crawlspace access door.

14. Seal breaches around pipes and other spaces leading to the crawlspace to prevent movement of crawlspace odors and particles.

15. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

16. Consider adopting the US EPA document, *Tools for Schools* (US EPA, 2000b), as a means to maintaining a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

17. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://www.state.ma.us/dph/beha/iaq/iaqhoFtme.htm.

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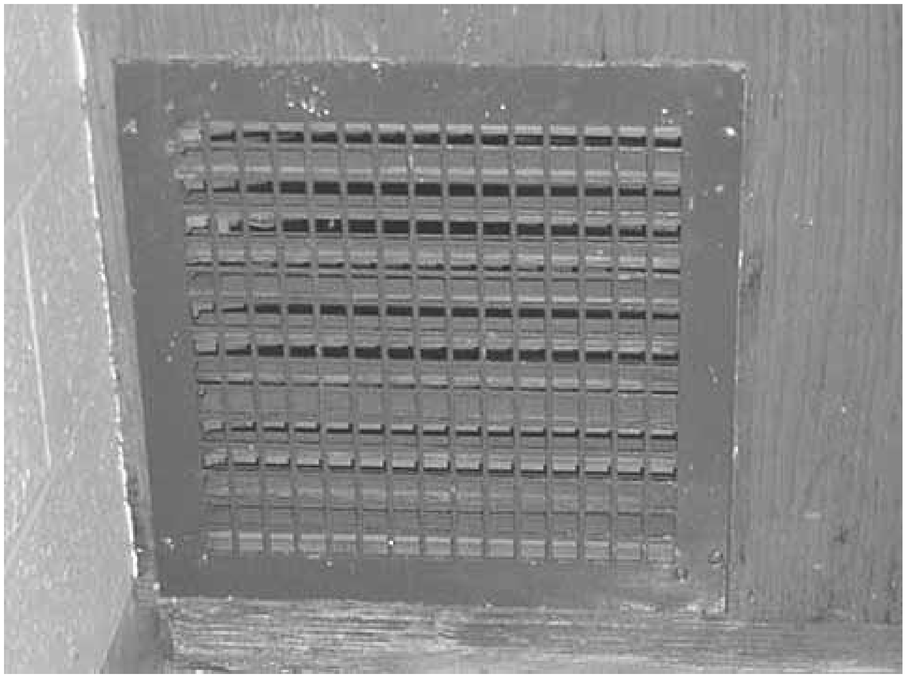
Picture 1

Classroom univent

Picture 2

Univent fresh air intake

Picture 3



Classroom exhaust

Picture 4

Blocked exhaust vent

Picture 5

Exhaust vent proximity to door

Picture 6

Water damaged ceiling tiles

Picture 7

Missing ceiling tile for water drainage to bucket

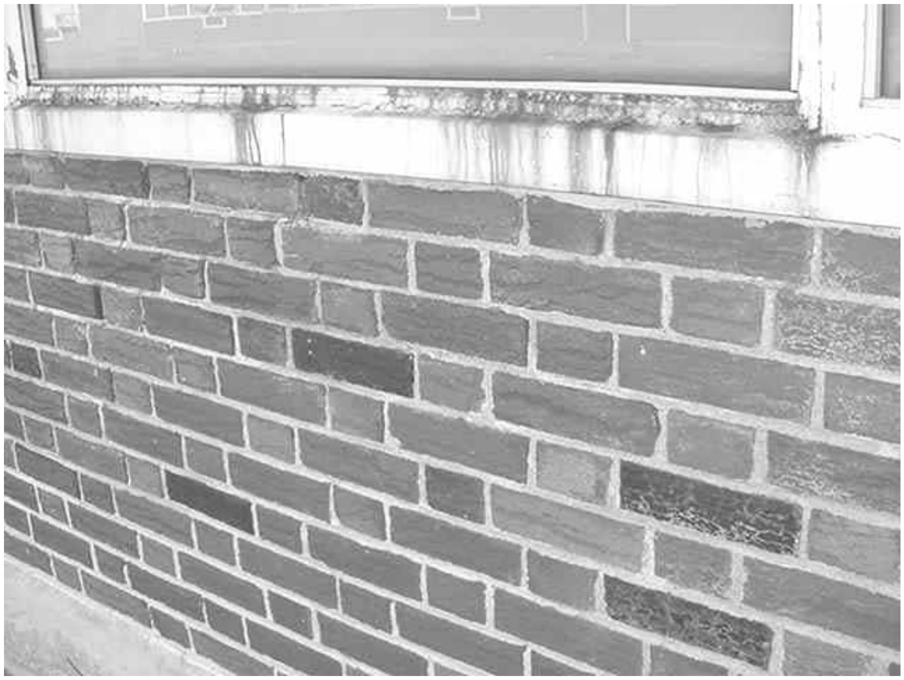
Picture 8

Interior view of condensation on classroom window

Picture 9

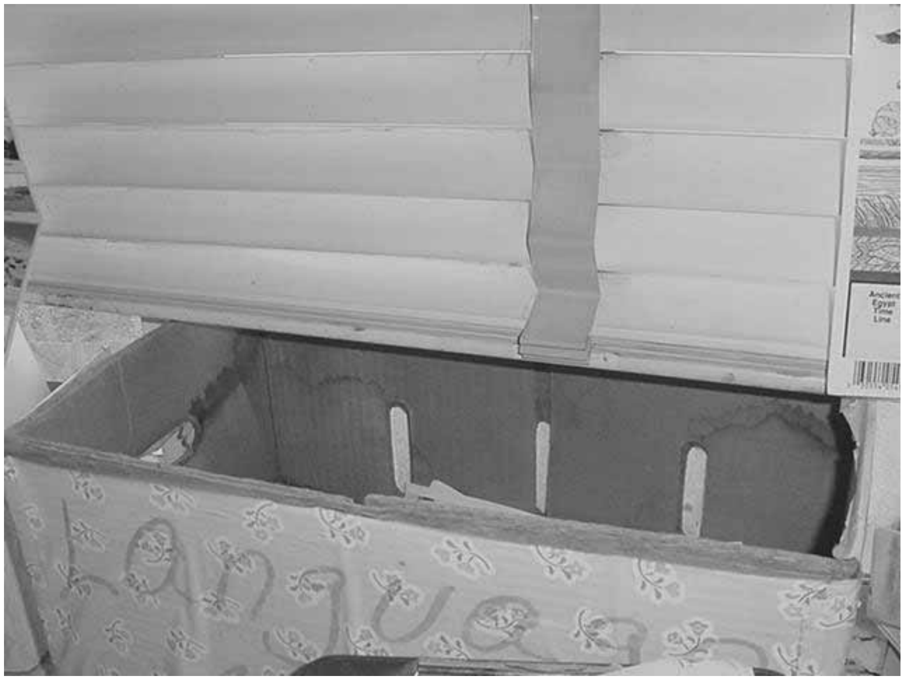
Exterior view of condensation on classroom window

Picture 10



Water damage to exterior of window frame

Picture 11



Water damaged materials

Picture 12

Spaces around window frame

Picture 13

Clinging plant growth against building

Picture 14

Plant growth against building

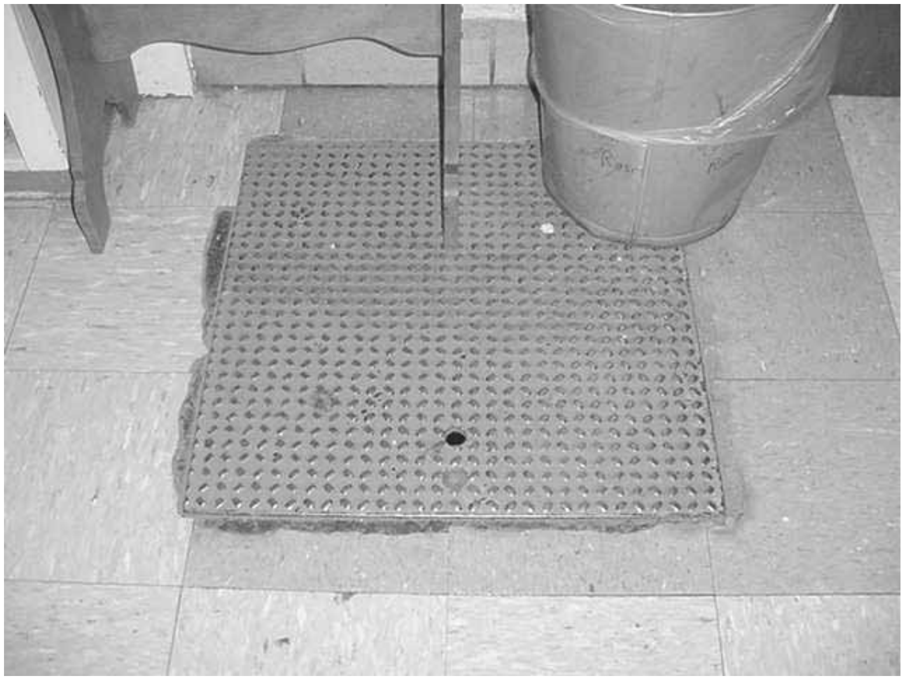
Picture 15

Plants placed near ventilation univent, note debris

Picture 16

Plant placed on carpeting

Picture 17



Crawlspace access door

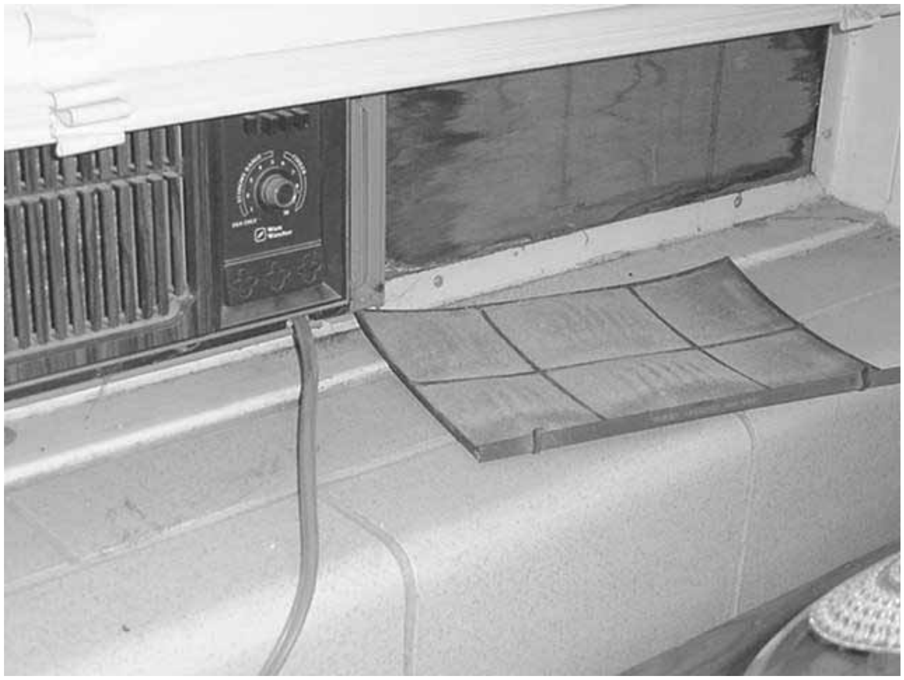
Picture 18

Spaces around pipes in univent air handling cabinet

Picture 19

Spaces around pipes

Picture 20



Air conditioner filter occluded with debris

Picture 21

Bird’s nest in support beam

John Greenleaf Whittier School **Indoor Air Results**

256 Concord St., Haverhill, MA 01830 **Table 1** **December 17, 2004**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background		51	43	422	ND	ND	19				Comments: overcast, slight wind.
Adjustment Counseling Office	0	78	29	765	ND	ND	16	N # open: 0 # total: 0	N	Y wall (off)	Hallway DO, PF, Comments: passive door vent.
art	22	75	29	793	ND	ND	13	Y # open: 0 # total: 6	Y univent	Y wall	Hallway DO, kiln, CD, DEM, items, FC re-use.
cafeteria	150	77	25	1063	ND	ND	19	Y # open: 0 # total: 8	Y ceiling	Y wall (weak)	Hallway DO,

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

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%

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Table 1

Indoor Air Results

December 17, 2004

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
computer lab	0	79	23	873	ND	ND	15	Y # open: 0 # total: 7	N	N	Hallway DO, DEM, Comments: 25 computers.
gym	70	75	35	732	ND	ND	12	N # open: 0 # total: 0	Y wall	Y wall	Hallway DO,
library	0	77	16	481	ND	ND	4	Y # open: 0 # total: 6	Y univent (off) blocked by: items	N	Plant on carpet, AD, Comments: potpourri.
main office	1	77	23	869	ND	ND	8	Y # open: 0 # total: 2	Y ceiling	N	Hallway DO, window-mounted AC, #MT/AT : 1.

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									Supply	Exhaust	
music and drama	20	72	36	756	ND	ND	11	Y # open: 0 # total: 3	Y univent	Y wall	Plants, Comments: crawlspace access door; concerns of odors from crawlspace.
Nurse's	1	78	27	920	ND	ND	12	Y # open: 0 # total: 2	N	N	Inter-room DO, cleaners, food use/storage, plants.
principal's office	1	74	25	811	ND	ND	8	N # open: 0 # total: 0	Y ceiling	N	window-mounted AC
Psychology	1	78	19	589	ND	ND	7	N # open: 0 # total: 0	N	N	Hallway DO, Inter-room DO, PF, items, Comments : portable AC.

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Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

John Greenleaf Whittier School

256 Concord St., Haverhill, MA 01830

Table 1

Indoor Air Results

December 17, 2004

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
1	27	77	26	1827	ND	ND	11	Y # open: 0 # total: 8	Y univent (weak)	Y wall (off, BD)	CD, PF, dust.
2	0	76	13	535	ND	ND	4	Y # open: 2 # total: 8	Y univent	Y wall (off, BD)	Hallway DO, #WD-CT: 40, CD.
3	26	76	29	1910	ND	ND	16	Y # open: 0 # total: 8	Y univent (off)	Y wall (off, BD) Occluded: dust/debris	Hallway DO, CD, PF, dust, FC re-use, food use/storage.

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4	18	76	18	828	ND	ND	6	Y # open: 0 # total: 7	Y univent Blocked by: boxes	Y wall (weak)	CD, DEM, PF, dust.
5	25	76	30	1401	ND	ND	12	Y # open: 1 # total: 8	Y (weak) Blocked by: plant(s)	Y wall (off)	CD, items, FC re-use, Comments: WD-boxes; condensation on windows.

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									Supply	Exhaust	
6	22	76	20	836	ND	ND	7	Y # open: 0 # total: 8	Y univent	Y wall (off) Occluded: dust/debris	Hallway DO, CD, PF, dust.
7	23	76	29	994	ND	ND	8	Y # open: 0 # total: 8	Y univent (off) Blocked by: furniture	Y wall	Hallway DO, CD, DEM, cleaners, items, pets.

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256 Concord St., Haverhill, MA 01830 **December 17, 2004**

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									Supply	Exhaust	
8	2	75	18	540	ND	ND	5	Y # open: 0 # total: 8	Y univent	Y wall Occluded: dust/debris	Hallway DO, CD, PF, dust, plants.
9	23	75	30	1270	ND	ND	16	Y # open: 0 # total: 7	Y (off) Blocked by: items	Y wall	CD, DEM.
10	23	75	27	875	ND	ND	7	Y # open: 0 # total: 7	Y univent	Y wall	CD, DEM.

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									Supply	Exhaust	
11	23	77	19	915	ND	ND	9	Y # open: 1 # total: 4	Y univent	Y wall	CD, PF.
12	0	81	21	630	ND	ND	11	Y # open: 0 # total: 4	Y univent (off)	Y wall (off)	Hallway DO, CD, cleaners, Comments: unlabelled bottles.
13	20	76	28	1552	ND	ND	36	Y # open: 0 # total: 4	Y univent (off)	Y wall (off)	Hallway DO, CD.
14	0	79	21	646	ND	ND	8	Y # open: 0 # total: 3	Y univent (off)	Y wall (off, BD)	Hallway DO, CD, DEM, PF, plants.

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									Supply	Exhaust	
15	28	76	25	1644	ND	ND	24	Y # open: 0 # total: 4	Y univent (off) items	Y wall (off) blocked by: boxes furniture	Hallway DO, CD.
17	24	74	19	985	ND	ND	10	Y # open: 1 # total: 4	Y univent (off)	Y wall (off)	CD.

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									Supply	Exhaust	
18	0	77	25	1043	ND	ND	5	Y # open: 0 # total: 4	Y univent (off)	Y wall (off, BD) blocked by: boxes furniture	Hallway DO, CD, DEM, cleaners, items, dust, plants, Comments: unlabelled bottles.
19	6	76	22	892	ND	ND	21	Y # open: 0 # total: 3	Y univent (off)	Y wall (off)	Hallway DO, CD, Comments: foot traffic.
20	1	76	25	965	ND	ND	13	Y # open: 0 # total: 3	Y univent (off)	Y wall	CD.

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