INDOOR AIR QUALITY ASSESSMENT

Winthrop Elementary School
65 Central Street
Ipswich, Massachusetts 01938

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
October 2009

Background/Introduction

At the request of Paul Bedard, Facilities Maintenance/Custodial Supervisor for Ipswich Public Schools, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality at the Winthrop Elementary School (WES) located at 65 Central Street, Ipswich, Massachusetts. BEH staff made an initial visit to the school in November 2008 to examine conditions at the school. On June 12, 2009, James Tobin, Environmental Analyst/Inspector in BEH's Indoor Air Quality Program, returned to the school to conduct air testing.

The WES is a two-story, brick building built in 1957 on a slab foundation. In 1987, an addition was built expanding the western side of the building. A modular classroom building was installed for use 12 years ago. The school houses general classrooms, a library, gymnasium, cafeteria/auditorium, art room, music room and office space. Windows are openable throughout the building.

Methods

Air tests for carbon dioxide, temperature, relative humidity and carbon monoxide were conducted with the TSI, Q-Trak, IAQ Monitor, Model 7565. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. BEH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 450 students in grades pre-K through 5 with approximately 40 staff members. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in 14 of 35 areas, indicating inadequate air exchange in 40% of the areas evaluated at the time of the assessment. It is also important to note that a number of areas had open windows or were empty/sparsely populated, both of which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to increase with higher occupancy and windows closed.

Fresh air for classrooms is supplied by unit ventilator (univent) systems (Picture 1). A univent draws outdoor air through a fresh air intake located on the exterior wall of the building (Picture 2), and return air from the room through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and distributed to the room through an air diffuser located in the top of the unit. Univents were operating in the majority of rooms at the time of the assessment; however, BEH staff found several univents switched ‘off’, preventing fresh air from being introduced into these rooms. Univent air diffusers and returns were blocked by furniture and other stored items in front and on top of the unit, thereby limiting airflow in these rooms. In one area, the univent had a missing panel exposing the interior of the unit (Picture 3). In order for univents to provide fresh air as designed, air diffusers, intakes and returns must remain free of obstructions. Importantly, these units must remain “on” and be allowed to operate while rooms are occupied. A univent operating in a mode that provides a continual supply of fresh, outdoor air can improve both indoor air quality and comfort, since this continual source of fresh air dilutes pollutants that typically accumulate in indoor environments.

Exhaust ventilation is provided by vents ducted to rooftop motors. Exhaust vents at the WES are located on the ceiling, wall, or at the top of storage closets/shelving (Pictures 4 through 7). Exhaust ventilation systems continuously remove air that has become stale from moisture, odors, and pollutants. In order to function properly, exhaust vents must be activated and allowed to operate without obstruction while rooms are occupied. Without adequate exhaust ventilation, excess heat and stale air can build up leading to indoor air quality and comfort complaints. The work room is not equipped with exhaust ventilation. This area contains photocopiers and a lamination machine each of which can be a source of pollutants such as heat and odors, particularly if the equipment is older and in frequent use.

Wall-mounted air handling units (AHUs) provide ventilation for the modular classroom wing (Picture 8). The modular wing houses three rooms; however, only two AHUs exist. One room lacks mechanical ventilation; therefore, windows and an exterior door are the only means of introducing fresh air to this area. AHUs draw fresh air through an air intake on the exterior of the modular classroom and then distribute it to the room through an air diffuser at the top of the AHU. Stale air from the room is returned to the AHU through a vent at the base of the unit to an exhaust vent on the building exterior. Thermostats that control the AHU system in the modular classrooms have fan settings of “on” and “automatic”. The “automatic” setting on the thermostat activates the AHU system at a preset temperature, and then deactivates the system once the preset temperature is reached. In the fan “on” setting, the AHU system provides continuous airflow to the rooms.

On the exterior wall of the modular classroom, the fresh air intake is directly above the exhaust vent (Picture 9). The configuration of the intake and vent is problematic since pollutants that are exhausted from the classroom can be brought back inside via the air intake**.** The exhaust vent should be ducted away from the fresh air intake. BEH staff also found the fresh air intakes coated with accumulated dust and debris (Picture 10).

Air conditioners (AC) were used in several rooms (Pictures 11 and 12). ACs are normally equipped with filters, which should be cleaned or changed as per manufacturers' instructions to avoid the build-up and re-aerosolization of dirt, dust and particulate matter.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation 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 heating, ventilating and air conditioning (HVAC) systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

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, consult Appendix A.

Indoor temperature measurements ranged from 66^{o} F to 70^{o} F, which were below or at the lower end of the MDPH recommended comfort range (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, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents deactivated/obstructed).

The relative humidity in the building ranged from 58 to 75 percent, which was above the MDPH recommended comfort range in some areas (Table 1). The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Elevated indoor relative humidity would be expected in a building that, with the exception of select areas, lacks AC to remove excess moisture from the air on a day when outdoor relative humidity is 80 to 90 percent (Table 1). Without a dehumidification system or central AC, indoor relative humidity is difficult to maintain in a comfort range when outdoor relative humidity is high. Relative humidity levels in the building 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

In order for building materials to support mold growth, a source of water exposure is necessary. Identification and elimination of the source of water moistening building materials is necessary to control mold growth. BEH staff examined the building to identify breaches in the building envelope that could provide a source of water penetration.

BEH staff examined the building to identify breaches in the building envelope that could provide a source of water penetration. BEH identified the following conditions that could lead to water penetration:

- Shrubs and trees growing against the building, holding moisture against exterior brick (Pictures 13 through 15);
- Plants and shrubs growing in front of fresh air intakes allowing moisture-laden air to be drawn in by the fresh air intake (Pictures 15 through 17); and,
- Exterior brick was damaged and water stained indicating a heavy and/or continuous water exposure (Pictures 18 and 19).

These conditions indicate that water has penetrated through the building envelope. Moisture laden air can infiltrate through breaches and condense on building materials. A heavy and/or continuous water exposure to the building exterior can undermine the integrity of the building envelope and provide a means of water entry into the building via capillary action through foundation concrete (i.e., cement slab) and masonry (Lstiburek & Brennan, 2001).

A number of rooms had water-damaged ceiling tiles, which can indicate leaks from the roof, plumbing system or through the building envelope. Water-damaged ceiling tiles can indicate sources of water penetration and provide a source of mold growth. Ceiling tiles should be replaced after a water leak is discovered and repaired.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed and discarded.

A number of classrooms had plants (Picture 20). Plants can be a source of pollen and mold, which can be respiratory irritants for individuals. Plants should be properly maintained and equipped with drip pans to prevent water damage to porous building materials, which can lead to mold growth. Plants should also be located away from ventilation sources (e.g., air intakes, univent diffusers) to prevent the entrainment and/or aerosolization of dirt, pollen or mold.

Aquariums were also located in a number of classrooms (Picture 21). Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors.

Other IAQ Evaluations

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions 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, BEH staff obtained measurements for carbon monoxide and PM2.5.

Carbon Monoxide

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 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).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of 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, 2006). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (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, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2006).

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 ranged from 1 to 2 ppm due to idling buses in front of the school (Table 1). Carbon monoxide levels measured inside the building were ND (Table 1).

Particulate Matter (PM2.5)

The US EPA has established NAAQS limits 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 to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2006). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA established a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 35 $\mu g/m^3$ over a 24-hour average (US EPA, 2006). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 6 $\mu g/m^3$ at the time of the assessment (Table 1). PM2.5 levels measured in the school ranged from 2 to 19 $\mu g/m^3$ (Table 1). Both indoor and outdoor PM2.5 levels were below the NAAQS PM2.5 level of 35 $\mu g/m^3$. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate 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.

Volatile Organic Compounds

Indoor air concentrations can be greatly impacted by the use of products 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 identify materials that can potentially increase indoor VOC concentrations, BEH staff examined rooms for products containing these respiratory irritants.

Cleaning products were found in rooms throughout the building. The type and brand of these products varied from room to room. Cleaning products contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. These products should be properly labeled and stored in an area that is not accessible to children. Additionally, a Material Safety Data Sheet (MSDS) should be available at a central location for each product in the event of an emergency. Consideration should be given to providing teaching staff with school issued cleaning products and supplies to prevent any potential for adverse chemical interactions between residues left from cleaners used by the schools facilities staff and those left by cleaners brought in by others.

Several classrooms contained dry erase boards and related materials. 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.

Other Conditions

Other conditions that can affect indoor air quality were observed during the assessment. In several classrooms, stored items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

A number of univent/supply air diffusers, exhaust vents and personal fans in classrooms were observed to have accumulated dust/debris (Picture 22). Re-activated supply vents/fans can aerosolize dust accumulated on fan blades/housing. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles.

Lastly, a classroom had a pet bird who was housed in a cage (Picture 23). Animal dander, fur and wastes can all be sources of respiratory irritants. Animal cages should be cleaned regularly to avoid the aerosolization of allergenic materials and/or odors.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made to improve indoor air quality:

1. Operate all ventilation systems throughout the building *continuously* during periods of school occupancy. To increase airflow in classrooms, set univent controls to “high”. School staff should be encouraged not to deactivate classroom univents; rather, report any complaints to the facilities department.
2. Inspect all exhaust motors and belts periodically for proper function. Repair and replace as necessary.
3. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
4. Consider installing exhaust ventilation in work room.
5. Use openable windows in conjunction with mechanical ventilation to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
6. Duct exhaust vents away from fresh air intakes on exterior wall of modular classrooms.
7. Clean accumulated dust and debris from fresh air intakes on exterior wall of modular classrooms.
8. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
9. Change filters for air-handling equipment (e.g., univents, AHUs and ACs) as per the manufacturer’s instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit

flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.

10. 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).
11. Cut shrubs and trees in a manner to maintain a space of 3 feet from the building exterior and univent fresh air intakes, to prevent moisture from being held against exterior brick and moisture-laden air to be drawn in by the fresh air intake.
12. Consider having exterior walls re-pointed and waterproofed to prevent water intrusion. This measure should include a full building envelope evaluation.
13. Repair any existing water leaks and replace any remaining water-damaged ceiling tiles. Examine the area above these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial, as needed.
14. Move plants away from univents in classrooms. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
15. Clean and maintain aquariums and animal cages to prevent mold growth and associated odors.

16. Store cleaning products properly and out of reach of students. All cleaning products used at the facility should be approved by the school department with MSDS' available at a central location.
17. 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.
18. Clean accumulated dust and debris periodically from univent air diffusers, exhaust vents and blades of personal fans.
19. Consider adopting the US EPA (2000) document, "Tools for Schools", as an instrument for maintaining a good indoor air quality environment in the building. This document is available at: http://www.epa.gov/iaq/schools/index.html.
20. Refer to resource manual and other related indoor air quality documents located on the MDPH's website for further building-wide evaluations and advice on maintaining public buildings. These documents are available at: http://mass.gov/dph/iaq.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. 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.

Lstiburek, J. & Brennan, T. 2001. Read This Before You Design, Build or Renovate. Building Science Corporation, Westford, MA. U.S. Department of Housing and Urban Development, Region I, Boston, MA

MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

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

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 2000. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/tools4s2.html.

US EPA. 2001. "Mold Remediation in Schools and Commercial Buildings". Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001. Available at: http://www.epa.gov/iaq/molds/mold_remediation.html.

US EPA. 2006. National Ambient Air Quality Standards (NAAQS). US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

Picture 1

Classroom Univent

Picture 2

Univent Fresh Air Intake on Exterior Wall

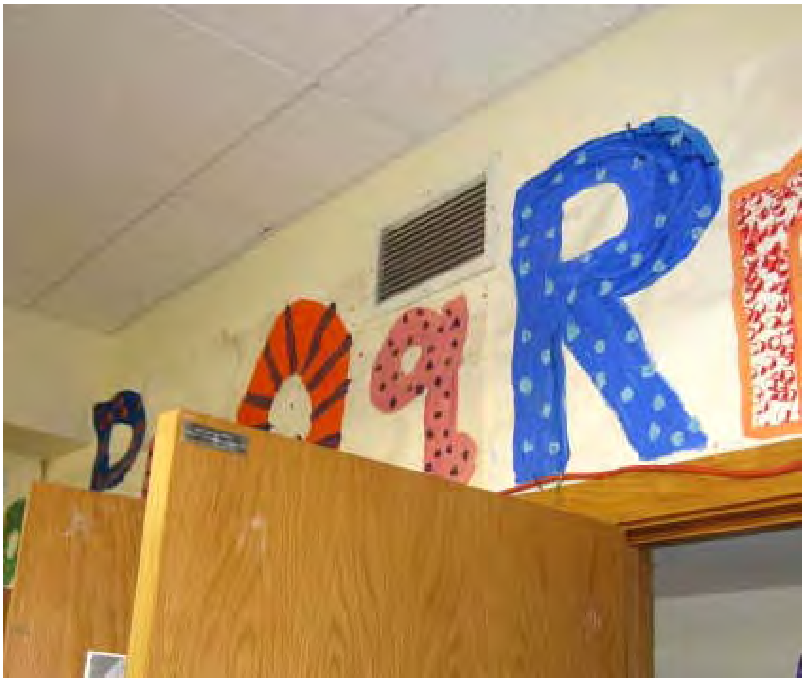
Picture 3

Stored Items on Top and in Front of Univent, Note Panel Removed

Picture 4

Exhaust Vent on Ceiling

Picture 5



Exhaust Vent on Wall

Picture 6

Exhaust Vent in Storage Closet

Picture 7

Exhaust Vent in Classroom Shelving

Picture 8

Air Handling Unit on Wall in Modular Classroom
Air Diffuser at Top, Exhaust Vent at Base

Picture 9

Air Intake Directly Above Exhaust Vent on Exterior Wall

Picture 10

Accumulated Dust and Debris on Air Intake

Picture 11

Air Conditioner in Window

Picture 12

Air Conditioner Ducted to Window by Hoses

Picture 13

Shrubs Growing Against Building

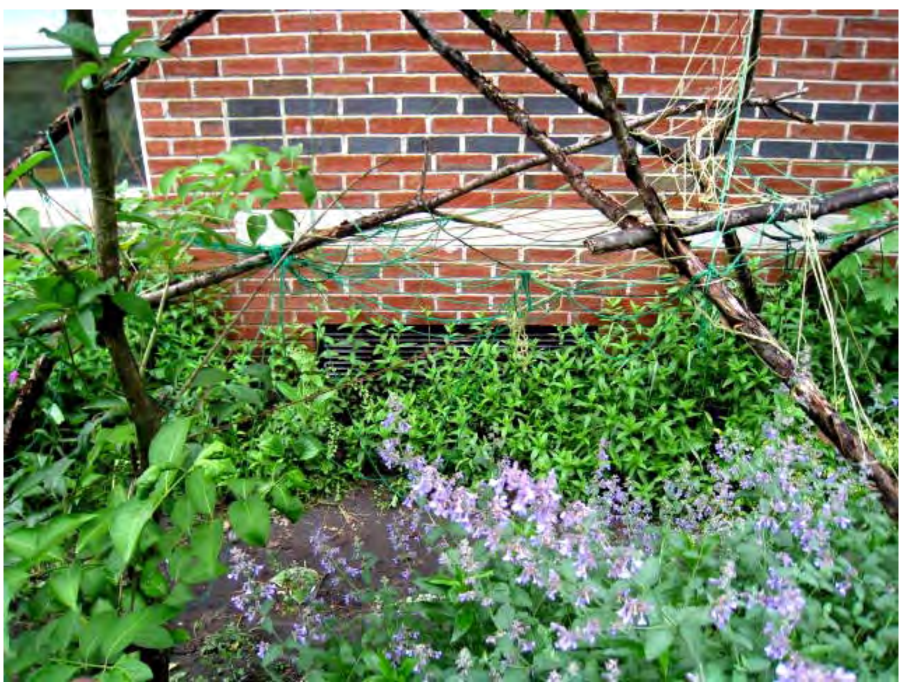
Picture 14

Shrubs Growing Against Building

Picture 15

Plants and Shrubs Growing in Front of Fresh Air Intake

Picture 16



Plants Growing in Front of Fresh Air Intake

Picture 17

Shrubs Growing near Fresh Air Intake

Picture 18

Water Stains on Exterior Brick and Storage Shed

Picture 19

Water Stains on Exterior Brick

Picture 20

Plants in Classrooms

Picture 21

Aquarium in Classrooms

Picture 22

Accumulated Dust and Debris on Fan Blades

Picture 23

Bird in Classroom

Location: Winthrop Elementary School **Indoor Air Results**

Address: 65 Central Street, Ipswich, MA **Table 1** **Date: 6 – 12 – 2009**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
outside school A.M.		62	80	442	1 – 2	6				Overcast; Buses idling about to leave
outside school P.M.		64	90	398	ND	13				Light rain
Library	3	66	67	545	ND	3	Y	UV off	Y	Stored items on UV; Exhaust vent dusty; PF; plants; CPs
Title I	2	66	67	531	ND	4	Y	Y	Y	Stored items on and in front of UV, UV panel open; window AC; PF
2	23	69	73	879	ND	9	Y	Y	Y	Stored items on UV
3	25	70	73	1084	ND	19	1 of 3 open	UV off	Y	DEM; PF; exterior door; indoor recess
4	0	69	70	759	ND	8	Y	Y	Y	Plants near UV; PFs
5	0	68	72	678	ND	8	Y	Y	Y	Stored items and furniture blocking UV; exterior door; DEM
6	1	69	70	778	ND	10	Y	Y	Y	Stored items and furniture blocking UV; DO

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
AC = air conditioner
AHU = air handling unit
aqua. = aquarium
CF = ceiling fan
CP = cleaning product
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
ND = non detect
PC = photocopier
PF = personal fan
TB = tennis balls
UF = upholstered furniture
UV = univent
WD = water-damaged

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Location: Winthrop Elementary School **Indoor Air Results**

Address: 65 Central Street, Ipswich, MA **Date: 6 – 12 – 2009**

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
7	25	69	73	1018	ND	10	Y	Y	Y	UV blocked by table; CPs; DEM; DO; exterior door
8	25	69	71	819	ND	6	Y	UV off	Y	Water cooler; UF; DO
9	1	69	70	924	ND	11	Y	UV off	Y	Aqua; window AC; TB
11	9	68	67	822	ND	5	Y	Y	Y	Stored items and PF on UV
13	17	68	67	781	ND	7	Y	Y	Y	Stored items on and in front of UV; window AC; water cooler
14	22	69	68	945	ND	12	Y	Y	Y	Stored items on UV; CPs; Aqua; DO
15	3	68	68	945	ND	6	Y	Y	Y	Aqua; plants; DO; Bird Cage
16	0	68	67	852	ND	9	Y	Y	Y	CPs
17	2	69	65	589	ND	8	Y	UV off	Y	DEM; DO

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Table 1 (continued)

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								Supply	Exhaust	
18	10	70	65	732	ND	10	Y	Y	Y	WD CTs; DO; PF
19	26	70	66	913	ND	12	Y	Y	Y	UV blocked by books and furniture; DO
20	25	70	65	968	ND	12	Y	Y	Y	UV blocked by furniture; PF; DEM; DO
21	3	70	64	794	ND	11	Y	Y	Y	UV blocked by furniture; DEM; PF
22	20	70	67	989	ND	19	Y	Y	Y	PF
23	24	70	66	1059	ND	14	Y	Y	Y	UV blocked by furniture
24	23	69	68	798	ND	9	Y	Y	Y	UV blocked in front; CPs; UF; AD; DEM
25	15	68	67	775	ND	19	Y	Y	Y	Stored items on and in front of UV; PF
26 Art	1	68	65	508	ND	5	Y	Y	Y	WD CTs; Kiln with local exhaust

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Indoor Air Results

Date: 6 – 12 – 2009

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
27	22	68	68	856	ND	18	Y	UV off	Y	DEM; carpet
Gym	0	67	73	633	ND	13	4 of 4 open	1 of 2 UV off	Y	
Physical Therapy	1	68	73	628	ND	7	Y	Y	Y	Exhaust blocked; AC
Nurse	1	68	73	738	ND	9	Y	N	N	
Cafeteria	64	68	75	654	ND	11		Y	Y	CPs; CFs; exterior door
Main office	2	68	72	631	ND	8	Y	N	N	Wall AC; plants
Work room	3	67	72	613	ND	8	N	N	N	3 PCs; DO; passive vent in door
Music	0	68	58	463	ND	2	Y	Y	Y	PF; DEM
Band Practice	0	68	58	459	ND	2	Y	N	N	2 DO

ppm = parts per million
μg/m^3 = micrograms per cubic meter
AC = air conditioner
AHU = air handling unit
aqua. = aquarium

CF = ceiling fan
CP = cleaning product
CT = ceiling tile
DEM = dry erase materials

DO = door open
MT = missing ceiling tile
ND = non detect
PC = photocopier

PF = personal fan
TB = tennis balls
UF = upholstered furniture
UV = univent
WD = water-damaged

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%
Particle matter 2.5 < 35 ug/m^3

Location: Winthrop Elementary School **Indoor Air Results**

Address: 65 Central Street, Ipswich, MA **Date: 6 – 12 – 2009**

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Speech	0	68	60	468	ND	3	Y	Y	Y	DEM

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
AC = air conditioner
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Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3