INDOOR AIR QUALITY ASSESSMENT

Paul F. Doyon Memorial School
216 Linebrook Road
Ipswich, Massachusetts 01938

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
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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 Paul F. Doyon Memorial School (DMS) located at 216 Linebrook Road, Ipswich, Massachusetts. BEH staff initially visited the school in November 2008 to examine conditions at the school. On June 11, 2009, James Tobin, Environmental Analyst/Inspector within BEH's Indoor Air Quality Program, returned to the school to conduct air testing.

The DMS is a one-story, brick building built in 1965 on a slab foundation. The building originally opened with 10 classrooms, offices, a nurse's room, a gymnasium, a cafeteria, a patio, entrance hall, boiler room and corridors. Core facilities were planned for 22-rooms, so the DMS has undergone a series of renovations. In 1967, 12 more classrooms, 2 small offices and a triangular library were added. In 1995, 4-rooms, a corridor and a library were added. In 2005, new windows with screens were added to the 100 wing of the school, new flooring and lights were added to the cafeteria. A new exit to the playground was added and several portions of the roof were replaced. The school has an interior courtyard containing shrubs and trees. 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 500 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 22 of 41 areas, indicating poor air exchange in approximately half of the areas surveyed during the assessment. It is also important to note that several 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. BEH staff also noted that the univent air diffuser in room 110 was damaged (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. Classroom exhaust vents are located in storage closets with undercut doors in order to allow air to move freely to the vent at the top of the closet (Pictures 4 through 6). Exhaust vents in some classrooms and offices were obstructed, and in one area, cardboard was used to block the vent. Exhaust ventilation systems in operation 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. Without adequate exhaust ventilation, these pollutants can accumulate in the room leading to indoor air quality and comfort complaints.

In addition to univents, the gymnasium has ceiling mounted air handling units (AHUs) to provide ventilation. AHUs distribute fresh air to the gymnasium through air diffusers and duct air back via return vents at the base of the unit (Picture 7). The AHUs in the gymnasium were not activated at the time of testing, as illustrated by the elevated carbon dioxide levels that were measured during the assessment (Table 1).

Air conditioners (AC) were used in several rooms (Picture 8). 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 69° F to 76° F, which were within or very close to the low end of the MDPH recommended comfort range (Table 1). The MDPH 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. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents/exhaust vents deactivated/obstructed).

The relative humidity in the building ranged from 48 to 59 percent, which was within the MDPH recommended comfort range (Table 1). The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. 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 identified the following conditions:

- Damaged and/or missing drip edges, gutters and downspouts allowing water to empty against the side of the building and pool at the base of the building (Pictures 9 through 11, and 15);
- Shrubs and trees growing against the building and in front of univent fresh air intakes, holding moisture against exterior brick and allowing moisture-laden air to be drawn in by the fresh air intakes (Pictures 12 through 14);
- Tree branches overhanging the roof (Pictures 14 and 15);
- Cracks and damaged caulking around fresh air intakes on exterior wall (Picture 16);
- Siding was damaged exposing insulation (Picture 17);
- Exterior brick and mortar was damaged and/or missing (Picture 10 and 18);
- Exterior brick was significantly water stained indicating a heavy and/or continuous water exposure (Pictures 11, 14, 15, 18 and 19); and,
- Efflorescence[1] on exterior brick (Picture 20).

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

[1] As moisture penetrates and works its way through building materials (e.g., masonry), water-soluble compounds dissolve, creating a solution. As this solution moves to the surface, the water evaporates, leaving behind white, powdery mineral deposits.

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. In room 305, water-damaged ceiling tiles were located on the south wall, adjacent to the hallway leading to the back of the school (Picture 21) and holes were observed in the ceiling tile system (Picture 22). A breach in a ceiling can allow dust, odors, and other pollutants to move into occupied areas. 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. Plants can be a source of pollen and mold, which can serve as respiratory irritants for some sensitive 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 23). 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 were non-detect (ND) at the time of the assessment (Table 1). Carbon monoxide levels measured inside the building were also 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 2 $\mu g/m^3$ at the time of the assessment (Table 1). PM2.5 levels measured in the school ranged from 3 to 25 $\mu g/m^3$ (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 (Picture 24). 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 (Picture 25). 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 26). 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.

Bird and insect nests were found in classrooms (Picture 27). Nests can contain bacteria and may also be a source of allergenic material. Nests should be placed in resealable bags to prevent aerosolization of allergenic material.

While examining the exterior of the building, BEH staff found trash cans located near fresh air intakes in the exterior wall (Picture 28). Fresh air intakes can draw in odors from the trash, which can cause indoor air quality complaints.

Lastly, BEH staff found carpet in several areas damaged and worn (Picture 29). In some areas duct tape was used in an effort to repair carpeting (Picture 30). Disintegrating textiles can be a source of airborne particulates, which can be irritating to the eyes, nose and throat. Carpet in schools has a normal life span of approximately eleven years (IICRC, 2002). The useful life span of a carpet and other flooring materials should be considered when long term planning for replacement is conducted.

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 (e.g., AHUs, univents and exhaust vents) 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. Contract with a ventilation engineer to inspect HVAC equipment for proper function. Repair or replace components as necessary to ensure adequate air supply and exhaust capability throughout the school’s classrooms, offices and common areas.

3. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
4. Make repairs to univent air diffusers as needed.
5. Consider installing local exhaust ventilation in work room for photocopiers and laminator.
6. 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.
7. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
8. Change filters for air-handling equipment (e.g., ACs, AHUs and univents) 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.
9. 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).

10. Repair and replace damaged/missing drip edges, gutters and downspouts. Ensure gutters and downspouts are clean and connected, and gutters drain water away from the foundation.

11. Cut shrubs and trees in a manner to maintain a space of 3 to 5 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. Trim tree branches that overhang the roof.

13. Seal around univent fresh air intakes to prevent water/pest penetration.

14. Consider having exterior walls re-pointed and waterproofed to prevent water intrusion. This measure should include a full building envelope evaluation.

15. 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.

16. 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.

17. Clean and maintain aquariums to prevent mold growth and associated odors.

18. 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.

19. 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.

20. Clean accumulated dust and debris periodically from univent air diffusers, exhaust vents and blades of personal fans.
21. Bird and insect nests should be placed in resealable bags to prevent aerosolization of allergenic material.
22. Store outdoor trash cans away from fresh air intakes on exterior wall.
23. Consider cleaning carpeting annually (or semi-annually in soiled high traffic areas) as per the recommendations of the Institute of Inspection, Cleaning and Restoration Certification (IICRC). Copies of the IICRC fact sheet can be downloaded at: http://www.cleancareseminars.com/carpet_cleaning_faq4.htm (IICRC, 2005).
24. Consider establishing a schedule for replacement of carpets based on IICRC recommendations.
25. 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.
26. 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

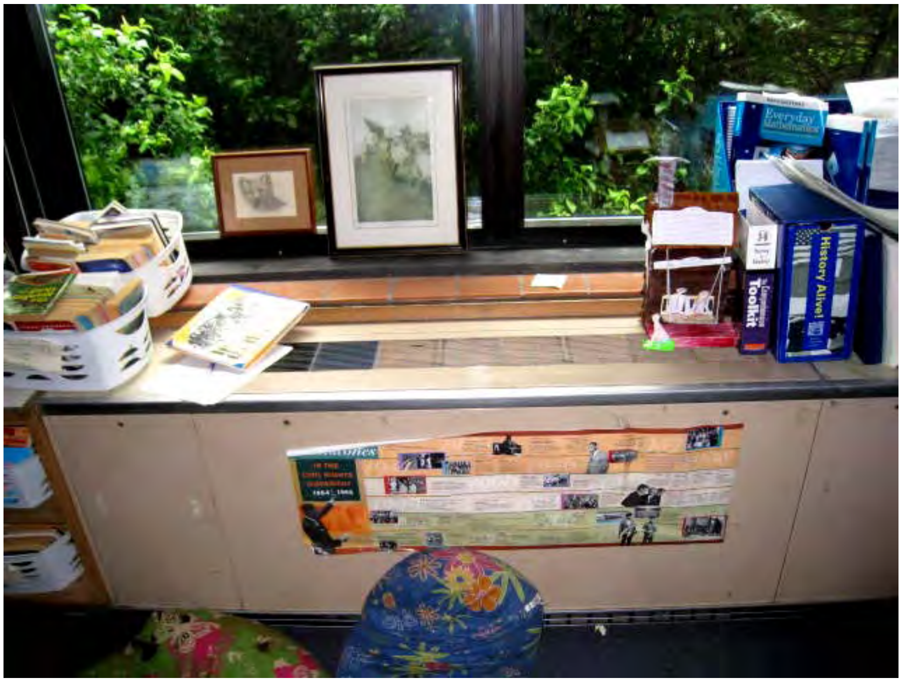
SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

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, Note Books and Stored Items on Top

Picture 2

Univent Fresh Air Intake on Exterior Wall

Picture 3

Damaged Univent Air Diffuser

Picture 4

Classroom Exhaust Vent

Picture 5

Classroom Storage Closet with Exhaust Vent

Picture 6

Exhaust Vent at the Top of the Closet

Picture 7

Gymnasium Air Handling Unit

Picture 8

Wall mounted Air Conditioner

Picture 9

Damaged/Missing Downspout

Picture 10

Damaged Downspout; Damaged Exterior Brick and Cement

Picture 11

Water Stained Bricks under Damaged Drip Edge

Picture 12

Shrubs and Trees Growing in Courtyard; Note Shrubs Growing Against Building

Picture 13

Shrubs Growing Against Building and in Front of Univent Fresh Air Intake

Picture 14

Water Stained Exterior Brick; Trees Overhanging Roof

Picture 15

Water Stained Exterior Brick under Damaged Drip Edge; Trees Overhanging Roof

Picture 16

Cracks and Damaged Caulking around Fresh Air Intake

Picture 17

Damaged Siding Exposing Insulation

Picture 18

Damaged and Water Stained Exterior Brick

Picture 19

Water Stained Brick

Picture 20

Efflorescence on Exterior Brick

Picture 21

Water Damaged Ceiling Tiles

Picture 22

Breach in Ceiling Tile

Picture 23

Aquarium in Classroom

Picture 24

Cleaning Product in Classroom

Picture 25

Accumulated Items in Classroom

Picture 26

Accumulated Dust on Fan Blades

Picture 27

Insect Nest in Classroom

Picture 28

Trash Cans Located near Fresh Air Intake

Picture 29

Classroom Carpet Damaged and Torn

Picture 30

Classroom Carpet Fixed using Duct Tape

Location: Paul F. Doyon Memorial School **Indoor Air Results**

Address: 216 Linebrook Road, Ipswich, MA **Table 1** **Date: 6 – 11 – 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	
Outdoor: Front of School		62	60	391	ND	1				
Outdoor: Courtyard		67	56	425	ND	2				
101	0	70	52	639	ND	5	Y	Y UV off	Y	Aqua; DEM; UF
102	19	69	59	874	ND	16	Y	Y UV off	Y	DO
103	0	70	53	607	ND	4	Y	Y	Y	DEM; DO
104	1	70	54	504	ND	3	Y	Y	Y	CPs; DEM
105	7	71	54	971	ND	9	Y	Y	Y	PF; DO
106	0	72	50	742	ND	6	Y	Y	Y	CPs; DEM: DO
107	8	72	53	1389	ND	9	Y	Y	Y	UV blocked by furniture

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
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

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m³)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
108	1	71	53	872	ND	6	Y	Y	Y	Stored items on UV; Aqua; DO; DEM
109	17	73	53	1197	ND	6	Y	Y	Y	PF; Plants; DO; Carpet old, worn, duct tape as repair
110	5	72	51	659	ND	6	Y	UV off, Diffuser damaged	Y	DO
301	15	71	56	1309	ND	7	Y	Y	Y	CPs; DO; Plants
302	16	71	56	1254	ND	13	Y	Y UV off	Y	CPs; DO; PF
303	17	71	55	984	ND	8	Y	Y	Y	Stored items on UV; Aqua; CPs; DEM; DO
304	17	70	56	1108	ND	9	Y	Y	Y	Stored items on UV; CPs; DEM; DO; Plants
305	21	71	57	1249	ND	8	Y	Y	Y	Stored items on UV; WD CTs; Plants; DO
201	5	72	53	983	ND	8	Y	Y	Y	Stored items on UV; DO

ppm = parts per million
μg/m³ = 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
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UF = upholstered furniture
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Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
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Location: Paul F. Doyon Memorial School **Indoor Air Results**

Address: 216 Linebrook Road, Ipswich, MA **Table 1 (continued)** **Date: 6 – 11 – 2009**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m³)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
202	0	72	53	936	ND	10	Y	Y	Y	Passive vent in door
203	21	72	53	789	ND	6	Y	Y	Y	UV blocked by furniture; DO
204	24	71	52	901	ND	6	Y	Y	Y	CPs
205	22	71	55	1242	ND	18	Y	Y	Y	UV air diffusers blocked; Aqua; PF; CPs; nests
206	0	71	54	943	ND	8	Y	Y	Y	
207	15	71	55	1191	ND	8	Y	Y	Y	UV blocked; Multiple partitions
208	0	70	57	974	ND	7	Y	Y	Y	UV blocked by furniture; Aqua; Plants hanging
209	15	71	56	1165	ND	12	Y	Y	Y	Aqua; DO
210	21	69	55	763	ND	7	Y	Y	Y	DEM; DO

ppm = parts per million
μg/m³ = 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/m³

Location: Paul F. Doyon Memorial School **Indoor Air Results**

Address: 216 Linebrook Road, Ipswich, MA **Table 1 (continued)** **Date: 6 – 11 – 2009**

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	
211	14	70	55	1054	ND	10	Y	Y	Y	Aqua; CPs; DEM; DO
SPED office	1	71	53	738	ND	3	Y	Y	N	Furniture and Stored items blocking UV, PF on UV; Passive vent in door
Speech	2	72	52	979	ND	9	Y	Y	N	Partitioned office; passive vent in door; DO to 201
Gym	0	69	55	1108	ND	25	N	Y	Y	Equipment stored on UV; ceiling mounted AHU
Network office	0	76	48	742	ND	8	N	N	Y	PFs; Door remains open
School Counselor	0	74	48	695	ND	7	N	N	Y	Passive vent in door; DO; Exhaust vent blocked by cardboard
Fitness	0	72	50	622	ND	4	Y	Y		Partitioned from Tutoring Center
Tutoring Center	3	71	51	628	ND	4	Y	UV in fitness		

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

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	
Library	26	69	54	633	ND	4	Y	Y 2 UV off	Y	MT
Language Program	3	70	54	757	ND	6	Y	Y		Wall mounted AC; CPs; WD CTs; TB; water stains on wall; passive vent in door
Health Room	3	72	54	784	ND	8	N	Y	Y	Wall mounted AC; DO
Faculty Lounge	3	72	53	968	ND	7	N	Y	Y	Window AC; vending machine; WD near window
Work room	1	73	50	768	ND	9	N	N	N	2 PCs; Laminator; sink; DO to hall and main office
Main office	2	70	54	615	ND	8	N			
Café	80	72	51	798	ND	10	Y	Y	Y	Supply vent under stage blocked; CFs
Stage	0	70	54	785	ND	8	N	Y	Y	

ppm = parts per million
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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