INDOOR AIR QUALITY ASSESSMENT

Reay E. Sterling Middle School
444 Granite Street
Quincy, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
February 2012

Background/Introduction

At the request of Mr. Andrew Scheele, Public Health Commissioner, Quincy Health Department and Mr. Kevin Segalla, Director of Custodians, Quincy Public Schools (QPS), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality (IAQ) concerns at the Reay E. Sterling Middle School (SMS), 444 Granite Street, Quincy, Massachusetts. The assessment was prompted by occupant reports of headaches, respiratory irritation, exacerbation of pre-existing asthma, and mold concerns.

On January 5, 2012, Cory Holmes and Sharon Lee, Environmental Analysts/Inspectors within BEH's IAQ Program conducted an assessment of the SMS. The SMS is a three-story brick and plaster building that was constructed in 1927. The school is made up of general classrooms, science classrooms, kitchen, cafeteria, auditorium, gymnasium, media center, specialists' rooms and office space. The heating/boiler plant was replaced approximately 6-8 years ago; the roof was replaced in 2011. Windows were reportedly replaced in the late 1980s and are openable throughout the building. Some building components, such as the ventilation systems, date back to the original construction of the building.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 7525. 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 350 students in grades 5 through 8 with approximately 45 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 26 of 53 areas, indicating poor air exchange in approximately half of the areas surveyed at the time of the assessment. It is important to note that the school does not have a functioning mechanical ventilation system. The school's original ventilation system, dating back to 1927, has been abandoned. A few classrooms were empty/sparsely populated at the time of assessment, which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to increase with higher occupancy.

Fresh air in classrooms was originally designed to be mechanically supplied by unit ventilator (univent) systems (Pictures 1 and 2). Univents are designed to draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 3) and return air through an air intake located at the base of each unit (Figure 1). Fresh and return air are typically mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. The 1927 vintage univents at SMS have no capabilities for filter installation (Picture 2). In modern univents, the mixture of fresh to return air is controlled mechanically or pneumatically. In contrast, the louvers in the univents at SMS were designed to be adjusted by hand (Picture 4).

As mentioned, univents are original to the construction of the building. Function of equipment of this age is difficult to maintain, since compatible replacement parts are often unavailable. According to the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), the service life[1] for a unit heater, hot water or steam is 20 years, assuming routine maintenance of the equipment (ASHRAE, 1991). Despite attempts to maintain the univents, the operational lifespan of the equipment has been exceeded by over 60 years. Maintaining the balance of fresh air to exhaust air will become more difficult as the equipment ages and as replacement parts become increasingly difficult to obtain. Currently, ventilation in the school is controlled by the use of openable windows and/or passive infiltration of air via the univent fresh air intakes (when louvers are opened by hand).

Exhaust ventilation is provided by passive exhaust vents located in "cubby holes" at floor level (Picture 5). As originally designed, fresh air was mechanically introduced into classrooms via the univents, which "pressurized" the room forcing stale classroom air and excess heat into the exhaust vents and up the ventilation shaft to an exhaust terminus on the roof (Picture 6). As the air rises up the ventilation shaft, negative pressure is created in the room, which facilitates the draw of air from the room into the exhaust shaft resulting in air exchange. The area of the exhaust vent available is adjusted by a louver attached to a pull chain (Picture 7). These exhaust vents remain functional, however, at the time of the inspection many of them had louvers shut or were obstructed by the storage of classroom items (Pictures 5 and 8). Without properly functioning supply and exhaust ventilation systems, normally occurring environmental pollutants can build up.

---

[1] The service life is the median time during which a particular system or component of …[an HVAC]… system remains in its original service application and then is replaced. Replacement may occur for any reason, including, but not limited to, failure, general obsolescence, reduced reliability, excessive maintenance cost, and changed system requirements due to such influences as building characteristics or energy prices (ASHRAE, 1991).

The Nurse's Office had no means for provision of fresh air, either from mechanical ventilation or through openable windows. However the Nurse's restroom had a switch-activated exhaust fan. To create air exchange QPS maintenance staff should ensure that this exhaust vent is ducted to the outdoors and functioning properly. To create air exchange, a passive vent should be installed in the hallway door or the door should be undercut by one to two inches. Similar measures should be taken for supply room 215 (Table 1).

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

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

The 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.

Temperature readings in the building ranged from 67 °F to 80 °F, some of which were above or below the MDPH recommended comfort guidelines in a number of areas the day of the assessment (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. Temperature control complaints were expressed in a number of areas of the building, particulary heat complaints due to solar gain through windows. 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 building's ventilation systems as designed.

The relative humidity measured in the building ranged from 12 to 27 percent at the time of the assessment, which was below the MDPH recommended comfort range in all areas surveyed (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

Moderate water damage to wall/ceiling plaster, peeling paint, and efflorescence were observed in a number of areas throughout the building (Pictures 9 through 12, Table 1). Water damage on the upper floors is most likely the result of historical water penetration through the roof, which was replaced in 2011. Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar, brick or plaster, water-soluble compounds dissolve, creating a solution. As the solution moves to the surface of the material, the water evaporates, leaving behind white, powdery mineral deposits. In addition, while brick is a porous material that allows moisture to evaporate, a layer of paint can serve as a water-impermeable barrier, which can trap moisture causing bubbling and peeling (Picture 12). A water-damaged corkboard was observed in room 207 (Picture 13). Corkboard can give off unpleasant odors if it becomes wet, consideration should be made for removal/replacement.

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/discarded.

Visible mold growth was observed in the refrigerator in the teacher's lunchroom. Upon opening the refrigerator used by staff for food storage, BEH staff found both the refrigerator and freezer door gaskets to be colonized with mold (Pictures 14 through 17). The refrigerator was a source of noticeable odor, had spillage of unknown origin and appeared not to have been cleaned for some time.

A number of classrooms had plants (Table 1). 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. Plants should also be located away from ventilation sources (e.g., univent air diffusers) to prevent the aerosolization of dirt, pollen or mold.

Clinging plants were observed growing on exterior brick (Pictures 3 and 18). Clinging plants can cause water damage to brickwork through insertion of tendrils into brick and mortar. Water can penetrate into the brick along the tendrils. Water trapped in brick can subsequently freeze and thaw during the winter. This freezing/thawing action can weaken bricks and mortar, resulting in wall damage.

Several aquariums and terrariums were observed in classrooms (Table 1). Aquariums should be properly maintained to prevent microbial/algal growth, which can emit unpleasant odors. Similarly, terrariums should be properly maintained to ensure soil does not become a source for mold growth/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 indoor, 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. On the day of the assessment, outdoor carbon monoxide concentrations were non-detect (ND). No levels of carbon monoxide were detected inside the building during the assessment (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 micrograms 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 29 $\mu g/m^3$ (Table 1). Indoor PM2.5 levels ranged from 14 to 24 $\mu g/m^3$ (Table 1), which 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 on countertops and in unlocked sink cabinets in rooms throughout the building (Table 1). 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 inaccessible to children. In addition, a Material Safety Data Sheets (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 facilities staff and those left by cleaners brought in by others.

Air fresheners/scented oils were found to be in use in some areas (Picture 19, Table 1). Air fresheners contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Many air fresheners contain 1,4-dichlorobenzene, a VOC which may cause reductions in lung function (NIH, 2006). Furthermore, deodorizing agents do not remove materials causing odors, but rather mask odors that may be present in the area.

A number of 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.

Several areas that contain photocopiers and laminators are not equipped with local mechanical exhaust ventilation to help reduce excess heat and odors (Table 1). Three lamination machines are located in room 112 (Picture 20). Lamination machines melt plastic and give off odors and VOCs. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992).

In an effort to reduce noise from sliding chairs, tennis balls were sliced open and placed on chair legs in some classrooms. Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g. spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997).

Other Conditions

In several classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks (Picture 21). 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 (Picture 22). 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. Also noted was an accumulation of chalk dust in some classrooms (Table 1), which can become airborne and act as irritants to the eyes and respiratory system.

Open utility holes and wall cracks observed in some rooms (Picture 23, Table 1). Open utility holes and wall cracks can provide a means of egress for odors, fumes, dusts and vapors between rooms and floors.

Upholstered furniture and cushions were observed in some classrooms (Picture 24, Table 1). Upholstered furniture and cushions are covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. These materials can be irritating to the eyes, nose and respiratory system. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, M.A., 1994). It is also recommended that upholstered furniture (if present in schools), be professionally cleaned on an annual basis.

Finally, personal fans, air diffusers and exhaust vents were observed to have accumulated dust/debris (Pictures 25 and 26). Re-activated fans can aerosolize dust accumulated on fan blades. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles.

Conclusions/Recommendations

The conditions noted at the SES raise a number of IAQ issues. The general building conditions, maintenance, work hygiene practices and the age/condition of ventilation equipment, if considered individually, present conditions that could degrade air quality. When combined, these conditions can serve to further degrade air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is required for remediation. The first consists of **short-term** measures to improve air quality and the second consists of **long-term** measures that will require planning and resources to adequately address the overall IAQ concerns.

Short-Term Recommendations

1. Regulate airflow in classrooms using windows, exhaust vents and hand adjusted univent damper controls. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
2. To create air exchange in the Nurse's office, QPS maintenance staff should ensure that the exhaust vent in the adjacent restroom is ducted to the outdoors and functioning properly. To create air exchange a passive vent should be installed in the hallway door or the door should be undercut 1-2". Similar measures should be conducted in supply room 215 (Table 1).
3. In order to reduce temperatures and heat in classrooms affected by solar gain several actions should be taken and/or considered:
    a. Open classroom univent air intake louvers during occupied hours to draw in cool outside air.
    b. Ensure exhaust vents are free of obstructions and louvers are open to facilitate the removal of excess heat.
    c. Consider mounting portable fans to facilitate air circulation.
    d. Consider applying solar (tinted) film to windows as needed to reduce solar gain/excess heat.
4. 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. If used store them away from occupied areas. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

5. Ensure any remaining roof/window leaks are repaired.
6. Scrape and clean efflorescence and loose paint from ceiling/wall plaster and brick. Do not repaint brick. Monitor and clean periodically as needed.
7. Clean and disinfect interior of refrigerators and freezers with mild detergent or antimicrobial agent. Consider replacing mold-contaminated gaskets. Clean spilled food promptly, and clean out the refrigerator of expired items on a regular schedule.
8. Remove clinging plants, trim overhanging branches, and remove trees from close proximity to exterior walls.
9. 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.
10. Clean and maintain aquariums and terrariums to prevent mold growth and associated odors.
11. Remove/replace water-damaged corkboard in room 207.
12. Refrain from using air fresheners and deodorizers to prevent exposure to VOCs.
13. Provide mechanical local exhaust for lamination machines in room 112 or relocate to well-ventilated area.

14. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled. Obtain Material Safety Data Sheets (MSDS) for all cleaning products used within the school and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).
15. Replace latex-based tennis balls with latex-free tennis balls or glides.
16. 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.
17. Clean personal fans, univent air diffusers, return vents and exhaust vents periodically of accumulated dust.
18. Clean chalk and dry erase trays to prevent accumulation of materials.
19. Seal all open utility holes and wall cracks in the building.
20. Professionally clean upholstered furniture and cushions annually or more frequently as needed. If not feasible, consider removal.
21. Consider adopting the US EPA document, "Tools for Schools" to maintain a good indoor air quality environment on the building (US EPA, 2000). This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.
22. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website: http://mass.gov/dph/iaq.

Long-Term Recommendations

1. Based on the age, physical deterioration and availability of parts, the BEH recommends that an HVAC engineering firm evaluate options for providing adequate ventilation school-wide. Since restoration the original unit ventilation system is not a likely option, consideration should be given to replacing them with modern univents and installing a mechanical exhaust ventilation system. Determine if existing airshafts, vents, ductwork, etc. can be retrofitted for (modern) mechanical ventilation.
2. Consider creating a centrally-located teacher's workroom equipped with local exhaust ventilation for photocopiers and lamination machines.

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

ASHRAE. 1991. ASHRAE Applications Handbook, Chapter 33 "Owning and Operating Costs". American Society of Heating, Refrigeration and Air Conditioning Engineers, Atlanta, GA.

Berry, M.A. 1994. Protecting the Built Environment: Cleaning for Health, Michael A. Berry, Chapel Hill, NC.

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

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.

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

NIH. 2006. Chemical in Many Air Fresheners May Reduce Lung Function. *NIH News*. National Institute of Health. July 27, 2006. http://www.nih.gov/news/pr/jul2006/niehs-27.htm

NIOSH. 1997. NIOSH Alert Preventing Allergic Reactions to Natural Rubber latex in the Workplace. National Institute for Occupational Safety and Health, Atlanta, GA.

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.

SBAA. 2001. Latex In the Home And Community Updated Spring 2001. Spina Bifida Association of America, Washington, DC.

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

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

US EPA. 1992. Indoor Biological Pollutants. US Environmental Protection Agency, Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Research Triangle Park, NC. ECAO-R-0315. January 1992.

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

Original 1920's Vintage Classroom Univent

Picture 2

Original 1920's Vintage Motor in Univent,
Note no Capabilities for Filters to be Installed in Units

Picture 3

Univent Fresh Air Intakes (Arrows), Also Note Clinging Plants on Brickwork

Picture 4

Fresh/Return Air Adjustment Control (Arrow)

Picture 5

Classroom Exhaust Vent "Cubby" Located at Floor Level, Note Storage of Classroom Items

Picture 6

Covered Exhaust Vent Terminus on Roof

Picture 7

Pull Chain/Louver System for Classroom Exhaust Vent (Arrow)

Picture 8

Classroom Exhaust Vent Obstructed by Classroom Items

Picture 9

Water-Damaged Plaster, Peeling Paint and Efflorescence on Classroom Wall

Picture 10

Water-Damaged Plaster and Peeling Paint on Classroom Wall

Picture 11

Water-Damaged Plaster, Peeling Paint and Efflorescence on Classroom Ceiling

Picture 12

Peeling Paint and Efflorescence on Painted Brick Wall in Hallway

Picture 13

Water-damaged Corkboard and Papers

Picture 14

Teacher's Lunchroom Refrigerator Colonized with Mold (Dark Staining)

Picture 15

Teacher's Lunchroom Refrigerator Colonized with Mold (Dark Staining)

Picture 16

Teacher's Lunchroom Refrigerator Colonized with Mold (Dark Staining)

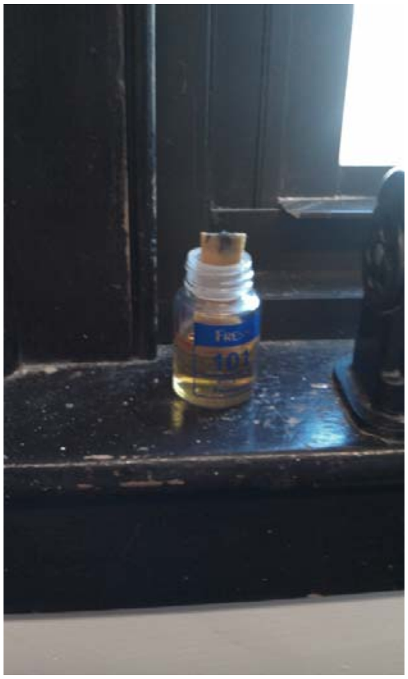
Picture 17

Teacher's Lunchroom Refrigerator Colonized with Mold (Dark Staining)

Picture 18

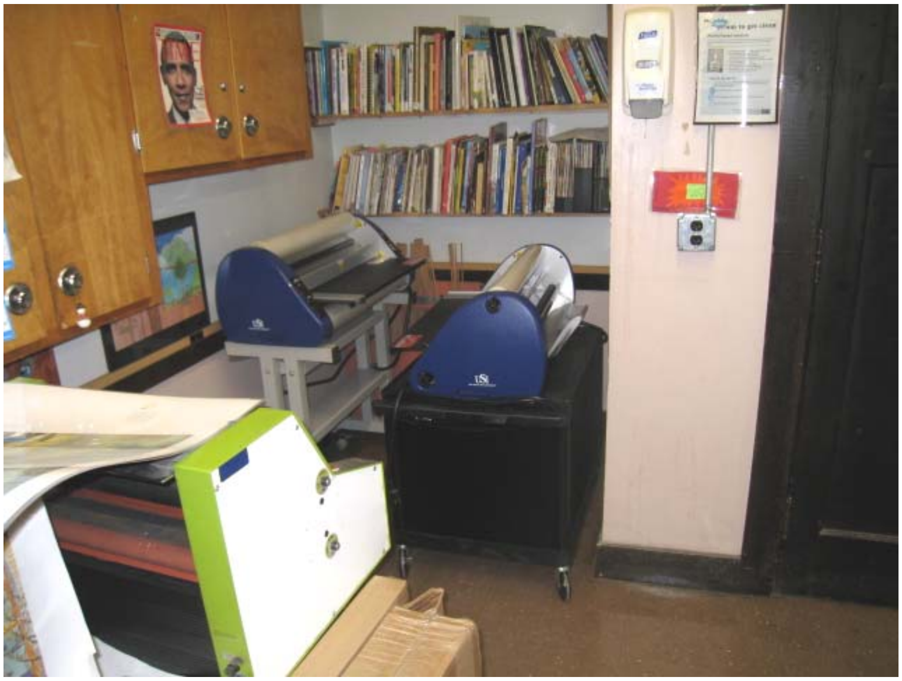
Clinging Plants Growing on Exterior Brick

Picture 19



Air Deodorizer in Classroom

Picture 20



Lamination Machines in Room 112

Picture 21

Accumulated Items in Classroom

Picture 22

Accumulated Dust/Debris on Computer in Classroom

Picture 23

Open Utility Hole in Classroom Ceiling

Picture 24

Upholstered Furniture and Cushions in Classroom

Picture 25

Accumulated Dust/Debris on Personal Fan in Classroom

Picture 26

Accumulated Dust/Debris on Exhaust Vent

Location: Sterling Middle School **Indoor Air Results**

Address: 444 Granite Street, Quincy, MA **Table 1** **Date: 1/5/2012**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Background	349	ND	<32	23	29					Overcast, cold
Speech/OT	570	ND	77	15	16	0	Y	N	N	AD, peeling paint
Boys' Locker Rm	436	ND	67	13	20	0	Y	N	Y	Leaky shower
Gym	706	ND	67	21	18	19	N	Y	Y	
Girls' Locker Rm	408	ND	67	15	19	0	N	N	Y	Efflorescence
Gym office	435	ND	68	17	18	0	N	N	N	
Cafeteria	738	ND	70	22	18	100	Y	N	N	Conference room
Conference Room	602	ND	75	13	16	0	Y	Y	N	DO
auditorium	464	ND	71	14	15	0	N	Y	Y	Cracked glass in ceiling
Nurse's office	619	ND	72	15	15	0	N	N	N	DO, cracked wall, recommend passive/undercut doors

ND = non detect
ppm = parts per million
μg/m³ = micrograms per cubic meter

AD = air deodorizer
CD = chalk dust
CPs = cleaning products

CT = ceiling tile
DEM = dry erase materials
DO = door open

PC = photocopier
PF = personal fan
TB = tennis balls

UF = upholstered furniture
WAC = window air conditioner
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%

Location: Sterling Middle School **Indoor Air Results**

Address: 444 Granite Street, Quincy, MA **Table 1 (continued)** **Date: 1/5/2012**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Nurse's bathroom							N	N	Y	Switch-activated exhaust
Main office	775	ND	75	16	17	8	Y	N	N	PC, PF
Principal's office	632	ND	77	14	14	0	Y	N	N	PC, PF
Asst Principal's office	652	ND	74	14	17	1	Y	N	N	DO, aquarium, WAC
Psychologist	603	ND	72	16	17	0	N	N	N	Interior windows (installed for passive ventilation) were closed
3rd Fl Teachers' Rm (301)	916	ND	77	19	19	0	Y	N	Y	DO
2nd Fl Teachers' Rm (201)	656	ND	75	15	20	0	Y	N	Y	PC, DO
Guidance 1	608	ND	76	14	15	0	Y	N	N	Peeling paint, UF, CPs, WAC
2nd Fl Teachers' Rm	864	ND	78	16	18	0	Y	N	Y	
2nd Fl Girls' Rm							Y	N	Y	Exhaust vent too high to examine

ND = non detect
ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
AD = air deodorizer
CD = chalk dust
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
PC = photocopier
PF = personal fan
TB = tennis balls
UF = upholstered furniture
WAC = window air conditioner
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%

Location: Sterling Middle School **Indoor Air Results**

Address: 444 Granite Street, Quincy, MA **Table 1 (continued)** **Date: 1/5/2012**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Guidance 2	670	ND	75	16	16	2	Y	N	N	AD, WAC, plants
3rd Fl Boys' Rm							Y	N	Y	Exhaust vent too high to examine
3rd Fl Girls' Rm							Y	N	Y dusty	Exhaust vent audible
102	531	ND	73	13	16	0	Y	Y Off dusty	Y	CD
104	934	ND	73	18	19	15	Y 1/4 open	Y	Y	DO
106	887	ND	73	15	19	20	Y 1/4 open	Y Blocked	Y Blocked	DO, 12 computers
112	989	ND	73	18	18	18	Y	Y Plants	Y Blocked	AD, CPs, 3 laminators
1st Fl Teachers' Rm 116	631	ND	71	18	21	3	Y	Y	Y	Water heater, dryers (ducted), mold growth in fridge
202	1034	ND	75	18	20	17	Y	Y Items	Y	DO, TB, DEM
204	964	ND	76	18	21	17	Y	Y Blankets	Y Blocked	DO, DEM, WD-wall plaster

ND = non detect
ppm = parts per million
μg/m³ = micrograms per cubic meter
AD = air deodorizer
CD = chalk dust
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
PC = photocopier
PF = personal fan
TB = tennis balls
UF = upholstered furniture
WAC = window air conditioner
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%

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
206	1032	ND	75	18	21	19	Y	Y	Y	DEM, CPs
207	833	ND	75	17	17	0	N	Y	Y	Water staining on walls, WD-corkboard
208	1136	ND	73	21	22	19	Y 1/4 open	Y Debris	Y Blocked	DO, CPs, DEM, items, ADs
210	991	ND	74	17	17	9	Y	Y	Y	DO, DEM, CD
210A	704	ND	70	15	21	8	Y	Y	Y	DO, DEM, marshmallow project drying on univent
214 Media center	929	ND	75	17	18	23	Y	Y	Y	9 computers
215 Supply room	548	ND	75	16	15	0	N	Y	Y Dusty	Exhaust is switch activated, PF, used occasionally for instruction, recommend passive or undercut door
216	1256	ND	75	12	20	16	Y 1/3 open	Y	Y Blocked	CPs, DEM
217	753	ND	76	15	17	9	N	Y	Y	CPs
218	545	ND	75	12	20	0	Y	Y	Y blocked	PF, WD-CT, CPs

ND = non detect
ppm = parts per million
µg/m³ = micrograms per cubic meter
AD = air deodorizer
CD = chalk dust
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
PC = photocopier
PF = personal fan
TB = tennis balls
UF = upholstered furniture
WAC = window air conditioner
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%

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
220	857	ND	75	16	17	0	Y	Y	Y	TB, PF, WD-wall plaster, DEM
222	810	ND	77	15	20	17	Y ¼ open	Y	Y	DEM, PF, utility holes around pipes in ceiling
224	923	ND	78	17	18	0	Y	Y	Y	DO, plants, dusty computer tops, utility holes around pipes in ceiling, DEM, peeling paint
301	1069	ND	77	18	18	4	Y	Y	Y Blocked	Wall crack, DO, DEM, peeling paint
302	792	ND	79	14	20	0	Y 2/4 open	Y	Y Blocked	DO, CPs, DEM, wall crack, efflorescence
304	974	ND	80	17	20	20	Y 1/4 open	Y Off	Y	DO, DEM, wall crack
306	803	ND	79	13	17	17	7 2/4 open	Y Off	Y	DO, CPs, DEMs, WD/peeling paint-wall plaster, wall crack
308	1295	ND	74	26	15	17	Y 1/4 open	Y	Y	DEM, CPs, 24 computer
310	775	ND	78	14	20	20	Y 2/4 open	Y	Y Blocked	DO, DEM, peeling paint
311	661	ND	79	17	14	0	Y	Y Blocked, items	Y Blocked	DO, CPs, items, TB, CD

ND = non detect
ppm = parts per million
μg/m³ = micrograms per cubic meter
AD = air deodorizer
CD = chalk dust
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
PC = photocopier
PF = personal fan
TB = tennis balls
UF = upholstered furniture
WAC = window air conditioner
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%

Location: Sterling Middle School **Indoor Air Results**

Address: 444 Granite Street, Quincy, MA **Table 1 (continued)** **Date: 1/5/2012**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
312	728	ND	79	14	18	9	Y 1/4 open	Y	Y Blocked	DO, WD-CT, CD, TB
313	1739	ND	78	27	17	17	Y	Y Off	Y Blocked	TB, aquarium, plants, radiators blocked
314	813	ND	79	14	20	20	Y 1/4 open	Y	Y Blocked	DO, DEM, plants, CPs, TB
316	1351	ND	77	21	18	16	Y	Y	Y	DO, PF, DEM
318	1244	ND	76	18	21	19	Y 1/4 open	Y	Y Blocked	DEM
320	1141	ND	77	18	22	17	Y	Y	Y	Plants, AD, TB
322	678	ND	77	13	24	12	Y ¼ open	Y	Y	DEM
324	837	ND	76	16	19	1	Y	Y	Y	DO, approx 6 students left minutes prior

ND = non detect
ppm = parts per million
μg/m³ = micrograms per cubic meter
AD = air deodorizer
CD = chalk dust
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
PC = photocopier
PF = personal fan
TB = tennis balls
UF = upholstered furniture
WAC = window air conditioner
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%