INDOOR AIR QUALITY ASSESSMENT

Leicester Primary School
170 Paxton Street
Leicester, MA

Prepared by:
The Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
December 2011

Background/Introduction

At the request of Mr. Carl Wicklund, Facilities Manager for Leicester Public Schools, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) conducted an indoor air quality (IAQ) assessment at the Leicester Primary School (LPS) located at 170 Paxton Street, Leicester, Massachusetts. The request was prompted by general indoor air quality complaints and deteriorating building conditions. On April 13, 2011 a visit to conduct a general IAQ assessment was made to the LPS by Sharon Lee, Environmental Analyst/Inspector for BEH's IAQ Program.

The school is a two-story brick building completed in 1974. The second floor is primarily general classrooms. The first floor contains general classrooms configured around a centrally located gymnasium and library. A new roof was reportedly installed approximately two years ago to address leaks.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity 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

This elementary school houses grades K through 2, with a student population of approximately 500 and a staff of approximately 60. The tests were taken under normal operating conditions. Test 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 39 areas surveyed, indicating poor air exchange throughout the building, likely the result of deactivated/non-functioning/poorly functioning ventilation equipment. Some areas were empty/sparsely populated at the time of inspection, which can result reduced carbon dioxide levels. Carbon dioxide levels would be expected to increase with higher room occupancy.

Fresh air in classrooms throughout the school is supplied by unit ventilator (univent) systems. A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building and returns air through an air intake located at the base of the unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit (Figure 1). Univents were found deactivated in the majority of classrooms at the time of assessment; as a result, there was no means to mechanically introduce fresh air. Univents were also obstructed by items such as chairs, tables, desks, and books (Picture 1). In some cases, crayons and pencil sharpeners were observed on top of univents, which can result in aerosolization of odors and particulates from these materials. In order to function as designed, univents must be activated and allowed to operate free of obstructions.

Also noted were dirt/dust covered air filters and accumulated material within the units (Pictures 2 and 3). Debris-saturated filters can decrease airflow and may serve as a reservoir of particulates that can be re-aerosolized and distributed to occupied areas.

Many of the univents at the LPS appeared to have been installed when the school was constructed in the 1970s. 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). The operational lifespan of this equipment has long passed. Given its age, continuing to maintain the balance of fresh air to exhaust air will be difficult at best.

The mechanical exhaust ventilation system consists of ceiling-mounted exhaust vents. Some exhaust vents were observed occluded with dust. Exhaust vents were not functioning in a number of classrooms, which can indicate that exhaust ventilation was turned off, or that rooftop motors were not functioning. As with the univents, exhaust vents need to be activated to function as designed. Exhaust vents should also be free of debris to prevent re-aerosolization of these materials, particularly when backdrafting can occur when exhaust vents are not functioning as designed. Without adequate supply and exhaust ventilation, excess heat and environmental pollutants can build up and lead to indoor air/comfort complaints.

Fresh air to common areas such as the library and gymnasium is provided by air-handling units (AHU) via ceiling- or wall-mounted vents. Air is returned to the AHU via ducted vents. Heating, ventilation and air conditioning (HVAC) equipment servicing these areas appeared to be operating at the time of assessment.

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[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).

In a few areas, no provision for supply ventilation was observed, including the music office and offices in close proximity to the library. Since these offices do not have windows, installing a passive supply vent or undercutting doors for make-up air should be considered.

A number of areas are provided with window-mounted or portable air conditioners (ACs). Portable ACs were ducted directly to the general exhaust in offices where they were installed (Picture 4; Table 1). Although this configuration removes the excess heat and exhaust from the AC unit, it prohibits the ability of the general exhaust vent to remove environmental pollutants from the room. As a result, during the heating season, excess heat and odors can became trapped in these areas. As with all ventilation equipment, ACs are also equipped with filters that should be cleaned as directed by the manufacturer or more frequently if necessary.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of building 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 HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The system has reportedly not been balanced due to budgetary constraints.

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.

Temperature measurements ranged from 70°F to 77°F, which were within the MDPH recommended comfort range at the time 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. A number of occupants expressed concerns associated with temperature and temperature control. 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. As discussed, given the age, condition and operating status of ventilation equipment, temperature control will continue to be difficult.

The relative humidity measured in the building ranged from 26 to 39 percent which was either below or close to the lower end of 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

Water-damaged ceiling tiles indicate leaks from either the roof or plumbing system. Water-damaged ceiling tiles were observed in a number of areas (Table 1). Stained tiles in room 211 appeared to be from a leaking roof drain. Water stains on the wall and a ceiling tile were also observed in classroom 204. Mr. Wickland reported that a new roof was installed circa 2009, which repaired the source of water moistening ceiling tiles. All damaged tiles should be replaced. Staff should report any ceiling tiles with recent water staining.

Water-damaged countertops were noted around sinks in some classrooms, particularly PS3 (Picture 5/Table 1). Spaces around sinks provide a means for water to penetrate into wooden countertops and cabinets. Over time, water-damaged wood can provide a medium for mold and mildew growth.

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.

Plants were observed in a number of areas, including on classroom univents (Table 1). Plants can be a source of pollen and mold which can be respiratory irritants to some individuals.

Plants should be properly maintained and equipped with drip pans and located away from univents to prevent the aerosolization of dirt, pollen and mold.

BEH staff examined the outside perimeter of the building to identify breaches in the building envelope and/or other conditions that could provide a source of water penetration. A number of signs moisture infiltration were identified, such as missing/damaged mortar around brick and efflorescence[2] on the surface of brickwork (Pictures 6 through 8). Both the roof and the building's exterior should be examined to determine source of water. While weepholes were observed in a few exterior wall portions, all weepholes should be identified and re-established to ensure water can be removed/drained from the building.

Other Indoor Air 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 indoor environment, BEH staff obtained measurements for carbon monoxide and PM2.5.

[2] Efflorescence is a characteristic sign of water damage 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.

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). No measurable levels of carbon monoxide were detected inside the building during the assessment (Table 1).

Particulate Matter

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 was measured at 6 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 3 to 20 $\mu g/m^3$ (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 indoors 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, use of stoves and/or microwave ovens in kitchen areas; 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 VOC concentrations, BEH staff examined classrooms for products that may contain these respiratory irritants.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as permanent markers, 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.

Household cleaning products, air fresheners and deodorizing materials were observed in several areas. Air deodorizers 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. Additionally, a Material Safety Data Sheet (MSDS) should be available at a central location for all school chemicals 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.

Laminators and photocopiers were observed in the library and first floor copy room. Although both of these areas are equipped with local exhaust ventilation, it was not operating at the time of the assessment. 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). Local exhaust should be activated/repaired to remove excess heat, odors and particulates when equipment is operating.

BEH staff observed tennis balls which had been sliced open and placed on chair and/or table legs presumably to reduce noise. 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 cause VOCs to off-gas. 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

Other conditions that can affect indoor air quality were observed during the assessment. In several classrooms, items were observed on the floor, 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 cleaned periodically to avoid excessive dust build up. A build up of chalk dust in chalk trays was observed in several classrooms (Table 1). These materials can be aerosolized by air movement from the ventilation system, doors opening and closing, or foot traffic and may present an eye or respiratory irritant.

As mentioned, dust was observed accumulated in univent interiors, exhaust vents, and personal and ceiling fans (Pictures 2, 3, and 9). This equipment should be cleaned periodically in order to prevent dust/debris from being aerosolized and distributed throughout the room.

Finally, signs of bird roosting and nesting materials were observed in univent intake louvers (Picture 8). If the ventilation system is activated, the possibility exists for nesting materials, bird waste and other related particulate to be drawn into the system and be distributed to occupied areas. Birds can be a source of disease, and bird wastes and feathers can contain mold and mildew, which can be irritating to the respiratory system.

Conclusions/Recommendations

The capacity of mechanical ventilation equipment to provide adequate fresh air and exhaust to classrooms is limited, as evidenced by air testing (i.e., carbon dioxide levels above 800 ppm). To remedy building problems, two sets of recommendations are made: **short-term** measures that may be implemented as soon as practicable and **long-term** measures that will require planning and resources to address overall IAQ concerns. In view of the findings at the time of the visit, the following recommendations are provided:

Short Term Recommendations

1. Operate all functional ventilation systems throughout the building (e.g., cafeteria, classrooms) continuously during periods of occupancy. An increase in the percentage of fresh air supply and/or increased exhaust capabilities is recommended. Particular attention should be made to the art room.

2. Repair the exhaust system as needed. Ensure classroom exhaust vents are turned on at the start of school and are allowed to operate during occupancy.
3. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
4. Make provisions for supply/make-up air for music and library offices either by ducting active supply ventilation or installing passive vent.
5. Disconnect portable AC units from general exhaust vents when the units are not in use. Ensure exhaust fans are operating at all times that the building is occupied to ensure pollutants, waste heat and moisture (generated from AC operation) are removed.
6. Use openable windows in conjunction with classroom univents and exhaust vents to facilitate air exchange until repairs that are more permanent can be made. 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. 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 dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
9. Work with staff to identify and repair any remaining leaks (e.g., roof drain impacting room 211). Replace any water-damaged ceiling tiles. Examine the area above these tiles

for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial, as needed.

10. Make repairs to water-damaged building materials throughout the building.

11. Remedy all exterior building envelope conditions that contribute to water infiltration into the building, such as:

    a. Repair cracked masonry and broken, missing mortar in exterior brickwork;

    b. Seal cracks in foundation;

    c. Seal open penetrations into the building; and

    d. Repair or replace broken/leaking windows.

12. Seal seams between counters and backsplashes in classrooms. Consider replacing with one-piece molded countertops as funds become available.

13. Ensure plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial, as needed. Move plants away from fresh air supply sources.

14. Ensure all cleaning products used at the facility should be approved by the school department with MSDSs available at a central location.

15. Refrain from using air fresheners or other air deodorizers.

16. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms.

17. Clean items, including chalk and dry erase marker trays regularly with a wet cloth or sponge to prevent excessive build-up.

18. Remove pencil sharpeners from on top of univents.

19. Consider replacing tennis balls with latex-free tennis balls or glides.

20. Ensure local exhaust is operating in the copy room and the library to remove odors and waste heat when operating the photocopiers and laminators.

21. Clean accumulated dust and debris periodically from the interior of univents, exhaust vents and blades of personal and ceiling fans.

22. Remove bird nests from fresh air intake vent (Picture 8) and clean with an appropriate antimicrobial. Consider installing wire mesh bird screens over air intakes to prevent further roosting as necessary.

23. 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.

24. 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.

Long Term Recommendations

1. Contact an HVAC engineering firm for a building-wide ventilation systems assessment. Based on historical issues with air exchange/indoor air quality complaints, age, physical deterioration and availability of parts for ventilation components, such an evaluation is necessary to determine the operability and feasibility of replacing the equipment.

2. Strong consideration should be given to replacing univents in classrooms. Consideration should also be given to replacing exhaust units.

3. Consider contacting a building envelope specialist to investigate settling of brick and efflorescence.

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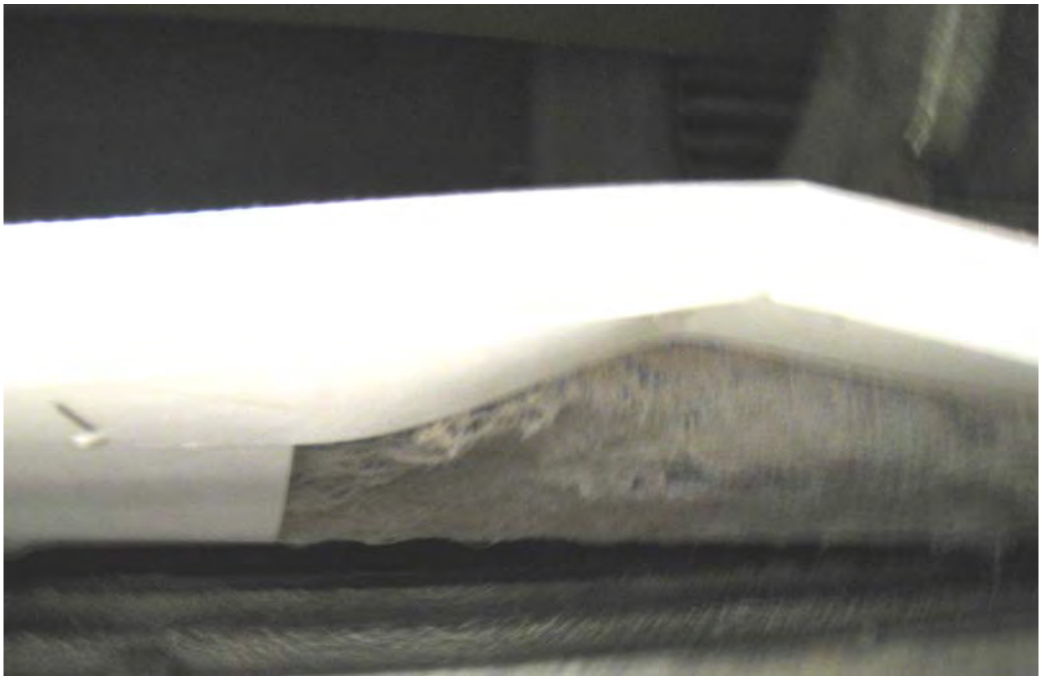
Picture 1

Classroom items obstructing airflow into univent return vent (bottom front)

Picture 2

Univent heating fins occluded with dust/debris

Picture 3



Close-up of univent filter occluded with dust/debris

Picture 4

Portable AC unit connected to general exhaust vent in Nurse's office

Picture 5

Space between sink countertop and backsplash

Picture 6

Efflorescence and missing/damaged mortar around brick

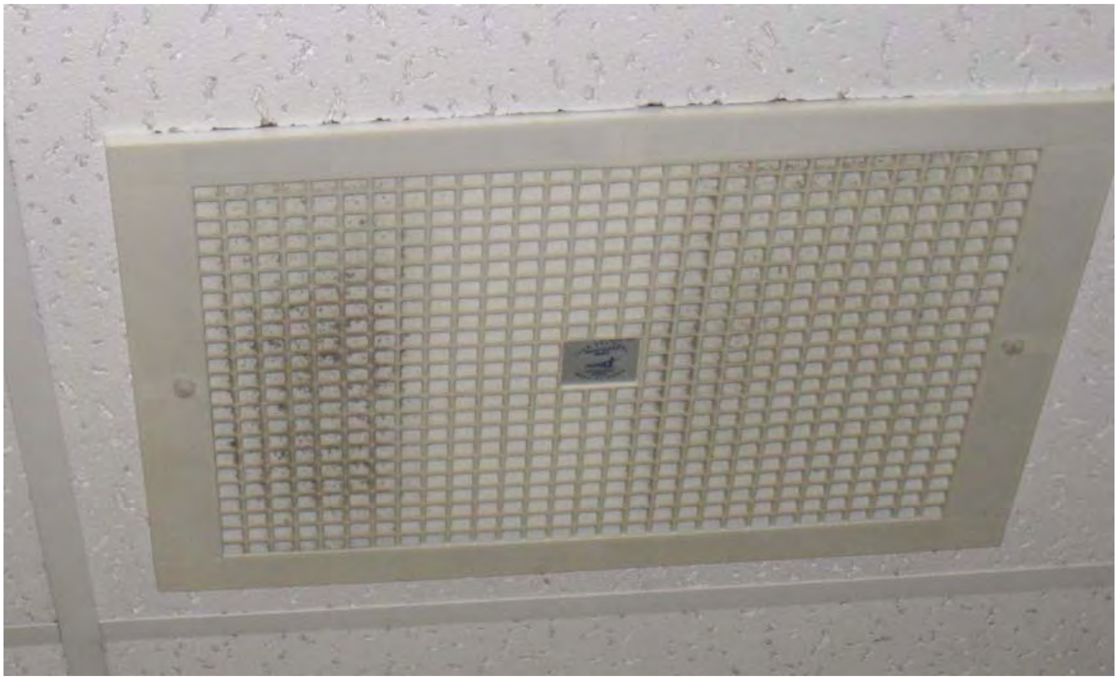
Picture 7

Efflorescence and missing/damaged mortar around brick

Picture 8

Efflorescence on exterior brickwork, also note bird nesting materials in vent

Picture 9



Dirt/dust accumulation on ceiling-mounted exhaust vent

Location: Leicester Primary School **Indoor Air Results**

Address: 170 Paxton Street Leicester, MA **Table 1** **Date: April 13, 2011**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background	435	ND	49	54	6					Rain
101	1294	ND	75	35	8	20	Y	Y	Y	Items/plants on UV, accumulated items
102	1509	ND	75	36	6	0	Y	Y	Y Off	
103	895	ND	70	39	5	0	Y	Y	Y Off	
104	1135	ND	74	32	6	6	Y	Y	Y Off	Crayons in/on UV-wax odors, DO, AC sealed with plastic-drafts
105	1418	ND	73	34	7	24	Y	Y	Y Off	DO, accumulated items
106	1555	ND	77	33	11	24	Y	Y	Y Off	AC, CD
107	962	ND	75	32	5	25	Y	Y	Y	Exhaust off/weak, DO, accumulated items
108	663	ND	75	28	3	1	Y	Y	Y Off	DO, accumulated items, PF

ppm = parts per million
µg/m^3 = micrograms per cubic meter
ND = non detect
AC = air conditioner
AD = air deodorizer
AT = ajar ceiling tiles
CD = chalk dust
CF = ceiling fan
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
PF = personal fan
PS = pencil shavings
TB = tennis balls
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%

Location: Leicester Primary School | **Indoor Air Results**

Address: 170 Paxton Street Leicester, MA | **Table 1 (continued)** | **Date: April 13, 2011**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
109	591	ND	74	28	3	1	Y	Y	Y Off	30 computers, AC-sealed with plastic
118 OT/PT	713	ND	74	30	4	2	Y	Y	Y	Plants on UV, AC-sealed with plastic, plants, seeds/dried food
201	1079	ND	72	36	9	10	Y	Y Off	Y	CPs, TB, PF, DO, water stain, window AC unit
202	1688	ND	74	39	12	20	Y	Y Off	Y	Items on top of UV, exhaust dusty/weak, TB, WD CT, AT, DO, CD, CP-wipes
203	1434	ND	76	35	14	17	Y	Y	Y	Items/plants on UV, exhaust dusty/weak, CD, CPs, DO
204	1702	ND	76	35	12	1	Y	Y Off	Y Off	Plants/items on UV, 3 WD CTs, water staining on wall, TB
205	1374	ND	76	32	12	20	Y	Y Off	Y Off	Dusty exhaust vent, DO, AT, CD
206 Art	689	ND	75	28	6	0	Y	Y	Y	DO, CD
207	1061	ND	76	34	11	24	Y	Y	Y	Items on UV, TB, CPs, accumulated items, PF, DO

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Address: 170 Paxton Street Leicester, MA — **Table 1 (continued)** — **Date: April 13, 2011**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
208	1175	ND	76	31	11	29	Y	Y	Y	Exhaust dusty/weak, TB, DO
209	767	ND	74	30	6	21	Y 1/3	Y Off	Y	DO, CD
210	950	ND	74	32	6	20	Y 1/3	Y Off	Y	Items/PS on UV, UV-dusty, DO, plants, CPs
211	671	ND	72	30	7	7	Y 1/3	Y	Y	CPs, PF, plants, WD CT from roof drain
212	1397	ND	77	31	6	23	Y	Y	Y	Plants on UV
213 Office	1297	ND	75	32	12	8	N	Y Passive	N	PCs, AD, AC
2nd Floor Boys Room		ND	77	32		0		N	Y	DO
2nd Floor Hallway										WD CTs
Burnham	882	ND	77	28	12	3	N	N	Y Off	DEM, CF, AD, recommend under cut door

ppm = parts per million
µg/m^3 = micrograms per cubic meter
ND = non detect
AC = air conditioner
AD = air deodorizer
AT = ajar ceiling tiles
CD = chalk dust
CF = ceiling fan
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
PF = personal fan
PS = pencil shavings
TB = tennis balls
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%

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Cafeteria	1149	ND	76	34	6	~100	Y	Y	Y	3 UVs, DO, items on UVs
First Floor Copy Room	789	ND	74	31	6	1	N	N	Y Off	PC, copier odors, DO, MT
Gym	691	ND	75	28	5	0	N	Y	Y	
K1	1719	ND	74	34	14	22	Y	Y	Y Off	Supply dusty, PF, CPs, WD from leaky sink, AC-sealed with plastic, plants
K2	1497	ND	74	36	7	21	Y	Y	Y	Dusty exhaust vent, AC-sealed with plastic, plants, AD
Library	695	ND	76	26	5	3	N	Y	Y Off	CF, laminator
Library Office	695	ND	76	27	7	0	N	N	N	AC, CF, DO
Main Office	1125	ND	73	34	4	2	N			AC, DO, PC, 3 WD CT
Music Office	1068	ND	77	31	8	2	N	N	Y Off	Consider installing passive supply vent for make-up air

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Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Nurse	1266	ND	73	35		2	N	Y Passive	N	CF, DO, AC ducted to exhaust
Oliver	669	ND	77	27	7	0	N	N	Y Off	CF, PF, DO, recommend under cut door
Principal's Office	756	ND	74	31	5	0	N	Y Passive	N	CF, AC, DO
PS1	713	ND	73	32	4	0	Y	Y	Y	Items on UV, CPs-odor, DO, AC-sealed with plastic
PS2	961	ND	74	35	7	16	Y	Y	Y	DO, CPs, WD
PS2/3 Bathroom		ND				0	N	N	Y Off	
PS3	1292	ND	73	38	20	20	Y	Y	Y Off	Items on UV, exhaust off/dusty, CPs, WD sink, DO

ppm = parts per million	AC = air conditioner	CF = ceiling fan	DO = door open	TB = tennis balls
µg/m^3 = micrograms per cubic meter	AD = air deodorizer	CP = cleaning products	MT = missing ceiling tile	UV = univent
ND = non detect	AT = ajar ceiling tiles	CT = ceiling tile	PF = personal fan	WD = water-damaged
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