INDOOR AIR QUALITY ASSESSMENT

Memorial Elementary School
11 Memorial School Drive
Leicester, MA

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

September 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 Memorial School (LMS) located at 11 Memorial School Drive, Leicester, MA. The request was prompted by general indoor air quality complaints and deteriorating building conditions. On April 7, 2011, a visit to conduct a general IAQ assessment was made to the LMS by Lisa Hébert, Environmental Analyst/Regional Inspector for BEH's IAQ Program.

The school is a two-story brick building constructed in 1954 as the former Leicester Junior High School. The school was converted into an elementary school circa 1995. The roof was reportedly replaced approximately four years ago to control water infiltration. Windows are openable throughout the building. It was reported to BEH staff that the school is in the process of replacing hallway carpeting with vinyl floor tile.

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 school houses approximately 420 third to fifth grade students and approximately 50 staff members. 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 twenty of thirty-five areas surveyed. Of note was that carbon dioxide levels in the art room exceeded 2,000 ppm. The elevated carbon dioxide levels measured in most areas of the school indicate poor air exchange throughout the building, particularly in classrooms that were fully occupied. These levels are due to deactivated/non-functioning/poorly functioning ventilation equipment. It is also important to note that some areas were empty/sparsely populated, which can greatly reduce 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 (Picture 1). A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building (Picture 2) and returns air through an air intake located at the base of the unit. 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 during the assessment, therefore no mechanical means of introduction of fresh air was being provided. Univents were also obstructed by items such as chairs, tables, desks, and books (Picture 3). In order to function as designed, univents must be activated and allowed to operate free of obstructions. Also noted within the air handling cabinets of univents were spaces through the concrete floor around utility pipes (Pictures 4 and 5). These breaches can create a pathway of migration for moisture, odors and/or particulates to be drawn from the crawlspace where it can be distributed by the univent into occupied areas.

Many of the univents at the LMS appeared to have been installed when the school was built in 1954. 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.

Exhaust ventilation in classrooms is provided by hearth-like structures at the base of walls that are connected to exhaust vents on the roof. At the time of the assessment, the exhaust system was found deactivated in many areas (Table 1). In addition, several classrooms had exhaust vents that were either shut or obstructed by various items (Picture 6). As with the univents, exhaust vents need to be activated and free from obstruction to function as designed. Without adequate supply and exhaust ventilation, excess heat and environmental pollutants can build up and lead to indoor air/comfort complaints.

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

[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 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 68°F to 76°F, which were within or close to 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. 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. Given the age, condition and operating status of ventilation equipment, temperature control would be expected to be difficult.

The relative humidity measured in the building ranged from 17 to 35 percent which was below 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

Chronic water damage was evident throughout the building in the form of water-damaged ceiling tiles, ceilings and walls throughout the building (Pictures 7 through 11; Table 1). The LMS appears to have a number of water penetration issues related to the building envelope (roof, windows and exterior walls). It was reported by school officials that the roof had been replaced approximately four years ago to limit water penetration. However, occupants reported active roof leaks in the library. Ceiling tiles should be replaced and water-damaged building materials should be repaired 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.

BEH staff examined the exterior of the building to identify breaches in the building envelope and other issues that could provide a source of water penetration. Several potential sources were identified:

- Damaged/deteriorated brick and mortar (Pictures 12 through 14);
- Cracks were evident in the foundation (Pictures 15 and 16);
- Missing/damaged sealant around univent air intakes (Picture 2). Depending on its age, this sealant may contain regulated materials (e.g., asbestos, polychlorinated biphenyls or PCBs). If so, materials should be addressed in accordance with state and federal regulations/guidance. For further information on regulatory compliance with asbestos and/or PCBs, consult the US Environmental Protection Agency, Massachusetts Department of Environmental Protection and the Massachusetts Department of Occupational Safety. For guidance on addressing PCB-containing materials in schools, consult MDPH guidance (Appendix B);
- Open spaces around utility pipes (Picture 17);
- Clinging plants on exterior walls, which holds moisture against the building (Picture 18); and
- Plant growth between foundation and tarmac (Picture 19).

The aforementioned conditions represent potential water penetration sources. Over time, these conditions can undermine the integrity of the building envelope and provide a means of water entry into the building via capillary action through foundation concrete and masonry

(Lstiburek & Brennan, 2001). The freezing and thawing action of water during the winter months can create cracks and fissures in the foundation. In addition, these breaches may provide a means for pests/rodents to enter 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.

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 5 to 17 $\mu g/m^3$ (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 (e.g., oil/reeds) 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.

BEH staff observed tennis balls which had been sliced open and placed on chair and/or table legs presumably to reduce noise (Picture 20). 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 volatile organic compounds (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. Of note, was the amount of stored foodstuffs/containers inside classrooms, (Pictures 21 and 22), which can serve as an attractant for insects and rodents. Rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine contains a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms (e.g., running nose or skin rashes) in sensitive individuals.

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.

Finally, a hole was observed in the ceiling near a light fixture in the food prep area. Holes in ceilings and walls can provide a pathway for dusts and odors into occupied areas.

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. Make repairs to 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. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
5. 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.
6. 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).

7. Work with staff to identify and repair any remaining leaks (e.g., library). 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.
8. Make repairs to water-damaged building materials throughout the building.
9. 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;
    d. Repair or replace broken/leaking windows;
    e. Determine if sealant around univent air intakes is composed of regulated materials, if so, consult EPA regulations and DPH guidance regarding PCBs in schools; and
    f. Remove plants/trees/vines from impacting the building.
    g. Reduce the amount of food/containers stored and/or prepared in classrooms. Stored and waste food products can be attractive to insect and rodent pests which can contribute to indoor air quality problems.
    h. Use the principles of integrated pest management (IPM) to rid this building of pests. Refer to the IPM Guide, which can be obtained at the following Internet address: http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf.
    i. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms.

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

10. Consider replacing tennis balls with latex-free tennis balls or glides.
11. Properly seal abandoned plumbing pipes in teacher's lounge.
12. Repair hole near light fixture in ceiling over food prep area.
13. 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.
14. 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 replacing interlocking ceiling tile system.

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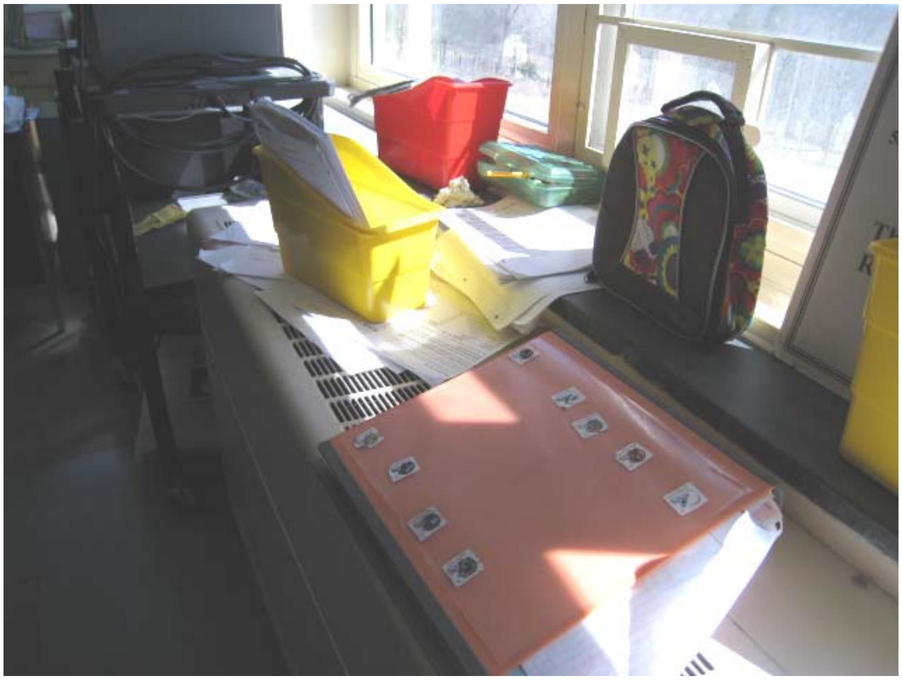
Picture 1

1950's Vintage Univent

Picture 2

Univent Fresh Air Intake, Note Missing/Damaged Sealant around Grate

Picture 3



Univent Air Diffuser Obstructed by Various Items

Picture 4

Spaces around Utility Pipes in Floor of Univent Cabinet

Picture 5

Spaces around Utility Pipes in Floor of Univent Cabinet

Picture 6

Classroom Exhaust Vent Obstructed by Box

Picture 7

Water-Damaged Ceiling Tiles

Picture 8

Missing/Water Damaged Ceiling Tiles

Picture 9

Cracked/Damaged Ceiling Plaster

Picture 10

Water-Damaged Wall Plaster

Picture 11

Water-Damaged Window/Wall Plaster

Picture 12

Damaged Exterior Brickwork

Picture 13

Damaged Exterior Brickwork

Picture 14

Damaged Exterior Brickwork

Picture 15

Damaged Brickwork and Foundation

Picture 16

Damaged Foundation

Picture 17

Open Spaces around Utility Pipes

Picture 18

Clinging Plants on Exterior Wall

Picture 19

Plant Growth between Foundation and Tarmac

Picture 20

Tennis Balls on Chair Legs

Picture 21

Food Products/Containers on Univent in Classroom

Picture 22

Food Products/Containers on Univent in Classroom

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

Address: 11 Memorial School Drive, Leicester, MA | **Table 1** | **Date: April 7, 2011**

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	265	ND	58	11	6					Sunny, clear, mild breeze
Library	920	ND	74	29	6	24	Y	Y	Y	Exhaust-off, WD CT, DO, PF
Computer Room	1259	ND	76	30	8	31	Y	Y	N	DO
Men's Restroom							N	N	Y	
Women's Restroom							N	N	Y	
Nurse	860	ND	73	30	9	5	Y	N	N	Exhaust in restroom, fish tank AC, AD
Vice Principal	884	ND	75	28	8	0	N	N	N	DO
Gym	1035	ND	72	35	17	~30	Y	Y	Y	DO
C	925	ND	72	32	10	0	Y	N	N	DO
D	1065	ND	73	30	6	1	Y	N	N	DO, DEM, WD CT, restroom vent-off
G	827	ND	73	30	8	0	N	N	N	DO, DEM, PF, CD

ppm = parts per million
μg/m^3 = micrograms per cubic meter
ND = non detect
WD = water-damaged
CT = ceiling tile
MT = missing ceiling tile
DEM = dry erase materials
DO = door open
PF = personal fan
AC = air conditioner
CD = chalk dust
CF = ceiling fan
TB = tennis balls
UV = univent
AD = air deodorizer

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	
E	800	ND	73	30	8	0	Y	N	N	DO, CD, WD CT, MT
F	830	ND	73	28	7	0	Y	N	N	DO, DEM, CD, fragrance sticks
Art	2092	ND	72	23	6	23	Y	Y off	N	Room split in halve, exhaust in home economics room next door, WD CT
Kitchen	727	ND	73	24	7	3	Y	N	Y	DO, electric appliances, hole in ceiling over food prep area
Teacher's Lounge	606	ND	71	27	5	0	Y	N	Y	Exhaust-off/blocked, sink not properly capped
Copy Room	530	ND	68	30	7	0	Y	N	Y	Exhaust-off, DO, DEM, dry fountain trap
Cafeteria	707	ND	69	27	5	120	Y	Y	Y	Exhaust blocked
Office	752	ND	74	29	5	3	Y	N	N	
Principal	660	ND	76	25	6	1	Y	N	N	Bathroom exhaust vent
3	495	ND	71	21	5	23	Y open	Y off	Y	DO, TB, DEM, UV open

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								Supply	Exhaust	
4	985	ND	71	20	6	26	Y	Y off	Y	PF, DEM
5	451	ND	71	23	6	6	Y	Y	Y	UV-off, exhaust-off/blocked, DO, DEM, CF, TB
6	789	ND	69	32	7	18	Y	Y	Y	UV-off, WD CT, TB, DEM
7	418	ND	69	20	6	23	Y	Y	Y	UV-off, exhaust blocked, TB, DEM, windows open
8	1017	ND	70	31	7	21	Y	Y	Y	UV-off, DO, DEM, WD CT
9	711	ND	73	23	6	24	Y	Y	Y	UV-off, DO, DEM
10	624	ND	70	30	7	22	Y	Y	Y	UV-off, TB, CD, DO
11	1067	ND	74	28	5	26	Y	Y	Y	UV-off, DO, TB, WD CT
13	995	ND	72	26	6	1	Y	Y	Y	UV-off, DO, TB
15	575	ND	71	27	9	27	Y	Y	Y	Window open, UV-off/blocked, DO

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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		Remarks
								Supply	Exhaust	
16	1108	ND	73	27	9	26	Y	Y	Y	UV-off, DO, TB, WD CT
17	912	ND	73	21	6	23	Y	Y	Y	UV-blocked, DO, exhaust-blocked, CD, DEM
18	1457	ND	74	27	6	26	Y	Y	Y	UV-off/blocked, DO, TB, PF
19	586	ND	72	17	7	23	Y	Y	Y	UV-off, Exhaust-off/blocked, DO, PF
20	1303	ND	74	25	8	26	Y	Y	Y	UV-off, DO, WD CT, DEM
21						0	Y	Y	Y	No occupants in room all day due to field trip, UV-off, DO, DEM, CF, window open, PF
22	1155	ND	73	24	7	19	Y	Y	Y	Exhaust blocked, DO, DEM, PF
23						0	Y	Y	Y	No occupants in room all day due to field trip, UV-off, DO, DEM, CF, cloth curtains, exhaust partially blocked
24	521	ND	73	19	6	4	Y	Y	Y	DO, DEM, CD, PF

ppm = parts per million
µg/m^3 = micrograms per cubic meter
ND = non detect
WD = water-damaged
CT = ceiling tile
MT = missing ceiling tile
DEM = dry erase materials
DO = door open
PF = personal fan
AC = air conditioner
CD = chalk dust
CF = ceiling fan
TB = tennis balls
UV = univent
AD = air deodorizer

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%

Appendix B

An Information Booklet Addressing PCB-Containing Materials in the Indoor Environment of Schools and Other Public Buildings

Prepared by

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Appendix B

INTRODUCTION

The purpose of this information booklet is to provide assistance to school and public building officials and the general public in assessing potential health concerns associated with polychlorinated biphenyl (PCB) compounds in building materials used in Massachusetts and elsewhere. Recently, the U.S. Environmental Protection Agency (EPA) provided broad guidance relative to the presence of PCBs in building materials, notably PCBs in caulking materials. The most common building materials that may contain PCBs in facilities constructed or significantly renovated during the 1950s through the 1970s are fluorescent light ballasts, caulking, and mastic used in tile/carpet as well as other adhesives and paints.

This information booklet, developed by the Massachusetts Department of Public Health's Bureau of Environmental Health (MDPH/BEH), is designed to supplement guidance offered by EPA relative to potential health impacts and environmental testing. It also addresses managing building materials, such as light ballasts and caulking, containing PCBs that are likely to be present in many schools and public buildings across the Commonwealth. This is because the Northeastern part of the country, and notably Massachusetts, has a higher proportion of schools and public buildings built during the 1950s through 1970s than many other parts of the U.S. according to a 2002 U.S. General Accounting Office report. The Massachusetts School Building Authority noted in a 2006 report that 53 percent of over 1,800 Massachusetts school buildings surveyed were built during the 1950s through 1970s. This information booklet contains important questions and answers relative to PCBs in the indoor environment and is based on the available scientific literature and MDPH/BEH's experience evaluating the indoor environment of schools and public buildings for a range of variables, including for PCBs as well as environmental data reviewed from a variety of sources.

<u>1. What are PCBs?</u>

Polychlorinated biphenyl (PCB) compounds are stable organic chemicals used in products from the 1930s through the late 1970s. Their popularity and wide-spread use were related to several factors, including desirable features such as non-flammability and electrical insulating properties. Although the original use of PCBs was exclusive to closed system electrical applications for transformers and capacitors (e.g., fluorescent light ballasts), their use in other applications, such as using PCB oils to control road dust or caulking in buildings, began in the 1950s.

2. When were PCBs banned from production?

Pursuant to the Toxic Substance Control Act (TSCA) of 1976 (effective in 1979), manufacturing, processing, and distribution of PCBs was banned. While the ban prevented production of PCB-containing products, it did not prohibit the use of products already manufactured that contained PCBs, such as building materials or electrical transformers.

3. Are PCBs still found in building materials today?

Yes. Products made with PCBs prior to the ban may still be present today in older buildings. In buildings constructed during the 1950s through 1970s, PCBs may be present in caulking, floor mastic, and in fluorescent light ballasts. Available data reviewed by MDPH suggests that caulking manufactured in the 1950s through 1970s will likely contain some levels of PCBs. Without testing it is unclear whether caulking in a given building may exceed EPA's definition of PCB bulk product waste of 50 parts per million (ppm) or greater. If it does, removal and disposal of the caulk is required in accordance with EPA's TSCA regulations (40 CFR § 761).

4. Are health concerns associated with PCB exposure opportunities?

Although the epidemiological evidence is sometimes conflicting, most health agencies have concluded that PCBs may reasonably be anticipated to be a carcinogen, i.e., to cause cancer.

PCBs can have a number of non-cancer effects, including those on the immune, reproductive, neurological and endocrine systems. Exposure to high levels of PCB can have effects on the liver, which may result in damage to the liver. Acne and rashes are symptoms typical in those that are exposed to high PCB levels for a short period of time (e.g., in industry / occupational settings).

5. If PCBs are present in caulking material, does that mean exposure and health impacts are likely?

No. MDPH/BEH's review of available data suggests that if caulking is intact, no appreciable exposures to PCBs are likely and hence health effects would not be expected. MDPH has conducted indoor tests and reviewed available data generated through the efforts of many others in forming this opinion.

6. How can I tell if caulking or light ballasts in my building may contain PCBs?

If the building was built sometime during the 1950s through 1970s, then it is likely that the caulking in the building and/or light ballasts may contain some level of PCBs. Light ballasts manufactured after 1980 have the words "No PCBs" printed on them. If the light ballast does not have this wording or was manufactured before 1980, it should be assumed that it contains PCBs.

7. What are light ballasts?

A light ballast is a piece of equipment that controls the starting and operating voltages of fluorescent lights. A small capacitor within older ballasts contains about one ounce of PCB oil. If light bulbs are not changed soon after they go out, the ballast will continue to heat up and eventually result in the release of low levels of PCBs into the indoor air.

8. Does the presence of properly functioning fluorescent light ballasts in a building present an environmental exposure concern?

No appreciable exposure to PCBs is expected if fluorescent light ballasts that contain PCBs are intact and not leaking or damaged (i.e., no visible staining of the light lenses), and do not have burned-out bulbs in them.

9. Should I be concerned about health effects associated with exposure to PCBs as a result of PCB-containing light ballasts?

While MDPH has found higher PCB levels in indoor air where light bulbs have burned-out, the levels are still relatively low and don't present imminent health threats. A risk assessment conducted recently at one school did not suggest unusual cancer risks when considering a worst case exposure period of 35 years for teachers in that school. Having said this, MDPH believes that facility operators and building occupants should take prompt action to replace bulbs and/or ballasts as indicated to reduce/eliminate any opportunities for exposure to PCBs associated with PCB-containing light ballasts.

10. When should PCB-containing light ballasts be replaced?

If ballasts appear to be in disrepair, they should be replaced immediately and disposed of in accordance with environmental regulatory guidelines and requirements. However, if light bulbs burn out, the best remedy is to change them as soon as possible. If light bulbs are not changed soon after they go out, the ballast will continue to heat up and eventually result in the release of low levels of PCBs into the indoor air. Thus, burned-out bulbs should be replaced promptly to reduce overheating and stress on the ballast. As mentioned, ballasts that are leaking or in any state of disrepair should be replaced as soon as possible.

It should be noted that although older light ballasts may still be in use today, the manufacturers' intended lifespan of these ballasts was 12 years. Thus, to the extent feasible or in connection with repair/renovation projects, the older light ballasts should be replaced consistent with the intended lifespan specified by the manufacturers.

11. Does MDPH recommend testing of caulking in buildings built during the 1950s - 1980?

Caulking that is intact should not be disturbed. If caulking is deteriorating or damaged, conducting air and surface wipe testing in close proximity to the deteriorating caulking will help to determine if indoor air levels of PCBs are a concern as well as determining the need for more aggressive cleaning. Results should be compared with similar testing done in an area without deteriorating caulking. In this way, a determination can be made regarding the relative contribution of caulking materials to PCBs in the general indoor environment.

12. What if we determine that caulking in our building is intact and not deteriorating?

Based on a review of available data collected by MDPH and others, the MDPH does not believe that intact caulking presents appreciable exposure opportunities and hence should not be disturbed for testing. As with any building, regular operations and maintenance should include a routine evaluation of the integrity of caulking material. If its condition deteriorates then the steps noted above should be followed. Consistent with EPA advice, if buildings may have materials that contain PCBs, facility operators should ensure thorough cleaning is routinely conducted.

13. Should building facilities managers include information about PCB-containing building materials in their Operations and Maintenance (O&M) plans?

Yes. All buildings should have an O&M plan that includes regular inspection and maintenance of PCB building materials, as well as thorough cleaning of surfaces not routinely used. Other measures to prevent potential exposure to PCBs include increasing ventilation, use of HEPA filter vacuums, and wet wiping. These O&M plans should be available to interested parties.

14. Are there other sources of PCBs in the environment?

Yes. The most common exposure source of PCBs is through consumption of foods, particularly contaminated fish. Because PCBs are persistent in the environment, most residents of the U.S. have some level of PCBs in their bodies.

15. Where can I obtain more information?

For guidance on replacing and disposing of PCB building materials, visit the US EPA website: http://www.epa.gov/pcbsincaulk/. For information on health concerns related to PCBs in building materials, please contact MDPH/BEH at 617-624-5757.