INDOOR AIR QUALITY REASSESSMENT

Winthrop Elementary School
162 First Street
Melrose, MA 02176

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
April 2007

Background/Introduction

At the request of Ruth Clay, Director of the Melrose Health Department, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) conducted an assessment of indoor air quality (IAQ) at the Winthrop Elementary School, 162 First Street, Melrose, Massachusetts. This assessment was a follow up to a previous IAQ assessment (MDPH, 2002). On December 5, 2006, Michael Feeney, Director of CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, and Sharon Lee, an Environmental Analyst with the ER/IAQ Program conducted the follow up assessment. Ms. Clay accompanied Mr. Feeney and Ms. Lee during the assessment.

The school is a two-story brick structure. The original school building was constructed around 1926. An addition was constructed in 1956. Openable energy efficient windows were installed throughout the building.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551.

Results

The school has approximately 400 kindergarten through fifth grade students and approximately 40 staff members. The tests were taken during normal operations at the school. 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 15 of 31 areas surveyed, indicating adequate air exchange in approximately 50 percent of the areas surveyed. Based on recommendations made in previous MDPH assessments (MDPH, 2001 and MDPH, 2002), the ventilation system in the 1926 building has been altered from its original design. These improvements have increased the provision of fresh air to classrooms since the previous CEH assessment, in which seventy seven percent (23/30 areas assessed) had carbon dioxide levels above 800 ppm. . Please note that air monitoring was done during school hours, however students were not present in some classrooms for 10 minutes prior to testing. In addition, a number of areas had limited occupancy, which can reduce carbon dioxide levels.

Fresh air to classrooms in the 1926 building is provided by an air handling unit (AHU) located in a large air mixing room on the ground floor of the building. Fresh air is passively provided to the air mixing room via sash windows in the area. Air is drawn through heating elements and into a fan unit. Heated air is distributed to classrooms via ductwork located in a crawlspace beneath the 1926 building that connects the AHU to classroom air diffusers. Exhaust ventilation is provided by rooftop fans connected to wall vents.

Unit ventilator (univent) systems provide fresh air to classrooms in the 1956 portion of the building. A univent draws air from 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 (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were operating at the time of assessment; however obstructions to airflow, such as boxes and tables blocking univents, were observed in a number of classrooms. In order for univents to provide fresh air as designed, fresh air diffusers and univent returns must be unblocked and remain free of obstructions. As with the 1926 portion of the building, exhaust ventilation in the 1956 building is provided by rooftop exhaust fans ducted to wall vents.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be balanced every five years to ensure adequate air systems function (SMACNA, 1994).

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, please refer to Appendix A of this report.

Temperature readings ranged from 68^{o} F to 73^{o} F, which in some areas were below the MDPH recommended comfort range. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity ranged from 21 to 38 percent, below the MDPH recommended comfort range. 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 common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Water-damaged woodwork/shelves were observed in one classroom. This damage is likely related to a leak from the exterior wall or roof. Water penetration and chronic moisture exposure of wood, plywood and corkboard can cause these materials to swell and serve as a growth medium for mold.

Water-damaged ceiling tiles were in Room 35. Water damage to the ceiling is an indication of a roof or pipe leak. Water-damaged ceiling tiles can also provide a source for mold growth and should be replaced after a water leak is discovered and repaired.

The American Conference of Governmental Industrial Hygienists (ACGIH) and the US Environmental Protection Agency (US EPA) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If porous materials are not dried within this time frame, mold growth may occur. Cleaning cannot adequately remove mold growth from water-damaged porous materials. The application of a mildewcide to moldy porous materials (e.g., ceiling tiles) is not recommended.

Lastly, plants were noted in several areas. Plants, soil and drip pans can serve as sources of mold growth, and thus should be properly maintained. Plants should have drip pans to prevent wetting and subsequent mold colonization of window frames. Plants and related materials should also be located away from univents and ventilation sources to prevent aerosolization of dirt, pollen or mold.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, CEH staff obtained measurements for carbon monoxide and PM2.5.

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 pollution 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).

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 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (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 established by the US EPA, 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. The outdoor carbon monoxide concentration was non-detect (ND) (Table 1). Carbon monoxide levels measured in the school were also ND.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. 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). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate 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 proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 18 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 10 to 40 $\mu g/m^3$, below the NAAQS PM2.5 level of 35 $\mu g/m^3$ in all but two areas. In classroom 35, where CEH staff measured a PM2.5 level of 38 $\mu g/m^3$, students had recently excited the building for lunch. In art hallway, a PM2.5 level of 38 $\mu g/m^3$ was measured. This can be attributed to the open crawlspace door

(Picture 1). An earthy odor was also detected in the hallway outside the art room. This odor is also related to the open crawlspace door. This door should remain closed at all times to prevent movement of crawlspace odors and particulates into occupied areas.

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.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are 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 determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC measurements throughout the building were also ND.

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC-containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Several classrooms contained dry erase boards and dry erase board markers. 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.

One classroom contained a spray lubricant (WD-40®). Spray lubricants contain petroleum distillates, which can be irritating to the eyes, nose and respiratory system and should be used in an area with adequate ventilation (WD-40 Company, 2003).

A photocopier mentioned in a previous report (MDPH, 2002) continues to be located in an unventilated room. Volatile organic compounds (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 ventilation is recommended in this area to help reduce excess heat and odors.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs in a few 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 cause TVOCs 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). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

A broken floor tile was note in a classroom. Materials from broken tiles are more likely to be aerosolized in high traffic areas. Floor tiles of this type and age often contain asbestos. Intact asbestos-containing materials (ACM) do not pose a health hazard. If damaged, ACMs can be rendered friable and become aerosolized. Friable asbestos is a chronic (long-term) health hazard, but will not produce acute (short-term) health effects (e.g., respiratory symptoms, headaches) typically associated with buildings perceived to have indoor air quality problems. Where ACMs are found damaged, these materials should be removed or remediated in a manner consistent with Massachusetts asbestos remediation laws (MDLI, 1993).

Conclusions/Recommendations

Based on conditions observed at the time of assessment, the following additional recommendations are made:

1. Ensure hallway door crawlspace is closed during school hours.
2. Repair water leak that is causing wetting of woodwork in classroom 35
3. Use openable windows in conjunction with classroom mechanical ventilation to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
4. Consider installing local exhaust ventilation in the photocopier area.
5. Discontinue the use of tennis balls on chairs to prevent latex dust generation.
6. Remove and replace damaged floor tile in classroom.

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Picture 1

Door to crawlspace ajar in art hallway

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

Address: 162 First Street, Melrose, MA | **Date: 12/5/2006**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (μg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background		49	18	306	0	0	18				
39	0	70	24	652	0	0	26	Y	Y	Y	Rug cleaner, DEM
35	1	70	23	596	0	0	38	Y	Y	Y	DEM TB
38	23	71	30	990	0	0	10	Y	Y	Y	DEM
37	22	70	28	880	0	0	10	Y	Y	Y	DEM
21	3	72	26	1043	0	0	14	Y	Y	Y	
1	0	68	27	938	0	0	22	Y	Y	Y	Use of WD40 in room Broken floor tile
2	20	70	28	1153	0	0	20	Y	Y	Y	
Art	22	70	31	1100	0	0	37	Y	Y	Y	Crawlspace odors

ppm = parts per million
μg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
DO = door open
FC = food container
GW = gypsum wallboard
MT = missing ceiling tile
NC = non-carpeted

ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals

TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WD = water-damaged
WP = wall plaster

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

Address: 162 First Street, Melrose, MA | **Date: 12/5/2006**

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
23	21	72	21	708	0	0	11	Y	Y	Y	TB, DEM, clutter
24	24	72	22	684	0	0	10	Y	Y	Y	DEM
Teacher lounge	0	71	25	767	0	0	13	Y	Y	Y	UF
22	22	72	28	1395	0	0	18	Y	Y	Y	Supply blocked with books TB
26	24	71	21	657	0	0	10	Y	Y	Y	CD, DEM
25	24	71	22	665	0	0	12	Y	Y	Y	Clutter
31	26	72	38	2302	0	0	32	Y	Y	Y	DEM, TB
27	19	71	22	714	0	0	15	Y	Y	Y	DEM

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T 2-3 Inner room A	0	69	27	846	0	0	13	Y	N	Y	Passive supply vent in door
T 2-3 Inner room B	0	68	27	818	0	0	15	Y	N	Y	Passive supply vent in door
33	17	68	26	847	0	0	13	Y	Y	Y	
32	22	70	27	864	0	0	16	Y	Y	Y	
35	22	71	25	711	0	0	11	Y	Y	Y	WD wood cabinet
30	20	71	23	686	0	0	11	Y	Y	Y	
34	23	69	24	720	0	0	13	Y	Y	Y	DEM, TB
T 2-3 Nurse's office	1	70	26	861	0	0	16	Y	Y	Y	

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									Supply	Exhaust	
Cafeteria	200+	70	28	931	0	0	10	Y	Y	Y	
OP/PT	0	73	25	787	0	0	7	Y	Y	Y	1 WD-CT
Art Room Hallway	0	71	26	1070	0	0	40	N	N	N	Door to crawlspace open
HVAC system air mixing room	-	64	21	495	0	0	10	N	Y	N	
Reading lab	1	75	27	797	0	0	8	N	Y	N	TB
Main office	2	72	20	622	0	0	9	Y	Y	Y	
Principal's office	0	73	21	775	0	0	11	Y	N	N	

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