INDOOR AIR QUALITY ASSESSMENT

Cyrus Pierce Middle School
10 Surfside Road
Nantucket, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality concerns at the Cyrus Pierce Middle School (CPMS), 10 Surfside Road, Nantucket, Massachusetts. The request was prompted by health concerns thought to be associated with indoor air quality.

On March 6, 2007, a visit to conduct an assessment of the CPMS was made by Michael Feeney, Director of BEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. The CPMS is multi wing, one story, cedar shake clad building constructed in 1954. The school is built on a concrete slab. The school was renovated in 1990. Windows throughout the building are openable.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). BEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The CPMS houses approximately 275 sixth to eighth grade students and approximately 50 staff members. Tests were taken during normal operations at the school. 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 20 of 26 areas, indicating inadequate air exchange in most areas surveyed. It is important to note that the outdoor temperature on the day of the assessment ranged from 15° F to 17° F. During cold weather temperature extremes, introducing fresh air into the heating, ventilating and air-conditioning (HVAC) systems is often limited to prevent heating coils from freezing and subsequently bursting.

Fresh air in classrooms is supplied by unit ventilator (univent) systems. 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 diffuser located on the top of the unit. BEH staff observed materials stored on top univents and/or furniture placed in front of univents (Picture 1). In order for univents to function adequately, they must remain free of obstructions. Mechanical exhaust ventilation in classrooms is provided by ceiling-mounted exhaust vents ducted to rooftop exhaust fans.

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 HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing was not available at the time of the assessment.

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, see Appendix A.

Temperature measurements ranged from 70° F to 76° F, which were within the MDPH recommended comfort range during 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.

The relative humidity measurements ranged from 12 to 19 percent during the assessment, which were 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 very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Water-damaged ceiling tiles were observed in several areas. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed.

Plants were observed in several classrooms (Picture 2). Plants can be a source of pollen and mold, which can be a respiratory irritant to some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Other IAQ Evaluations

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, BEH 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, 2006). 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. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured inside 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 PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 5 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 2 to 29 $\mu g/m^3$, which were below the NAAQS PM2.5 level of 35 $\mu g/m^3$ in all 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 particulates 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.

Of note was the PM2.5 measurement in the wood shop. During the course of this assessment, wood dust odor was noted in the hallway (between classrooms 15 and 17) leading to the wood shop. As reported by the shop teacher, the wood dust collector is in disrepair (Picture 3), so an exterior door is opened to provide ventilation. By opening an exterior door, cold air entering the door pressurizes the wood shop, which then forces wood dust and other shop odors into the hallway. Wood dust is irritating to the eyes, nose and throat and should be vented directly outdoors via a functioning wood dust collection system.

Indoor air quality can also be negatively influenced by the presence of materials 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 determine whether VOCs were present in the building, air monitoring for TVOCs was conducted during the assessment. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC concentrations were ND in all but one area surveyed (Table 1).

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.

Accumulated items were observed in many classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, univents, bookcases and desks. The materials stored in classrooms provide surfaces for dust to accumulate. Storage of materials in this manner makes cleaning difficult for custodial staff. Dust can be irritating to eyes, nose and respiratory tract.

Conclusions/Recommendations

In view of the findings at the time of the assessment, CEH makes the following recommendations:

1. Repair the wood dust collector. Install a door sweep and weather-stripping on the wood shop door to serve as a barrier to prevent wood dust migration into the hallway.

2. Remove water-damaged ceiling tiles in a manner consistent with recommendations found in "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (2001). Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.

3. Increase the amount of fresh air for rooms with carbon dioxide levels above 800 ppm. To maximize air exchange, operate both supply and exhaust ventilation continuously during periods of school occupancy.

4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

5. Ensure plants have drip pans. Avoid over watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary. Keep plants away from univents in classrooms.

6. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up. To control for dusts, a HEPA filter equipped vacuum cleaner should be used.

7. Consider adopting the US EPA (2000) document, “Tools for Schools”, to maintain a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

8. Refer to resource manuals and other related indoor air quality documents for additional building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH’s website: http://mass.gov/dph/indoor_air.

References

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Picture 1

Univent Blocked By Hamster Pen

Picture 2

Plants in Classroom

Picture 3

Wood Dust Collector

Location: Cyrus Pierce Middle School **Indoor Air Results**

Address: 10 Surfside Road, Nantucket, MA **Date: 3/6/2007**

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		<32	12	375	0	0	5				
15	17	74	16	1230	0	0	7	Y	Y	Y	DO
17	23	74	16	1152	0	0	5	Y	Y	Y	DO
10	0	72	13	575	0	0	3	Y	Y	Y	DO
19	0	72	12	632	0	0	6	Y	Y	Y	Wood odor DO
21	0	73	12	601	0	0	10	Y	Y	Y	Plants Univent blocked with furniture DO
12	20	72	15	841	0	0	11	Y	Y	Y	DO
23 wood shop	15	73	12	561	0	0	29	Y	Y	Y	Wood dust collector inoperable

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: Cyrus Pierce Middle School **Indoor Air Results**

Address: 10 Surfside Road, Nantucket, MA **Date: 3/6/2007**

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		Remarks
									Supply	Exhaust	
CPS	2	72	12	946	0	0	9	Y	N	N	DO
CPS private office	0	72	12	972	0	0	6	Y	N	N	
Principal	1	70	19	862	0	0	5	Y	Y	Y	
Medical office	2	70	18	891	0	0	5	Y	N	N	
22	2	72	18	1320	0	0	2	Y	Y	Y	2 WD CT DO
20	1	73	17	1207	0	0	4	Y	Y	Y	DO
18	2	72	18	1577	0	0	7	Y	Y	Y	DO
16	2	73	15	1207	0	0	4	Y	Y	Y	DO Plants 2 WD CT

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									Supply	Exhaust	
26	3	73	15	978	0	0	7	Y	Y	Y	DO UF
1	3	72	15	1179	0	0	8	Y	Y	Y	DO
6	18	72	14	835	0	0	6	Y	Y	Y	DEM
3	21	72	16	1050	0	0	9	Y	Y	Y	DEM Plants
5	8	72	16	1174	0	0	4	Y	Y	Y	Plants on univent
8	13	72	17	999	0	0	4	Y	Y	Y	Plants on univent Clutter
11	1	73	12	617	0	0	4	Y	Y	Y	DO
13	22	76	16	1261	0	0	6	Y	Y	Y	DO

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									Supply	Exhaust	
7	4	72	14	931	0	0	3	Y	Y	Y	DO Plants
9	7	73	14	896	0	0	5	Y	Y	Y	DO DEM Plants
21	0	73	12	601	0	0	10	Y	Y	Y	Univent blocked with furniture Plants

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