INDOOR AIR QUALITY ASSESSMENT

Executive Office of Health and Human Services
IT Project Management Office
399 Washington Street
Boston, Massachusetts 02108

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
May 2009

Background/Introduction

At the request of Doug Shatkin, Human Resources Director, Office of Children, Youth & Families, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality concerns at the Executive Office of Health and Human Services' Information Technology (IT) Project Management Office, 399 Washington Street, Boston, Massachusetts. The request was prompted by indoor air quality and comfort concerns.

On March 16, 2009, Mike Feeney, Director, and James Tobin, Environmental Analyst/Inspector for BEH's Indoor Air Quality (IAQ) Program visited the building to conduct an assessment. During the assessment, BEH staff were accompanied by Suzanne Gorham, Senior Project Manager. Mr. Tobin returned to the building on March 20, 2009 accompanied by Sharon Lee, Environmental Analyst/Inspector in BEH's IAQ Program, and Dan Morrissey, Property Manager. Ms. Gorham was also present.

The IT Project Management office occupies the third and fourth floors of a five-story building. The IT office space consists of perimeter offices, work stations (cubicles), and common areas. Windows are openable in perimeter areas.

The building was previously visited by BEH staff in November 1998, prior to building renovations to the third, fourth and fifth floors; and again in March 2000 when the Appellate Tax Board occupied the third floor. Reports detailing conditions observed at the time of those assessments, as well as recommendations for improving indoor air quality were issued (MDPH, 1998; MDPH, 2000).

The entrance of the building has an elevator lobby and stairwell in the front of the building. The front stairwell terminates at the third floor lobby of the IT office. A second stairwell and service elevator are located in the back of the building. Both stairwells and the service elevator terminate in the basement. The basement, first and second floors of the building were vacant at the time of the assessment.

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.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in 52 of 56 areas surveyed, indicating adequate air exchange in the large majority of areas at the time of the assessment. The heating, ventilating and air conditioning (HVAC) system consists of air handling units (AHUs), which draw outside air in through air intakes and distribute it to occupied areas via ceiling-mounted air diffusers (Picture 1). Exhaust ventilation is provided by infiltration of air into an above ceiling open plenum return, which draws air through passive ceiling grates (Picture 2). This system has no ductwork, but uses the entire above ceiling space to draw air back to the AHUs. Several areas had missing, damaged or dislodged ceiling tiles. Missing ceiling tiles in an open plenum return system compromises the efficiency of exhaust ventilation to remove stale air from the building.

A number of offices lack exhaust grates including a third-floor conference room. BEH staff noted a lingering dry erase marker odor upon entering this room, where a meeting reportedly concluded 30 minutes earlier. Without adequate exhaust ventilation, excess heat and environmental pollutants can accumulate and cause irritation and/or discomfort, especially when doors to these areas are closed.

The network server room on the fourth floor lacks exhaust ventilation and a means of air-conditioning (AC). At the time of the assessment, a personal fan was positioned to blow air out through the open door into the hallway and adjacent areas. The server room houses heat-generating equipment. Lack of adequate ventilation in these types of rooms can result in excessive heat buildup leading to malfunction of computers, network and/or communication equipment as well as comfort complaints.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of 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 Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

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

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, consult Appendix A.

Indoor temperature measurements ranged from 70° F to 78° F, which were within the MDPH recommended range in all areas surveyed (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 measured in the building ranged from 21 to 26 percent at the time of the assessment, 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

BEH staff performed visual inspection of building materials for water damage and/or microbial growth. Several areas had water-damaged/missing ceiling tiles which can indicate leaks from either the roof or plumbing system (Picture 3). 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/discarded.

Basement Examination

BEH staff examined the basement of the building. The basement door at bottom of the front stairwell in the basement opens to a hallway, where, to the right, a door opens to a water meter room; to the left, a door opens to a vacant retail space (Pictures 4 – 6). In the retail space, carpets were old and water-damaged. At the back of the retail space, a hallway leads to a stairwell and service elevator that connects to a pump room, where BEH staff found standing water (Pictures 7 – 9). Due to the stagnant water, this area of the building also acts as a breeding ground for mosquitoes. Mr. Morrissey reported that a program was in place with a pest control company to eradicate mosquito breeding. The rear stairwell and service elevator are both in close proximity to the pump room. The door to the pump room was open at the time of the assessment. In this situation, there is no barrier between the pump room and hallway which would allow water vapor and/or odors as well as mosquitoes, if present, to migrate into adjacent areas.

Other IAQ Evaluations

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

Carbon Monoxide

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2006). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2006).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). No detectable levels of carbon monoxide were measured in the building (Table 1).

Particulate Matter (PM2.5)

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram 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 μg/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 the day of the assessment were measured at 13 μg/m^3. PM2.5 levels measured inside the building ranged from 2 to 7 μg/m^3 (Table 1), which were below the NAAQS PM2.5 level of 35 μg/m^3. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in buildings can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Volatile Organic Compounds

Indoor air concentrations can be greatly impacted by the use of products containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to identify materials that can potentially increase indoor VOC concentrations, BEH staff examined rooms for products containing these respiratory irritants.

As previously mentioned, BEH noted a lingering dry erase marker odor in a conference room without exhaust ventilation. Offices and meeting rooms throughout both floors contained dry erase boards and related materials. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Other Conditions

A number of air diffusers, exhaust grates and personal fans were observed to have accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles. Re-activated air diffusers and fans can also aerosolize dust accumulated on vents/fan blades. As previously mentioned, ceiling tiles were missing in several areas. Missing ceiling-tiles can provide pathways for drafts, dust and particulates to migrate into occupied areas.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made to improve indoor air quality:

1. Install exhaust grates to areas currently without a means of exhaust ventilation.
2. Install AC system in the fourth floor network server room.
3. Replace missing ceiling tiles to maintain balance in the HVAC system and prevent odors and particulate migration. Ensure that the integrity of the ceiling plenum remains intact to increase efficiency of the ventilation system.

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

5. Change filters for air-handling equipment (e.g., AHUs and ACs) as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.

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 for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

7. Ensure roof/plumbing leaks are repaired. Remove/replace any remaining water damaged ceiling tiles. Examine the areas above and around for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

8. Ensure doors in basement remain closed including the stairwell and pump room. Seal these doors with weather stripping to render them airtight and prevent mosquitoes and/or odors from traveling to occupied spaces.

9. Continue working with pest control company to limit mosquito breeding in basement pump room.

10. Clean air diffusers, exhaust grates and personal fans periodically of accumulated dust.

11. 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.

References

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Picture 1

Air Diffuser

Picture 2

Exhaust Grate

Picture 3

Water-Damaged Ceiling Tiles near Light Fixture

Picture 4

Basement Door at the Bottom of Front Stairwell

Picture 5

Door to Water Meter Room

Picture 6

Door to Basement Retail Space

Picture 7

Water-Damaged Carpet in Basement Retail Space

Picture 8

Pump in Pump Room

Picture 9

Standing Water in Pump Room

Location: Executive Office of Health and Human Services, IT Project Management Office **Indoor Air Results**

Address: 399 Washington Street, Boston, MA **Table 1** **Date: 3 – 16 – 2009**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
background		43	34	343	ND	13				
310	1	72	24	604	ND	5	Y	Y	Y	
311	3	73	23	673	ND	5	N	Y	Y	
325	0	72	23	645	ND	4	N	Y	Y	AC; server; tile floor
324	0	72	24	668	ND	5	N	Y	Y	DEM; DO
318	1	73	24	690	ND	5	N	Y	Y	DO
319	1	73	24	682	ND	5	N	Y	Y	DEM; DO
323	0	74	23	694	ND	3	N	Y	Y	DEM
322	1	74	23	690	ND	4	Y	Y	Y	DEM; DO; Plants
317	0	75	22	622	ND	4	N	Y	Y	DEM

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter

AC = air conditioner
AD = air deodorizer
CPs = cleaning products
CT = ceiling tile

DEM = dry erase materials
DO = door open
MT = missing ceiling tile
ND = non detect

PC = photocopier
PF = personal fan
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%
Particle matter 2.5 < 35 ug/m^3

Location: Executive Office of Health and Human Services, IT Project Management Office **Indoor Air Results**

Address: 399 Washington Street, Boston, MA **Table 1 (continued)** **Date: 3 – 16 – 2009**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
330	1	75	22	687	ND	5	N	Y	Y	
326	4	76	23	811	ND	4	Y	Y	Y	DEM; DO
327	9	78	22	847	ND	4	Y	Y	Y	DO
328	7	77	22	844	ND	4	N	Y	Y	Microwave; DEM; Plants
316	5	75	21	665	ND	4	N	Y	Y	DEM; DO
315	0	75	21	569	ND	5	N	Y	Y	DEM; Plants
301	0	74	21	628	ND	4	N	Y	Y	DEM; DO; Plants
302	0	73	22	634	ND	4	N	Y	Y	DEM
314	1	73	24	778	ND	5	N	Y	N	

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								Supply	Exhaust	
303	3	72	26	954	ND	2	N	Y	Y	
305	0	73	23	668	ND	5	N	Y	Y	DEM; DO
306	0	74	22	654	ND	5	N	Y	Y	
307	0	74	21	623	ND	7	Y	Y	Y	Space heater; DEM; DO
304	1	74	22	654	ND	4	N	Y	Y	DEM
329	0	73	23	781	ND	6	N	Y	N	Meetings prior to assessment, occupants gone 30 min; marker smell in room
312	7	75	22	679	ND	5	N	Y	Y	DEM
313	1	76	21	670	ND	5	N	Y	Y	
Kitchen near 311	0	74	21	629	ND	6	N	Y	N	Refrigerator; microwave; MTs; CPs

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								Supply	Exhaust	
300	0	73	23	740	ND	5	N	Y	Y	DEM
308	1	73	22	623	ND	5	Y	Y	Y	DEM
309	0	73	21	585	ND	4	Y	Y	Y	DEM
4000/4007	3	73	23	675	ND	5	Y	Y	Y	Plants
4th Floor, CTO Conference Room	0	73	21	569	ND	5	Y	Y	Y	DEM
4008 – 4011	4	74	23	692	ND	4	Y	Y	Y	DO
4015	0	74	21	649	ND	4	Y	Y	Y	DEM; DO; Plants
4016	0	75	21	631	ND	4	N	Y	Y	PF; DEM; DO

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Address: 399 Washington Street, Boston, MA | Date: 3 – 16 – 2009

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
4017	0	74	21	615	ND	5	N	Y	Y	DEM; DO
4012 – 4014	1	74	21	674	ND	4	N	Y	Y	DO
4018	0	74	21	608	ND	5	N	Y	Y	DO
4019	0	74	21	596	ND	5	N	Y	Y	DEM; DO
4020/4021	1	73	22	630	ND	4	N	Y	N	DO
4022	0	74	21	598	ND	5	N	Y	Y	DEM
4028	1	74	22	594	ND	5	N	Y	Y	DEM; DO
4029	1	74	22	598	ND	6	N	Y	Y	DEM; DO
4030	0	73	22	593	ND	5	N	Y	Y	DO

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								Supply	Exhaust	
4037	0	73	22	575	ND	5	N	Y	Y	
4039	0	72	22	571	ND	5	N	Y	N	DEM; DO
4046	0	71	23	573	ND	5	N	Y	N	WD CTs
4040 – 4045	2	70	22	486	ND	7	N	Y	Y	DEM; DO
4047	1	70	23	497	ND	6	N	Y	N	DEM
4031 – 4036	2	73	22	555	ND	6	N	Y	Y	DEM; DO
4025	0	73	21	585	ND	5	N	Y	N	DEM; DO
4026	0	72	21	571	ND	6	N	Y	N	DEM
4023/4024	1	72	22	610	ND	6	N		N	PF

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	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

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								Supply	Exhaust	
4th floor, Vending Machine Area	0	74	22	638	ND	5	N	N	Y	Vending Machines; PC; Laminator
4th floor, Office off Vending Area	1	75	22	678	ND	6	N	Y	Y	DO
4th floor, Server Room	0	77	21	676	ND	5	N	Y	N	MTs; PFs blowing out opened door

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