INDOOR AIR QUALITY
POST-OCCUPANCY ASSESSMENT

Massachusetts Department of Revenue
67 Millbrook Street
Worcester, Massachusetts

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

Background/Introduction

In response to a request from Gerald Covino, Project Manager, Office of Leasing, Division of Capital Asset Management (DCAM), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) conducted post-occupancy air testing at the DOR offices located at 67 Millbrook Street, Worcester, Massachusetts. This air sampling was conducted to assess the indoor air quality of newly occupied space leased by Massachusetts state agencies. On July 30, 2010, a visit to conduct indoor air quality testing was made by Michael Feeney, Director of BEH's IAQ Program.

The DOR is located on the third floor of a rehabilitated former factory building. The floor is subdivided into various program sections and has a combination of private offices and work stations. DOR also has storage space in a below-grade basement, where a room exists for document viewing. The basement room has a raised floor that is carpeted. The building has no openable windows.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor 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. Screening for total volatile organic compounds was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). BEH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The tests were taken during normal operations. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas tested, indicating adequate air exchange at the time of the assessment (Table 1). Fresh air is provided by air handling units (AHUs) located in mechanical rooms. Fresh air is drawn into AHUs through intakes at the rear of the building, is heated or cooled and delivered to occupied areas via ducted air diffusers. Return air is drawn into ceiling-mounted return vents and ducted back to AHUs.

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, please see Appendix A.

Indoor temperatures ranged from 67°F to 72°F (Table 1), which were within or close to the lower end of 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.

Relative humidity measurements ranged from 42 to 53 percent, which were within 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

No water damage was noted in third floor DOR locations. However, BEH staff detected a musty odor in the basement records examination room, where DOR staff reported that the foundation had experienced water penetration. Water reportedly accumulated underneath the

raised floor, which is carpeted (Picture 1). It is likely that under certain conditions, this area of the basement may experience further water damage. Water penetration would likely accumulate in the false floor cavity, chronically moistening the wood and carpeting.

The American Conference of Governmental Industrial Hygienists (ACGIH) and the US Environmental Protection Agency (US EPA) recommend 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. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to porous materials is not recommended.

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. On the day of the assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). No measureable levels of carbon monoxide were detected in 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). Levels of PM2.5 ranged from ND to 3 $\mu g/m^3$ during the assessment (Table 1). Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of activities that occur indoors and/or mechanical devices 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) within the building. VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total volatile organic compounds (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 on the day of the assessment were ND (Table 1). No measurable levels of TVOCs were detected in the building during the assessment (Table 1).

Other Conditions

The northernmost AHU mechanical room appears to have formerly contained a washroom. A number of disconnected drains and pipes exist in this area, some of which were sealed with fiberglass insulation (Picture 2). Abandoned pipes and drains should be permanently sealed with an appropriate material to prevent possible odor backup.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Consideration should be give to removing the false floor and carpeting from the basement records viewing room to prevent wood rot, mold growth and associated odors. Consider using floor tile or other non-porous surface for this area.

2. Seal all abandoned pipes and drains with a permanent sealant.

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

4. 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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OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, D.C. EPA 402-K-01-001. March 2001. http://www.epa.gov/iaq/molds/mold_remediation.html

US EPA. 2006. National Ambient Air Quality Standards (NAAQS). US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html

Picture 1

Records Examination Room in Basement

Picture 2

Abandoned Drain Sealed With Insulation

Location: Department of Revenue

Address: 67 Millbrook St., Worcester, MA

Indoor Air Results

Date: 7/30/2010

Table 1

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (ug/m3)	Windows Openable	Ventilation		Remarks
Outside (Background)		73	42	392	ND	ND	6				
70	0	72	46	476	ND	ND	ND	N	Y	Y	
Reg. Mgr	0	70	45	446	ND	ND	ND	N	Y	Y	
2	1	69	46	570	ND	ND	ND	N	Y	Y	
22	2	70	47	560	ND	ND	ND	N	Y	Y	
34	3	70	47	565	ND	ND	ND	N	Y	Y	
11	0	69	48	558	ND	ND	ND	N	Y	Y	
13	3	69	47	570	ND	ND	ND	N	Y	Y	
23	3	69	48	560	ND	ND	ND	N	Y	Y	
26	0	69	48	560	ND	ND	ND	N	Y	Y	
Man 6	0	69	47	543	ND	ND	ND	N	Y	Y	

ppm = parts per million

ND = non detect

TVOCs = total volatile organic compounds

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

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: Department of Revenue

Address: 67 Millbrook St., Worcester, MA

Indoor Air Results

Date: 7/30/2010

Table 1 (continued)

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (ug/m3)	Windows Openable	Ventilation		Remarks
Man 5	1	68	48	570	ND	ND	1	N	Y	Y	
R11	0	69	45	530	ND	ND	1	N	Y	Y	
R16	0	67	46	500	ND	ND	2	N	Y	Y	
58	0	69	46	553	ND	ND	3	N	Y	Y	
47	3	70	42	540	ND	ND	3	N	Y	Y	
Man 9	3	70	47	515	ND	ND	3	N	Y	Y	
130	0	71	45	785	ND	ND	1	N	Y	Y	
99	1	72	46	485	ND	ND	1	N	Y	Y	
89	1	72	45	475	ND	ND	1	N	Y	Y	
283r	3	72	44	478	ND	ND	ND	N	Y	Y	

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Location: Department of Revenue **Indoor Air Results**

Address: 67 Millbrook St., Worcester, MA **Date: 7/30/2010**

Table 1 (continued)

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (ug/m3)	Windows Openable	Ventilation		Remarks
116	0	71	44	456	ND	ND	ND	N	Y	Y	
136	3	71	45	459	ND	ND	2	N	Y	Y	
127	0	71	45	424	ND	ND	2	N	Y	Y	
135	0	70	45	424	ND	ND	3	N	Y	Y	
Basement	0	72	53	400	ND	ND	ND	N	Y	Y	

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