INDOOR AIR QUALITY
POST-OCCUPANCY ASSESSMENT

Massachusetts Department of Industrial Accidents
360 Merrimack Street
Lawrence, Massachusetts

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

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Background/Introduction

In response to a request from Gerald Covino, Project Manager, 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 Department of Industrial Accidents (DIA), 360 Merrimack St., Lawrence, Massachusetts. This air sampling was conducted to assess the indoor air quality of newly occupied space leased by Massachusetts state agencies. On July 9, 2010, a visit to conduct indoor air quality testing was made by Michael Feeney, Director of BEH's IAQ Program.

The DIA is located on the second floor of a rehabilitated mill building along the south shore of the Merrimack River. 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 exceeded 800 parts per million (ppm) in 18 out of 25 areas at the time of testing, indicating a lack of sufficient air exchange (Table 1). The majority of levels measured above 800 ppm were slight exceedances. Fresh air is provided by a ceiling-mounted air handling unit (AHU). Fresh air is drawn into the AHU through an intake on the Merrimack River side of the building and is heated or cooled and delivered to occupied areas via ducted air diffusers. It is important to note that the elevated carbon dioxide levels were most likely associated with the activation of the air-conditioning system, which was in operation at the time of the assessment. AHUs tend to limit outside air intake during air-conditioning mode to reduce relative humidity and facilitate cooling.

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 70°F to 75°F (Table 1), which were within the MDPH recommended comfort range. 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.

Relative humidity measurements ranged from 41 to 46 percent, which were also within the MDPH recommended comfort range the day of the assessment (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

Some areas of interior brickwork showed signs of efflorescence near windows (Pictures 1 and 2). Efflorescence is caused by water penetration dissolving minerals within the brick/mortar as it flows through. The water evaporates on the surface of the brick leaving behind a dry white residue. While efflorescence is a characteristic sign of water penetration, it is not mold growth. Although some efflorescence was seen, water penetration issues appeared to be minimal.

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 8 $\mu g/m^3$ (Table 1). No measurable levels of PM2.5 were detected in the building 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 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) 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 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

One location, area 213, was a missing a ceiling tile (Table 1). To prevent dust and debris in the ceiling plenum from entering occupied space, the ceiling tile should be replaced.

Conclusions/Recommendations

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

1. Make adjustments to mechanical ventilation to increase introduction of fresh/outside air.
2. Replace missing ceiling tiles.
3. Clean efflorescence from interior brick walls and monitor for further water penetration. If further water penetration occurs, exterior brick may need re-pointing/waterproofing.
4. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
5. 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

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989.

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL.

MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

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.

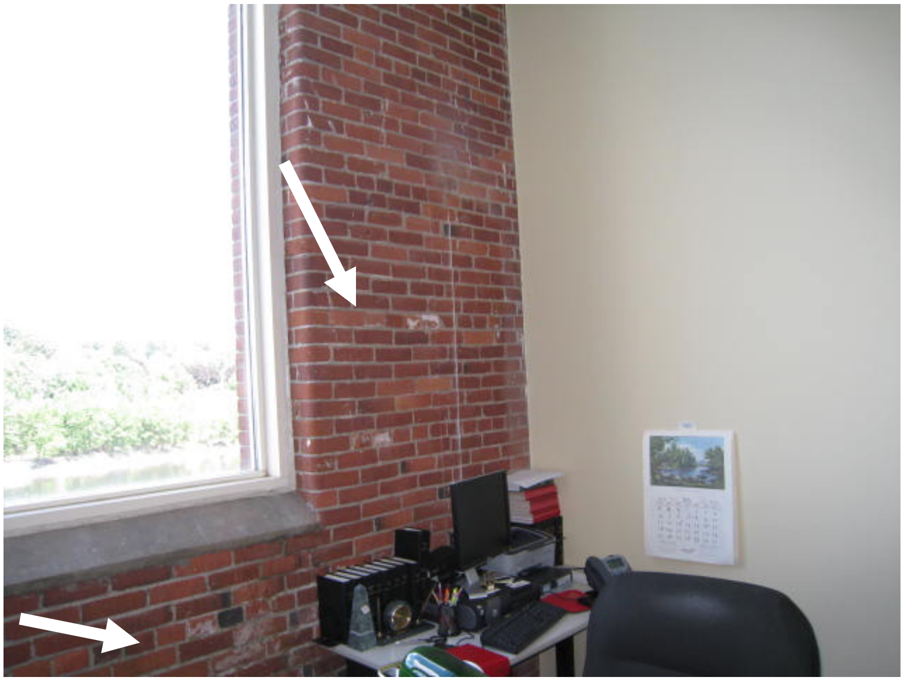
SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

US EPA. 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

Exterior Brick and Windows

Picture 2



Small Amount of Efflorescence near Windows (Arrows)

Location: Massachusetts Department of Industrial Accidents **Indoor Air Results**

Address: 360 Merrimack St., Lawrence, Massachusetts **Date: 7/9/2010**

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)			53	373	ND	ND	8				
303/304	1 72	74	44	840	ND	ND	ND	N	Y	Y	
216/215	0	73	44	849	ND	ND	ND	N	Y	Y	
205	0	73	44	822	ND	ND	ND	N	Y	Y	
206	0	72	44	824	ND	ND	ND	N	Y	Y	
207	0	72	45	802	ND	ND	ND	N	Y	Y	
208	0	72	45	821	ND	ND	ND	N	Y	Y	
209	0	71	44	777	ND	ND	ND	N	Y	Y	
210	1	72	41	803	ND	ND	ND	N	Y	Y	
212	1	71	44	803	ND	ND	ND	N	Y	Y	

ppm = parts per million ND = non detect

µg/m^3 = micrograms per cubic meter

TVOCs = total volatile organic compounds

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems	Temperature: Relative Humidity:	70 - 78 °F 40 - 60%

Location: Massachusetts Department of Industrial Accidents **Indoor Air Results**

Address: 360 Merrimack St., Lawrence, Massachusetts **Table 1 (continued)** **Date: 7/9/2010**

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (ug/m3)	Windows Openable	Ventilation		Remarks
213	1	72	41	788	ND	ND	ND	N	Y	Y	1 missing ceiling tile
214	1	73	41	790	ND	ND	ND	N	Y	Y	
215 hall	0	70	46	811	ND	ND	ND	N	Y	Y	
218	0	70	46	766	ND	ND	ND	N	Y	Y	
219	0	73	41	809	ND	ND	ND	N	Y	Y	
220	0	73	45	766	ND	ND	ND	N	Y	Y	
221	0	75	41	805	ND	ND	ND	N	Y	Y	
222	4	75	42	904	ND	ND	ND	N	Y	Y	
224	0	72	45	780	ND	ND	ND	N	Y	Y	

ppm = parts per million ND = non detect

µg/m^3 = micrograms per cubic meter

TVOCs = total volatile organic compounds

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems		

Location: Massachusetts Department of Industrial Accidents **Indoor Air Results**

Address: 360 Merrimack St., Lawrence, Massachusetts **Table 1 (continued)** **Date: 7/9/2010**

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (ug/m3)	Windows Openable	Ventilation		Remarks
225	3	73	46	779	ND	ND	ND	N	Y	Y	
226 restroom	0	72	46	813	ND	ND	ND	N	Y	Y	
230	1	74	43	863	ND	ND	ND	N	Y	Y	
231	0	74	44	873	ND	ND	ND	N	Y	Y	
232	0	74	44	877	ND	ND	ND	N	Y	Y	
233	0	74	43	827	ND	ND	ND	N	Y	Y	
234	0	73	44	830	ND	ND	ND	N	Y	Y	

ppm = parts per million ND = non detect

µg/m^3 = micrograms per cubic meter

TVOCs = total volatile organic compounds

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems	Temperature: Relative Humidity:	70 - 78 °F 40 - 60%