INDOOR AIR QUALITY
POST-OCCUPANCY ASSESSMENT

Health and Human Services Center
330 Lynnway
Lynn, MA

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

Background/Introduction

In response to a request from Bruce Tebo, Project Manager, Division of Capital Asset Management (DCAM), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) conducted post-occupancy indoor air quality (IAQ) testing at the Health and Human Services (HHS) Center, 330 Lynnway, Lynn, Massachusetts. This evaluation was conducted as part of enhanced efforts to assess the air quality of office space leased by Massachusetts state agencies pre- and post-occupancy. On September 23, 2011, a visit to conduct an IAQ assessment was made by Sharon Lee, an Environmental Analyst/Inspector within BEH's IAQ Program.

This HHS Center consists of staff from Department of Children and Families (DCF) and Department of Mental Health (DMH) and occupies the second floor of a multi-story building that also houses medical, legal and consulting firms. Other businesses located at this complex include warehouses for office supplies and food distributors.

Methods

Air tests for carbon monoxide, carbon dioxide, 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. BEH staff also performed visual inspection of building materials for water damage and/or microbial growth and other conditions that may potentially impact indoor air quality.

Results

The DCF and DMH offices have a combined employee population of nearly 150 and can be visited by up to 220 people during a regular day. Tests were taken during normal operations. 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, indicating optimal air exchange at the time of assessment. The space was not fully occupied at the time of testing, hence carbon dioxide levels would be expected to be higher with full occupancy.

Fresh air is provided by rooftop air-handling units (AHUs). Fresh air is drawn into the AHUs through a bank of filters, heated or cooled, and delivered to occupied areas via ducted supply diffusers. Return air is drawn into ceiling-mounted vents and ducted back to the rooftop AHUs. Some offices are designed to have supply vents and passive exhaust vents; the positive pressure created by supply ventilation aides in the removal of stale air from these areas.

AHUs for these areas are controlled by thermostats, which have fan settings of "on" and "auto". The automatic setting on the thermostat activates the system at a preset temperature. Once a preset temperature is measured by the thermostat, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system. At the time of assessment, BEH observed that the thermostat located in area 262 was not functioning (i.e. no display was observed), resulting in a lack of ventilation control. A number of occupants in offices around area 262 expressed concerns regarding thermal discomfort. Without adequate thermostat control of the HVAC system, naturally occurring pollutants (i.e. waste heat) can accumulate.

In a pre-occupancy memo issued by the MDPH (2011), BEH staff recommended providing exhaust ventilation to the copier area by installing ductwork tied to the bathroom exhaust system. At the time of this assessment, BEH staff observed supplemental exhaust in the copier area, which is reportedly tied to the bathroom exhaust system. However, upon examination it appeared that the bathroom exhausts were not operating or operating very weakly.

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). It was reported that the system was balanced prior to occupancy.

The Massachusetts Building Code requires a minimum ventilation rate of 20 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, please see Appendix A.

Indoor temperatures ranged from 72°F to 76°F (Table 1), which were within the MDPH recommended comfort range at the time of assessment. 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. As discussed, thermal discomfort was expressed at the time of assessment. Occupants/staff should work with building management to address thermal/comfort related concerns.

With the exception of the MDF/server rooms, relative humidity measurements ranged from 55 to 70 percent in occupied areas (Table 1), which were above the MDPH recommended comfort range in many areas. Relative humidity in the MDF/server rooms was significantly lower, 40 and 42 percent, due to the operation of supplemental air-conditioning. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Operation of the ventilation system should serve to remove moisture from the air and provide cooling. On the day of assessment, the outdoor relative humidity level was 75 percent. Based on relative humidity levels measured within the building, the current thermostat settings for the ventilation system may not be sufficient for the removal of normally occurring indoor air pollutants (e.g. water vapor from respiration). Moisture removal is important, since the sensation of heat conditions increases as relative humidity increases.

The relationship between temperature and relative humidity is known as the heat index. As indoor temperature rises, the addition of humid air increases occupant discomfort and heat complaints. If moisture levels are decreased, the comfort of the individuals increases. Without adequate ventilation, indoor pollutants and moisture will accumulate.

While temperature is mainly a comfort issue, increased relative humidity can affect building materials. Indoor relative humidity in excess of 70 percent for extended periods of time can provide an environment for mold and fungal growth (ASHRAE, 1989). For example, prolonged periods where indoor relative humidity levels exceed 70 percent can result in condensation generation on windows. Condensation from the windows can pool at the base of the window frame and, if not dried, can result in moistening of wall materials.

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

In order for building materials to support mold growth, a source of water exposure is necessary. Water-damaged ceiling tiles were observed in two areas of the building, 231 and 243 (Picture 1). Bubbled paint was also observed in room 243 (Picture 1), indicating water had moistened the corner of the wall. Unlike other areas occupied by the HHS Center that have additional floors above them, this is the top most floor of this portion of the building. Ductwork located above the ceiling tile system penetrates through the roof to the AHU (Picture 2). Given the number of recent severe weather events, it is likely that the leakage experienced in this area is the result of wind-driven rain causing water to enter the building around ductwork.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). 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 moldy porous materials is not recommended.

Neither the ceiling tile nor the gypsum wallboard (GW) was moist at the time of assessment. However, since it is unclear how long the GW had been wet, measures should be taken to exam the GW. If warranted, it should be removed and replaced in accordance with US EPA (2001) recommendations. This area should be monitored for further leakage.

Plants were observed in some areas (Table 1). In one area, bugs/flying insects were observed around plants. Some plants were also placed on paper towels and cloth napkins. Plants can be a source of pollen and mold which can be respiratory irritants to some individuals. Plants should be properly maintained and equipped with drip pans and should be located away from supply vents to prevent the aerosolization of dirt, pollen and mold. Drip pans should be examined periodically to prevent buildup of materials.

In a few areas, water dispensers were located on carpet (Picture 3) as was a refrigerator (Table 1). Spills/condensation from these appliances can be a source of moisture in carpeting that can lead to water damage and mold growth. When possible, these units should be located in tiled areas or placed on a waterproof mat.

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 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. Outdoor carbon monoxide concentrations were non-detectable (ND) the day of assessment (Table 1). No measureable levels of carbon monoxide were detected in the building (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.

On the day of assessment, outdoor PM2.5 was measured at 23 μg/m^3 (Table 1). PM2.5 levels measured indoors ranged from 7 to 19 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, 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 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 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. Indoor air concentrations can be greatly impacted by the use VOC containing products. BEH staff observed VOC containing products in a few locations.

Dry erase materials were observed in some offices and common areas. Materials such as permanent markers, 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.

An assortment of air fresheners and deodorizing materials (i.e. fragrant oil reed diffusers, plug-ins and spray canisters) were observed in a number of areas (Picture 26). Air deodorizers contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Many air fresheners contain 1,4-dichlorobenzene, a VOC which may cause reductions in lung function (NIH, 2006). Furthermore, deodorizing agents do not remove materials causing odors, but rather mask odors that may be present in the area.

Conclusions/Recommendations

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

1. Evaluate thermostat in room 262, replace if necessary to ensure appropriate ventilation is provided to this area.
2. Work with building management and staff to identify areas of uneven heating/cooling to determine appropriate settings to improve thermal comfort. Modifications to thermostat settings should also serve to reduce indoor relative humidity levels during the cooling season.
3. Ensure bathroom exhaust ventilation is operating while the building is occupied. If these fans are not sized appropriately to exhaust air from these areas, consider installing/replacing exhaust fans to increase airflow and remove pollutants from the indoor environment.
4. Change filters for air-handling equipment as per the manufacturer's instructions or more frequently if needed.
5. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
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. Monitor for signs of water damage following rainstorms around ductwork in area 243. Seal areas around rooftop ductwork as needed to prevent further leakage.
8. Repair/replace water-damaged building materials as necessary to prevent mold growth.
9. Place rubber mats under water dispensers and refrigerators to prevent water from wetting carpet.
10. Providing plants with drip pans and avoid over-watering. Examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
11. Refrain from using VOC-containing air deodorizing products.
12. 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

Water-damaged ceiling tile and bubbled/stained wall paint in area 243

Picture 2

Ductwork above area 243

Picture 3

Water cooler on carpeting

Location: HHS Center **Indoor Air Results**

Address: 330 Lynnway, Lynn, MA **Table 1** **Date: 9/23/2011**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Background	377	ND	73	75	23					overcast
Hallway 202/206	486	ND	73	63	15	0	N	Y	Y	
201	540	ND	75	57	15	2	Y	Y	N	
202	478	ND	74	59	16	0	N	Y	Y	
203	455	ND	73	59	15	0	N	Y	Y	
204	460	ND	73	57	15	0	N	Y	Y	
205/MDF Server Room	493	ND	74	40	7	0	N	Y	Y	WAC
206	473	ND	73	62	15	0	N	Y	Y	DO
207	470	ND	76	56	15	0	N	Y	Y	
208	485	ND	74	56	16	0	N	Y	Y	DO
209	475	ND	73	62	15	0	N	Y	Y	DO

ppm = parts per million
AD = air deodorizer
DO = door open
WAC = wall air conditioner
μg/m^3 = micrograms per cubic meter
CT = ceiling tiles
PC = photocopier
WD = water-damaged
ND = non-detect
DEM = dry erase materials

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: HHS Center | **Indoor Air Results**

Address: 330 Lynnway, Lynn, MA | **Table 1 (continued)** | **Date: 9/23/2011**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
210	481	ND	75	55	13	0	N	Y	Y	Door jamming
211	516	ND	74	58	15	0	N	Y	Y	PC
212	478	ND	74	59	14	0	N	Y	Y	Insects swarming around plants, planters on cloth, DO
213	471	ND	74	59	12	0	N	Y	Y	Water cooler on carpet
214	491	ND	75	62	14	0	N	Y	Y	DO
215	508	ND	75	62	15	0	N	Y	Y	DO
216	474	ND	74	64	14	0	N	Y	Y	
217	549	ND	75	62	15	0	N	Y	Y	DO
218	587	ND	76	62	15	0	N	Y	Y	DO, strong perfume
219	585	ND	73	60	16	2	N	Y	Y	DO
220	568	ND	74	60	18	0	N	Y	Y	DO

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								Supply	Exhaust	
221	636	ND	74	57	18	0	N	Y	Y	DO
222	665	ND	74	59	19	0	N	Y	Y	
224	476	ND	73	55	18	0	N	Y	Y	DO
225	465	ND	73	56	18	0	N	Y	Y	DO
227	478	ND	74	60	18	0	N	Y	Y	
227A	518	ND	74	57	18	0	N	Y	Y	
228	512	ND	73	58	18	0	N	Y	Y	
229	517	ND	74	62	19	0	N	Y	Y	DO
230	581	ND	74	58	19	0	N	Y	Y	
231	582	ND	75	61	18	0	N	Y	Y	WD-CT
232	689	ND	74	69	18	0	N	Y	Y	Light out

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								Supply	Exhaust	
									Low	
232A	553	ND	75	67	17	0	N	Y	Y	
233A	543	ND	74	67	16	1	N	Y	Y Dusty	
233	534	ND	74	65	18	0	N	Y	Y	
234	579	ND	75	63	16	0	N	Y	Y	
235	555	ND	74	66	16	1	N	Y	Passive	DO, AD
236	539	ND	74	67	16	1	N	Y	Passive	AD
237	518	ND	74	66	16	0	N	Y	Passive	DO, musty
238	538	ND	74	65	16	1	N	Y	Passive	DO
239	632	ND	76	66	15		N	Y	Y	

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								Supply	Exhaust	
241	581	ND	75	64	16	1	N	Y	Passive	DO
242	562	ND	75	67	16	0	N	Y	Passive	DO
243	562	ND	75	67	19	0	N	Y	Passive	DO, WD-CT/WD-wall paint
244	568	ND	75	67	16	1	N	Y	Passive	DO
245	537	ND	75	66	16	1	N	Y	Passive	DO
246	516	ND	75	66	15	1	N	Y	Passive	DO
247	544	ND	75	66	16	0	Y	Y	Y	
248	504	ND	76	68	17	0	N	Y	Passive	DO, plants
249	572	ND	75	68	17	0	N	Y	Passive	DO
250	525	ND	76	68	16	0	N	Y	Passive	DO, AD, Plants
250	538	ND	75	68	18	0	N	Y	Passive	DO, AD

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								Supply	Exhaust	
251	587	ND	75	68	16	0	N	Y	Passive	DO
253	529	ND	75	66	16	1	N	Y	Passive	
254	569	ND	75	64	17	0	N	Y	Y	
258	603	ND	76	68	16	0	Y	Y	N	DO
259	809	ND	76	67	15	0	N	Passive	Y	
260	529	ND	75	68	17	0	N	Y	Passive	DO, PF
261	582	ND	75	68	16	0	N	Y	Passive	DO
262	604	ND	75	68	15	0	N	Y	Passive	Thermostat off, DO
263	558	ND	75	67	15	0	N	Y	Passive	DO
264	566	ND	75	68	16	0	N	Y	Passive	DO
265	516	ND	75	67	15	0	N	Y	Passive	

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								Supply	Exhaust	
266	502	ND	74	70	16	0	N	Y	Y	DO
267	516	ND	74	70	16	0	N	Y	Passive	DEM
269	516	ND	75	67	15	0	N	Y	Y	DO
270	573	ND	75	68	15	0	N	Y	Y	DO
271	516	ND	75	67	15	0	N	Y	Passive	DO
272	588	ND	75	67	15	0	N	Y	Passive	DO
273	535	ND	75	67	15	0	N	Y	Passive	DO
274	526	ND	75	63	16	0	N	Y	Passive	DO
276/MDF Server Room	548	ND	72	48	10	0	N	Y	Y	WAC
2073	552	ND	74	66	16	3	N	Y	Y	
2083	568	ND	75	67	16	3	N	Y	Y	Plants

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600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2105	613	ND	75	69	15	3	N	Y	Y	
2115	540	ND	75	69	14	5	N	Y	Y	
2125	582	ND	75	69	15	2	N	Y	Y	
2148	603	ND	75	70	15	0	N	Y	Y	
2158	562	ND	76	68	15	2	N	Y	Y	
2166	508	ND	76	69	16	3	Y	Y	Y	

ppm = parts per million
µg/m^3 = micrograms per cubic meter
ND = non-detect
AD = air deodorizer
CT = ceiling tiles
DEM = dry erase materials
DO = door open
PC = photocopier
WAC = wall air conditioner
WD = water-damaged

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