INDOOR AIR QUALITY
POST-OCCUPANCY ASSESSMENT

Massachusetts Department of Disability Services
140 High Street
Springfield, MA

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
December 2012

Background/Introduction

At the request of 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 Department of Disability Services (DDS) located at 140 High Street, Springfield, Massachusetts. The purpose of the visit was to assess the indoor air quality (IAQ) of newly occupied space leased by Massachusetts state agencies. On November 9, 2012, a visit to conduct IAQ testing was made by Kathleen Gilmore, Environmental Analyst/Regional Inspector within BEH's IAQ Program. Mr. Covino and Mr. Vincent Laberinto, Construction Project Manager for the Office of Leasing and State Owned Property accompanied Ms. Gilmore during the assessment. Ms. Gilmore previously visited the building on August 27, 2012 to conduct a pre-occupancy assessment and a report was issued.

The DDS occupies the first and third floor of a former hospital originally constructed in the early 1900s, with a west wing addition built in 1968. The DDS office space has been completely renovated and consists of offices, open work areas/cubicles, conference rooms, storage and common areas. Floors are carpeted in most areas. Windows are not openable.

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. BEH/IAQ staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The DDS offices have an employee population of approximately 120 and up to 50 people may visit the office on a daily basis. 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 at the time of assessment, indicating good air exchange throughout the building. It is important to note that a number of areas were empty or sparsely populated during this visit, which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with full occupancy.

The heating, ventilating and air conditioning (HVAC) system consists of air-handling units (AHU) located in the basement, which draw in fresh air and distribute it to occupied areas via ceiling-mounted air diffusers and fresh air intake vents (Pictures 1 and 2). The offices do not have return ventilation; rather the system consists of ceiling-mounted exhaust grilles ducted directly to the outside powered by rooftop motors.

Fan coil units (FCUs) are located along the base of walls under windows and/or mounted to ceilings (Pictures 3 and 4) and provide supplemental heating or cooling to perimeter areas. FCUs do not introduce outside air; these units are limited to recirculing air only. The FCUs were operating in all of the areas surveyed during the assessment. In some areas, FCUs were blocked/obstructed by several items including cardboard boxes, books and other stored materials (Picture 5). In order for FCUs to facilitate airflow as designed, they must remain free of obstructions. FCUs located at the base of walls appear to be original to the building, which would make them approximately 50 years old. Mechanical ventilation equipment of this age is difficult to maintain because replacement parts are often unavailable.

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.

Minimum design ventilation rates are mandated by the Massachusetts State Building Code (MSBC). Until 2011, the minimum ventilation rate in Massachusetts was higher for both occupied office spaces and general classrooms, with similar requirements for other occupied spaces (BOCA, 1993). The current version of the MSBC, promulgated in 2011 by the State Board of Building Regulations and Standards (SBBRS), adopted the 2009 International Mechanical Code (IMC) to set minimum ventilation rates. **Please note that the MSBC is a minimum standard that is not health-based**. At lower rates of cubic feet per minute (cfm) per occupant of fresh air, carbon dioxide levels would be expected to rise significantly. A ventilation rate of 20 cfm per occupant of fresh air provides optimal air exchange resulting in carbon dioxide levels at or below 800 ppm in the indoor environment in each area measured. MDPH recommends that carbon dioxide levels be maintained at 800 ppm or below. This is because most environmental and occupational health scientists involved with research on IAQ and health effects have documented significant increases in indoor air quality complaints and/or health effects when carbon dioxide levels rise above the MDPH guidelines of 800 ppm for schools, office buildings and other occupied spaces (Sundell et al., 2011). 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 temperature measurements ranged from 71 °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.

Relative humidity measurements ranged from 12 to 24 percent (Table 1), which were below the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. 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. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor contaminants whose irritant effects can be enhanced when the relative humidity is low.

Microbial/Moisture Concerns

In order for building materials to support mold growth, a source of water exposure is necessary. No evidence of building leaks and/or other moisture concerns were observed or reported. It was noted however, that water dispensers were located on carpeted areas (Picture 6). 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.

Plants were observed in office areas (Picture 7). Plants should be properly maintained and equipped with drip pans. Plants should be located away from ventilation sources (e.g., FCUs) to prevent aerosolization of dirt, pollen or mold. Plants should not be placed on porous materials, since water damage to porous materials may lead to microbial growth.

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/IAQ 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). No measureable levels of carbon monoxide were detected inside the building during the assessment (Table 1).

Particulate Matter

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate includes 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.

During the November 9, 2012 assessment, outdoor PM2.5 was measured at 10 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 3 to 7 $\mu g/m^3$ (Table 1), which were below the NAAQS PM2.5 level of 35 $\mu g/m^3$. 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 volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Total volatile organic compounds (TVOCs) can result in eye and respiratory irritation if exposure occurs. 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/IAQ staff examined rooms for products containing these respiratory irritants.

Photocopiers and lamination machines were located in hallways and administrative areas of the building. Lamination machines melt plastic and give off odors and VOCs. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992). When possible, photocopiers and lamination machines should be located in areas equipped with local exhaust ventilation.

Other Conditions

Missing and ajar ceiling tiles were observed in some areas (Picture 8). Breaches in the ceiling tile system can provide pathways for dust, dirt, odors and other pollutants to move into occupied areas.

Conclusions/Recommendations

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

1. Remove materials and obstructions from FCU intakes and diffusers.
2. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
3. 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).
4. Consider moving water dispensing equipment to areas with tiled floors instead of carpeting, or installing waterproof mats to prevent leaks from damaging carpet.
5. Avoid overwatering of plants. Ensure flat surfaces around plants are free of potting soil and other plant debris. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Do not place plants on porous materials (e.g., paper/cardboard).
6. Replace missing ceiling tiles. Ensure all ceiling tiles are flush to prevent movement of materials from the plenum.
7. 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

HVAC Fresh Air Supply Diffuser

Picture 2

Fresh Air Intake Vent

Picture 3

Fan Coil Unit

Picture 4

Ceiling-mounted Fan Coil Unit

Picture 5

Obstructed Fan Coil Unit

Picture 6

Water Dispenser Located on Carpet

Picture 7

Plant in Office Space

Picture 8

Ajar Ceiling Tile

Location: Massachusetts Department of Disability Services **Indoor Air Results**

Address: 140 High Street, Springfield, MA **Date: 11/9/2012**

Table 1

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (ug/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Intake	Exhaust	
Background	492	ND	38	35	10					Sunny, breezy
101 Waiting Room	592	ND	74	24	3	0	N	Y	Y	
102 Interview Room	672	ND	72	20	4	0	N	Y	Y	
103 Interview Room	595	ND	75	15	4	0	N	Y	Y	
104 Reception	599	ND	71	21	3	1	N	Y	Y	
105	505	ND	76	14	4	0	N	Y	Y	DO, PF, personal heaters
106	644	ND	72	27	4	0	N	Y	Y	
107	669	ND	73	20	3	1	N	Y	Y	
108	477	ND	75	15	4	1	N	Y	N	Personal heater, PF
109 IDF	759	ND	76	14	5	0	N	Y	N	MT, ceiling -mounted FCU

ppm = parts per million
µg/m3 = micrograms per cubic meter
ND = non-detect
CT = ceiling tile
DO = door open
FCU = fan coil unit
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan

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: Massachusetts Department of Disability Services **Indoor Air Results**

Address: 140 High Street, Springfield, MA **Table 1 (continued)** **Date: 11/9/2012**

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (ug/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Intake	Exhaust	
110	653	ND	74	19	4	0	N	Y	Y	
111 Open Office Space	608	ND	73	19	4	2	N	N	Y	FCU blocked
113	692	ND	75	17	3	1	N	Y	Y	DO, FCU blocked
114	655	ND	75	16	4	1	N	Y	Y	
115	679	ND	74	20	4	2	N	Y	Y	
116 Corridor	502	ND	73	23	3	0	N	Y	Y	PC
117	473	ND	75	14	5	0	N	Y	Y	
118 Break room	463	ND	75	14	4	0	N	Y	Y	DO, NC, refrigerator, microwave, water dispenser
119 Open Office Space	441	ND	76	12	4	3	N	Y	Y	FCU blocked, personal heaters on, MT
120	622	ND	75	14	3	0	N	Y	Y	DO, personal heater, personal fan

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								Intake	Exhaust	
122	613	ND	76	15	4	1	N	Y	Y	DO,CT ajar, PF, PC, plant
123 Men's Rest Room	477	ND	76	17	3	0	N	N	Y	
124 Women's Rest Room	602	ND	76	15	3	0		N	Y	
128 Training Room	633	ND	74	15	4	0	N	Y	Y	
301 Waiting room	488	ND	75	13	6	0	N	Y	Y	Water dispenser on carpet
302 Interview Room	474	ND	76	13	6	0	N	Y	Y	FCU blocked
303 Interview Room	533	ND	75	12	5	0	N	Y	Y	
305 Client Rest Room	523	ND	73	16	7			N	Y	
307 Reception	586	ND	75	16	7	0	N	N	N	PC, plant
309	623	ND	75	15	6	1	N	Y	Y	

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Table 1 (continued)

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (ug/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Intake	Exhaust	
310	599	ND	76	15	6	0	N	Y	Y	
311	645	ND	75	13	5	2	N	Y	Y	Plants
313 Conference Room	508	ND	76	12	6	0	N	Y	N	DO, ceiling-mounted FCU
314	621	ND	74	13	7	0	N	Y	Y	
315	666	ND	73	14	6	0	N	Y	Y	Ceiling-mounted FCU
317	514	ND	75	15	6	4	N	Y	Y	FCU, PF, personal heaters
319	448	ND	74	13	5	6	N	Y	Y	DO, plants, PFs, printer
320 Break Room	466	ND	74	14	6	0	N	Y	Y	Refrigerator, microwave, toaster
322 File Room	518	ND	75	15	6	0	N	Y	Y	PC, printer, scanner, boxes
323	633	ND	75	15	5	2	N	Y	N	DO, PC, plants

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								Intake	Exhaust	
324	658	ND	76	14	6	7	N	Y	Y	FCU blocked, PF, PC, printer, microwave, personal heater, plants
326	578	ND	73	15	6	1	N	Y	Y	
327	627	ND	75	15	5	1	N	Y	Y	PF, personal heater
328	674	ND	76	13	6	5	N	Y	Y	FCU blocked, PC, PFs (4), toaster, microwave
330 Men's Rest Room	670	ND	74	14	5		N	N	Y	
332 Women's Rest Room	602	ND	74	13	6		N	N	Y	
333	569	ND	75	15	5	2	N	Y	Y	
334	474	ND	75	13	6	0	N	Y	Y	
335	523	ND	75	14	5	1	N	Y	Y	DO, FCU blocked, PF
337	484	ND	75	15	7	0	N	Y	Y	FCU blocked, plants, printer

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								Intake	Exhaust	
339 MDF Room	478	ND	76	14	7	0	N	Y	Y	
340	529	ND	74	13	6	3	N	Y	Y	DO, plants, personal heaters
341	475	ND	76	15	6	0	N	Y	Y	
343 Conference Room	452	ND	74	14	6	0	N	Y	Y	
344	502	ND	73	15	5	5	N	Y	Y	PFs, PC, plants, personal heaters
345 vestibule	545	ND	73	14	6	0	N	Y	Y	
346	566	ND	74	13	6	0	N	Y	Y	
348	498	ND	75	14	5	0	N	Y	Y	
350	439	ND	74	15	6	0	N	Y	Y	
352	501	ND	75	14	5	1	N	Y	Y	PF, plant

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