INDOOR AIR QUALITY ASSESSMENT

Department of Children and Families
Shetland Park Office Complex
45 Congress Street
Salem, MA

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

At the request of Mark Waterbury, Chief Operating Officer, Executive Office of Health and Human Services, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) conducted an indoor air quality (IAQ) assessment at the Massachusetts Department of Children and Families (DCF) located at the Shetland Park Office Complex, 45 Congress Street, Salem, Massachusetts. The DCF occupies space on the top floor of the north-facing portion of the building. On April 19, 2010, a visit was made to this building by Michael Feeney, Director of BEH's Indoor Air Quality (IAQ) Program. The purpose of the assessment was to identify building-related issues and/or concern.

Methods

Tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted with a TSI, Q-Trak, IAQ Monitor, Model 7565. Air tests for airborne particle matter with a diameter less than 2.5 micrometers (PM2.5) 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.

Results

The DCF houses approximately 50 employees. Tests were taken during normal operations (i.e. during the work day). Locations of test results are reported using the number of the telephone/computer jack closest to the location of air sampling and 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 surveyed, indicating adequate air exchange throughout the DCF offices. The DCF's heating, ventilation and air-conditioning (HVAC) system consists of a gas heating/electric cooling split system. Gas-fired air-handling units (AHUs) suspended from the ceiling system provide heated air to the space. Chilled air is provided by condensers located on the roof. Fresh air is drawn into air intakes located on rooftop of the building. Ceiling-mounted air diffusers ducted to the AHUs distribute fresh tempered air to occupied areas. Return air is drawn into ceiling-mounted vents, which are equipped with pleated filters. Some return air is ducted back to AHUs, where it is mixed with fresh air and redistributed to the office space. Air is also exhausted out of the building through vents located on the exterior of the building. Exhaust flues on the exterior of the building are equipped with wind shields to help prevent re-entrainment of exhaust air once it leaves the building.

Digital wall-mounted thermostats control the HVAC system. Each thermostat has fan settings of "on" and "automatic". The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated.

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 date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each area have 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 information concerning carbon dioxide, please see Appendix A.

Indoor temperature measurements ranged from 67 ºF to 75 ºF, which were within the MDPH recommended comfort guidelines, apart from the waiting room (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70 ºF to 78 ºF 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.

Building occupants reported issues regarding fluctuating temperatures in offices along the eastern exterior wall of the building. BEH staff noted that a number of offices do not have return vents. With doors closed rooms without return vents will experience increased temperature from solar gain on the window systems in the morning hours on cloudless days. As a result, unless the doors for these offices are left open, adequate venting will not occur and such areas will have high temperatures.

Indoor relative humidity levels ranged from 35 to 50 percent, which were within or close to the lower end of 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

Water-damaged ceiling tiles and building materials were observed in a few areas. 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.

Plants were observed in a number of offices. Plants, soil and drip pans can serve as sources of mold growth and should be properly maintained. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Flowering plants can be a source of pollen. Therefore, plants should be located away from ventilation sources to prevent aerosolization of mold, pollen and particulate matter.

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. 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 12 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 2 to 9 $\mu g/m^3$ (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.

At the time of assessment, one office occupant had reportedly lit a candle just minutes prior to the BEH assessment/testing. While the PM2.5 level for this room was not particularly elevated, over time particulates (i.e. soot) produced from burning a candle can build up.

Conclusions/Recommendations

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

1. Continue to coordinate with building management, administration, HVAC vendor and DCF staff to achieve/maintain optimal comfort levels.
2. Ensure that the thermostat is set to the fan "on" position to operate the ventilation system continuously during business hours.
3. Consider installing return vents for offices experiencing solar gain heat and recommend opening office doors as an interim measure.
4. Consider having the HVAC system balanced by an HVAC engineering firm prior to lease renewal. Adopt a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
5. Ensure plants have drip pans and avoid over-watering. Examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
6. Refrain from lighting candles inside the office.
7. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://www.mass.gov/dph/iaq.

References

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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.

Location: Salem DCF **Indoor Air Results**

Address: 45 Congress St., Salem, MA **Table 1** **Date: 4/19/2012**

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 (outdoors)	351	ND	62	48	12	3				
Waiting room	635	ND	67	50	2	0	N	Y	Y	
Break room	478	ND	73	37	7	0	N	Y	Y	Refrigerator, coke machine
2	601	ND	73	37	6	1	Y	Y	N	
4	506	ND	72	37	6	2	N	Y	Y	
4	594	ND	75	36	6	0	Y	Y	N	
6	657	ND	75	36	5	1	Y	Y	Y	
11	747	ND	73	36	4	1	Y	Y	Y	
Record room 12	472	ND	73	36	6	0	N	Y	Y	2 water-damaged ceiling tiles
22	744	ND	73	37	4	1	Y	Y	Y	Plants
23	739	ND	73	40	4	2	Y	Y	Y	
33	724	ND	73	41	3	3	Y	Y	Y	

ppm = parts per million μg/m^3 = micrograms per cubic meter ND = non detect

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: Salem DCF **Indoor Air Results**

Address: 45 Congress St., Salem, MA **Table 1 (continued)** **Date:4/19/2012**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
35	791	ND	73	38	4	0	Y	Y	N	
36	763	ND	73	38	4	0	Y	Y	N	
37	716	ND	73	35	3	0	Y	Y	Y	Door open
38	773	ND	74	36	4	1	Y	Y	N	Door open
39	670	ND	74	36	4	1	Y	Y	N	Door open
40	708	ND	72	39	3	0	Y	Y	Y	Door open
41	766	ND	74	38	3	1	Y	Y	N	
42	704	ND	73	36	3	0	Y	Y	Y	
43	648	ND	72	37	3	0	N	Y	Y	
44	464	ND	73	36	9	0	Y	Y	Y	Door open
47	485	ND	73	36	7	0	N	Y	Y	Door open
52	560	ND	73	35	9	3	N	Y	Y	

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	> 800 ppm = indicative of ventilation problems		

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Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
58	477	ND	73	36	7	2	N	Y	Y	
61	511	ND	73	37	9	0	N	Y	Y	
67	534	ND	73	38	7	5	N	Y	Y	
71	487	ND	73	37	8	0	N	Y	Y	Door open
75	484	ND	72	37	6	1	N	Y	Y	
76	505	ND	72	36	7	0	N	Y	Y	
82	503	ND	72	38	6	0	N	Y	Y	
89	489	ND	72	37	5	0	N	Y	Y	
94	501	ND	72	37	5	2	N	Y	Y	
101	405	ND	72	37	6	0	N	Y	Y	
102	510	ND	73	36	4	0	N	Y	Y	
104	405	ND	72	37	5	0	N	Y	Y	Door open

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Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
106	659	ND	72	38	4	0	N	Y	Y	Door open
107	501	ND	72	37	5	0	N	Y	Y	Rodent trap
108	515	ND	72	37	7	0	N	Y	Y	
112	586	ND	72	38	6	0	N	Y	Y	
117	661	ND	73	36	4	0	N	Y	N	Door open
119	612	ND	74	36	4	0	N	Y	Y	
128	639	ND	74	36	4	0	N	Y	Y	
134	652	ND	74	36	5	1	N	Y	Y	
136	642	ND	74	36	5	0	N	Y	Y	
137	657	ND	74	36	4	0	N	Y	Y	Door open
141	685	ND	74	36	4	1	N	Y	Y	
146	666	ND	73	37	4	0	N	Y	Y	

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								Supply	Exhaust	
155	737	ND	73	38	4	4	N	Y	Y	
156	694	ND	74	35	4	0	Y	Y	N	Door open
160	628	ND	75	35	7	1	N	Y	N	Door open
163	688	ND	72	38	4	1	N	Y	N	Door open
168	714	ND	73	37	3	1	Y	Y	Y	
181	701	ND	73	37	3	1	N	Y	N	
183	613	ND	72	37	4	0	N	Y	Y	

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