INDOOR AIR QUALITY ASSESSMENT

Department of Early Education and Care
Metro Boston Regional Office
1250 Hancock Street, Suite 120-S
Quincy, MA

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

Background/Introduction

In response to a request from Virginia Platt, Project Manager, Division of Capital Asset Management (DCAM), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) conducted an indoor air quality (IAQ) evaluation at the Massachusetts Department of Early Education and Care's (MDEEC) Metro Boston Regional Office located at President's Place, 1250 Hancock Street, Suite 120-S, Quincy, Massachusetts. On February 8, 2012, a visit was made to the MDEEC by Sharon Lee, an Environmental Analyst/IAQ Inspector within BEH's IAQ Program. The purpose of the assessment was to assist DCAM in identifying building related issues/concerns for remediation and/or corrective actions as part of a lease renewal process.

The MDEEC is located on the first floor of a multi-story building constructed in 1989. The first floor consists of a few food establishments, conference space and offices. The remaining stories consist of office spaces and medical/dental practices. The MDEEC, which consists of small offices and a common meeting area, has wall-to-wall carpeting, gypsum wallboard (GW), and dropped ceilings. Windows are not openable.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 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. MDPH/BEH staff performed visual inspection of building materials for water damage and/or microbial growth.

Results

The MDEEC has an employee population of approximately 26, with 10 to 15 visitors typically per day. The MDEEC also conducts training sessions with 25 to 75 attendees once or twice per week. The tests were taken during normal operations and 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 but one area surveyed, indicating adequate air exchange at the time of the assessment. Fresh air is drawn (Picture 1) into an air-mixing closet where the air-handling unit (AHU) is located (Picture 2). Passive return vents in the open work areas (i.e., cubicles and reception) return air back to the air-mixing room (Picture 3). The AHU draws air from the air-mixing room then heats/cools and filters it for distribution into the occupied space via ceiling-mounted air diffusers (Picture 4). Please note, the AHU air intake was occluded with dust and debris at the time of assessment (Picture 5). Control boxes located above the suspended ceiling system regulate distribution of air to occupied areas. In general, offices are not designed to have return vents. Offices have fresh air diffusers that pressurize the space, forcing air into hallways via undercut doors.

Digital wall-mounted thermostats regulate the control boxes (located above the ceiling plenum) that provide ventilation to the various zones of the office. Thermostats have fan settings of *on* and *automatic*. Thermostats were in the *automatic* setting during the assessment. The automatic setting on the thermostat activates the heating, ventilation and air-conditioning (HVAC) system at a preset temperature. Once a preset temperature is reached by the thermostat, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system. MDPH recommends that thermostats be set to the *on* position during occupied periods, as this setting provides a continuous source of air circulation.

Dedicated exhaust ventilation appeared to be provided by vents on a column (Picture 6). This type of exhaust vent is designed to remove normally occurring waste heat and pollutants from the workspace. A dedicated switch-activated exhaust is located in the bathroom. Consideration should be given to ensuring the bathroom exhaust operates at all times that the office is occupied as a means to prevent odors and moisture from penetrating into the office space.

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 system balancing was unknown at the time of the assessment. Ms. Platt indicated a balancing report would be available after the lease is finalized.

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 Department of Public Health 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.

Temperature readings ranged from 72^{o} F to 75^{o} F, which were within 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.

MDEEC staff expressed concerns regarding uneven temperature control and excess heat. When examining the AHU in the air mixing room, MDPH/BEH staff observed computers and other electronic equipment, indicating that this room also functions as an IT room. Such equipment produces a significant amount of waste heat, which can increase the temperature of air within the air mixing room. As warm air is drawn into the AHU, it is further tempered (heated during the winter/cooled during summer) and distributed to occupant areas. The circulation of warm air is likely resulting in heat or uneven temperature complaints. Consideration should be given to lowering the temperature setting for the thermostat, since the air is being pre-heated by electronic equipment. Concurrently, operating the AHU in the fan mode would serve to move more air throughout the space.

A second approach to consider may include partitioning the air-mixing room to create a smaller room by erecting walls from ceiling to floor, and installing air-conditioning to cool the dedicated IT space. Installation of cooling capacity is necessary to ensure the room is maintained at an appropriate temperature. Excessive heat can result in damage to the computers' hardware.

Staff also expressed concerns about air blowing directly onto their workspaces. In a number of areas, air diffusers are located directly above work stations (Picture 4). Since reconfiguration of cubicles is difficult, consideration should be given to either moving supply diffusers or replacing currently existing four-way diffusers with those that distribute air in only two or three directions.

Relative humidity measurements ranged from 13 to 16 percent, which were below the MDPH recommended comfort guidelines. The MDPH recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. 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 were observed in a few areas (Table 1), which can indicate leaks from either the roof or plumbing system. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

Caulking around the toilet in the bathroom appeared to be failing at the time of assessment. Water/condensation can result in moistening of materials beneath the tiled floor. Overtime, this can undermine the integrity of the grout and cemetious material adhering tiles to the floor. Measures should be taken to ensure the spaces around the toilet are watertight to prevent damage to flooring.

A water dispenser was located in a carpeted area (Picture 7); spills/leaks from such appliances can be a source of moisture in carpeting that can lead to water damage and mold growth. These units should be located in tiled areas or placed on a waterproof mat.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed/discarded.

Plants were observed in some cubicles/offices. Plants can be a source of pollen and mold, which can serve as respiratory irritants for some sensitive individuals. Plants should be properly maintained and equipped with drip pans to prevent water damage to porous building materials. Plants should also be located away from ventilation sources (e.g., air diffusers, portable fans) to prevent the aerosolization of dirt, pollen or mold.

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, MDPH/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 effects. 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-detect (ND) at the time of assessment (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 concentrations were measured at 12 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 8 to 9 $\mu g/m^3$ (Table 1), which were reflective of outside ambient conditions and below the NAAQS level. 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 identify materials that can potentially increase VOC concentrations, BEH staff examined areas for products that may contain these respiratory irritants.

Household cleaning products, air fresheners and deodorizing materials were found in several areas (Table 1). Cleaning products and 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.

Other Conditions

Food was placed on tables uncovered in the kitchen area, and crumbs were observed on a number of surfaces. Food and food wastes (i.e., crumbs) are an attractant to insects and rodents. Food should be stored in an airtight container, and crumbs should be cleaned frequently to avoid attraction of pests. Evidence of rodent activity, including a glue trap with fecal matter was observed behind the cooler in the reception area (Picture 8). Rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine contains a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce allergic symptoms (e.g., running nose or skin rashes) in sensitive individuals following repeated exposures. A three-step approach is necessary to eliminate rodent infestation:

1. removal of the rodents;
2. cleaning of waste products from the interior of the building; and
3. reduction/elimination of pathways/food sources that are attracting rodents.

To eliminate exposure to allergens, rodents must be removed from the building. Please note that removal, even after cleaning, may not provide immediate relief since allergens can exist in the interior for several months after rodents are eliminated (Burge, 1995). Once the infestation is eliminated, a combination of cleaning and increased ventilation and filtration should serve to reduce allergens associated with rodents.

Personal fans were observed in some areas. Fan blades from these units can accumulate dust/debris. Re-activated fans can aerosolize accumulated dust. Fans should be cleaned regularly to prevent aerosolization of dust.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made to improve indoor air quality in the building:

1. To increase the circulation of air and increase comfort, consider operating the HVAC equipment with the fan in the *on* setting during occupied hours.
2. Consider methods for reducing temperature of air provided to the occupied space.
    a. Lower thermostat temperature to reduce heating of air pre-heated by the IT equipment that is also housed in the air-mixing room.
    b. Consider partitioning a portion of the air-mixing room to create a dedicated IT room to prevent pre-heating of air being drawn into the AHU. Please note, a means for cooling the IT room is typically necessary to prevent overheating of equipment.
3. Change filters regularly to ensure proper filtration. Ensure filters are in place and that they fit properly.
4. Clean AHU air intake, air diffusers, return vents and personal fans periodically of accumulated dust/debris.
5. Consider relocating supply diffusers or replacing the current four-way diffusers, where necessary, with those that direct air bi-laterally or in three directions to limit the amount of air blowing directly onto occupants.

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 particle arrestance (HEPA) filter-equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Remove water-damaged ceiling tiles and examine for source of water. Replace all missing and ajar ceiling tiles and monitor for future leaks.
8. Ensure all ceiling tiles are flush to prevent movement of materials from the plenum.
9. Consider installing a waterproof mat beneath the water cooler to collect water spill/overflow and prevent moistening of carpeting.
10. Reseal around toilet to prevent water damage below tiled floor.
11. It is highly recommended that the principles of integrated pest management (IPM) be used to rid the building of pests. A copy of the IPM recommendations can be obtained from the Massachusetts Department of Food and Agriculture (MDFA) website: http://www.mass.gov/agr/pesticides/publications/docs/IPM_kit_for_bldg_mgrs.pdf Activities that can be used to eliminate pest infestation may include the following activities:
    a. Rinse out recycled food containers. Seal recycled containers in a tight-fitting lid to prevent rodent access.
    b. Remove non-food items that rodents are consuming.
    c. Store food in tight-fitting containers.

d. Avoid eating at workstations. In areas were food is consumed, periodic vacuuming to remove crumbs is recommended.

e. Regularly clean crumbs and other food residues from ovens, toasters, toaster ovens, microwave ovens, coffee pots and other food preparation equipment.

f. Examine each room and the exterior walls of the building for means of rodent egress and seal. Holes as small as ¼ inch are enough space for rodents to enter an area. If doors do not seal at the bottom, install a weather strip as a barrier to rodents. Reduce harborages (cardboard boxes) where rodents may reside (MDFA, 1996).

12. 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://mass.gov/dph/iaq.

References

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Picture 1

Fresh air intake

Picture 2

AHU

Picture 3

Return vent for air returned to air-mixing room

Picture 4

Ceiling-mounted air diffusers, note location above desk

Picture 5

AHU air intake, note debris against intake vent

Picture 6

Dedicated exhaust vent

Picture 7

Water cooler on carpeting

Picture 8

Rodent droppings in glue trap

Location: Department of Early Education and Care **Indoor Air Results**

Address: 1250 Hancock St, Quincy, MA **Table 1** **Date: 2/8/2012**

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	391	ND	37	49	12					Sunny, slight breeze
Conference room	673	ND	72	14	8	3	N	Y	N	DO
1	679	ND	73	14	8	2	N	Y	Y	
2	700	ND	74	14	8	4	N	Y	Y	
3	653	ND	73	13	8	0	N	Y	N	DO, boxes/paper
4	672	ND	74	13	8	1	N	Y	Y	Plants, food, CPs
5 (reception)	846	ND	75	13	9	1	N	Y	Y	1 WD CT, water cooler on carpet, PC, sticky traps behind cooler
6 (kitchen)	795	ND	74	16	8	0	N	Y Dusty	N	Food left on table, DO, toaster over, microwave, CPs, PF
7 (file room)	783	ND	74	14	9	0	N	Y	Y	Files, DO
8	746	ND	74	13	9	2	N	Y	Y	
9	728	ND	74	13	9	2	N	Y	Y	Paper products, CPs, food

ppm = parts per million
μg/m³ = micrograms per cubic meter
ND = non detect
DO = door open
WD = water-damaged
PC = photocopier
CT = ceiling tile
CPs = cleaning products
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	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
10	733	ND	74	13	8	0	N	Y	Y	DO, CPs, food
11	725	ND	74	13	8	1	N	Y	Y	DO, thermostat near computer
12	748	ND	75	14	8	0	N	Y	Y	

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