INDOOR AIR QUALITY ASSESSMENT

Lemuel Shattuck Hospital
Quality/Risk Management Office
170 Morton Street
Jamaica Plain, Massachusetts

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

Background/Introduction

In response to a request from Mr. Thomas Campbell, Deputy Director of Facilities Management, Lemuel Shattuck Hospital (LSH), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) conducted air testing at the LSH Office of Quality/Risk Management (OQRM) located at 170 Morton Street, Jamaica Plain, Massachusetts. The assessment was prompted by an employee's concerns of being located in close proximity to a ceiling return vent for the heating, ventilation and air conditioning (HVAC) system. On February 9, 2011, Cory Holmes, an Environmental Analyst/Regional Inspector in BEH's Indoor Air Quality (IAQ) Program, conducted an IAQ assessment. Mr. Holmes was accompanied by Mr. Campbell during the assessment.

OQRM is located on the first floor of the main LSH building. The OQRM consists of open work space, small offices, and common areas. The space has a vinyl floor tile, cloth dividers and a dropped ceiling tile system. Windows are openable throughout the OQRM space.

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

Results

Tests were taken during normal hours of 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 areas, indicating optimal air exchange at the time of the assessment (Table 1). Mechanical ventilation is provided by air-handling units (AHUs) located in mechanical rooms. Fresh heated/cooled air is distributed to occupied areas via ducted ceiling diffusers (Picture 1). Return air is drawn into ceiling-mounted vents and ducted back to air-handling units (Picture 2). The vent in Picture 2 is located directly above an employee work station and cannot be moved due to the location of concrete support pillars. At the time of assessment, MDPH/BEH/IAQ staff suggested that the vent be modified through the installation of a deflector or replaced with a vaned adjustable return vent to prevent a less optimal draw of air more likely to impact comfort parameters of the employee sitting below the vent.

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 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 68°F to 74°F (Table 1), which were within or close to the lower end of 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 10 to 24 percent, which were below the MDPH recommended comfort range in all areas surveyed 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

Several areas had water-damaged ceiling tiles which can indicate sources of water penetration from either the building envelope or plumbing system (Pictures 1 and 2/Table 1). Water-damaged ceiling tiles can provide a source for moisture/microbial growth and should be replaced after a water leak is discovered and repaired.

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-detect (ND) at the time of the assessment (Table 1). 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 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 the day of the assessment were measured at 7 $\mu g/m^3$. PM2.5 levels measured inside the building ranged from 4 to 6 $\mu g/m^3$ (Table 1). Both indoor and outdoor PM 2.5 levels were below the NAAQS PM2.5 level of 35 $\mu g/m^3$. Frequently, indoor air levels of particulate matter (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.

Other Conditions

A number of air diffusers and return vents were observed to have accumulated dust/debris. When activated supply vents can aerosolize dust accumulated on louvers. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles.

Conclusions/Recommendations

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

1. Consider installing a deflector on the return vent or replacing current vent with a vaned adjustable type vent to improve occupant comfort.
2. Ensure water leaks are repaired. Replace all remaining water-damaged ceiling tiles. Examine the area above these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial, as needed.
3. Clean personal fans, univent air diffusers, return vents and exhaust vents periodically of accumulated dust.
4. 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.

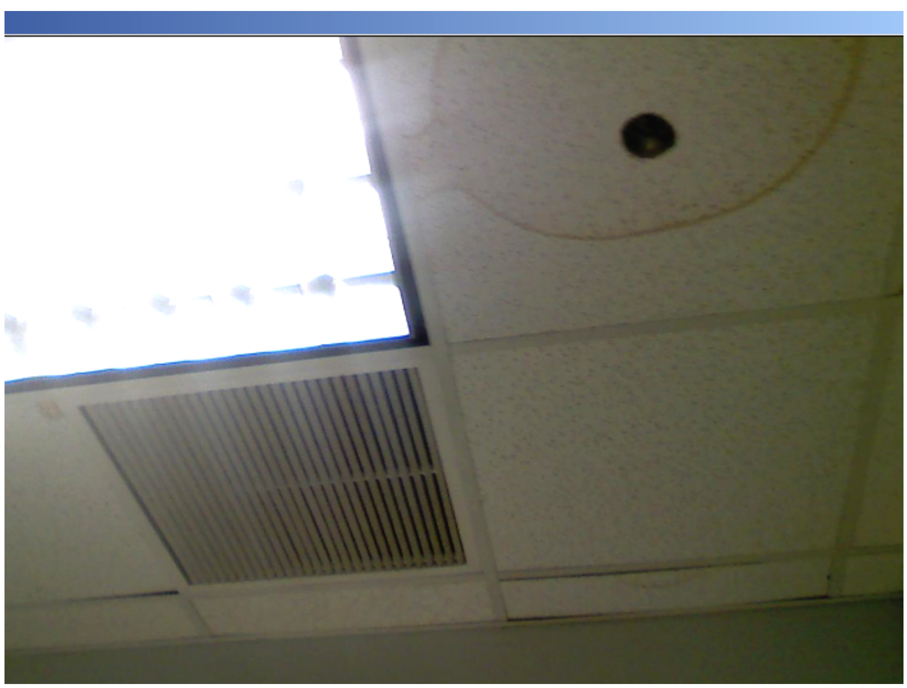
SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

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

Ceiling-Mounted Supply Vent, Note Water-Damaged Ceiling Tiles

Picture 2



Ceiling-Mounted Return Vent, Note Water-Damaged Ceiling Tiles

Location: Quality/Risk Management Office | **Indoor Air Results**

Address: Lemuel Shattuck Hospital, 180 Morton St, Jamaica Plain, MA | **Table 1** | **Date: 2/9/2011**

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 (outside)	329	ND	<32	11	7					Cold, scattered clouds, winds WSW 15-29 mph, gusts up to 39 mph
McLaughlin Office	618	ND	69	24	4	0	N	Y	N	5 WD CTs
Screening	607	ND	68	18	4	3	Y	Y	N	Thermostat fan "auto"
Beaudette Office	687	ND	69	16	4	1	N	Y	Y	DO, dust/debris accumulation on vents
Bruno-Morrison Office	684	ND	71	14	4	2	N	Y	Y	DO, 3 WD CTs
Quality Management	627	ND	72	10	6	2	Y	Y	N	
Front Clerical	600	ND	73	10	6	1	N	Y	Y	4 WD CT
McErlane Office	709	ND	73	11	5	1	N	Y	Y	DO
Credentialing Office	662	ND	74	11	6	2	N	Y	Y	DO, 2 WD CT

ppm = parts per million
μg/m3 = micrograms per cubic meter
ND = non-detect
WD = water-damaged
CT = ceiling tile
DO = door open

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%