INDOOR AIR QUALITY ASSESSMENT

Cape Cod Community College
South Classroom Building
2240 Iyannough Road
West Barnstable, MA

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
May 2014

Background/Introduction

In response to a referral from the Massachusetts Department of Labor Standards, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) conducted an indoor air quality (IAQ) assessment at the South Classroom Building (SCB) on the Campus of Cape Cod Community College in West Barnstable, Massachusetts. On March 25, 2014, a visit to conduct an IAQ assessment was made by Cory Holmes, Environmental Analyst/Inspector and Ruth Alfasso, Environmental Engineer/Inspector, from BEH's IAQ Program.

The SCB is a three-story, red brick building constructed in the late 1960s. The top two floors of the building have undergone minor interior renovations over the years; however, the majority of building components are original. The ground floor has been completely renovated and serves as a dental hygiene clinic/lab. The building contains classrooms, clinical labs, offices and storage rooms. A number of areas have carpeting, some of which has been recently replaced, while other areas have non-porous floor tiles. Reportedly, replacement of remaining older carpeting will be addressed as funds become available and/or as needed. Windows are openable throughout the building.

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. Screening for volatile organic compounds was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID) and RAE

Systems Mini-RAE 2000 PID. BEH/IAQ staff performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The SCB has an employee population of approximately 45 with up to a 1000 students visiting daily for classes/meetings. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in all areas tested, indicating a lack of air exchange at the time of assessment. It is important to note that the top floor has no means of mechanical ventilation but relies on openable windows for introduction of outside air. It is also important to note that the assessment occurred after several days of subzero weather. During extreme cold conditions, windows are shut and fresh air intakes on the building exterior are often limited to reduce the amount of cold air supplied to mechanical ventilation equipment. Limiting cold air increases thermal comfort of occupants and prevents freezing of pipes, which can lead to flooding and mold growth.

Mechanical ventilation in classrooms and common areas throughout the second floor is provided by air-handling units (AHUs) located on exterior walls (Picture 1). Fresh air is drawn into the AHU through an air intake located on the exterior of the building (Picture 2) and delivered to occupied areas via wall or ceiling-mounted air diffusers. Exhaust air is drawn into wall-mounted exhaust units also located on exterior walls. Without adequate supply and exhaust ventilation, excess heat and environmental pollutants can build up, leading to indoor air/comfort complaints.

It is also important to note that mechanical ventilation equipment is original to the construction of the building, (i.e., over 40 years old). Equipment of this age is often difficult to maintain because replacement parts are often unavailable. According to the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), the service life[1] for a unit heater, hot water or steam is 20 years, assuming routine maintenance of the equipment (ASHRAE, 1991). It appears that the operational lifespan of this equipment has been exceeded. Maintaining the balance of fresh air to exhaust air will become more difficult as the equipment ages and as replacement parts become increasingly difficult to obtain.

Modern mechanical ventilation has been installed throughout the ground floor dental hygiene area (Pictures 3 through 5). While this equipment was found operating, it appears that outside air was limited due to cold weather conditions noted earlier.

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 assessment.

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

---

[1] The service life is the median time during which a particular system or component of …[an HVAC]… system remains in its original service application and then is replaced. Replacement may occur for any reason, including, but not limited to, failure, general obsolescence, reduced

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).

---

reliability, excessive maintenance cost, and changed system requirements due to such influences as building characteristics or energy prices (ASHRAE, 1991).

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 at the time of assessment ranged from 68°F to 75°F (Table 1), which were within or close to 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. In addition, it is difficult to control temperature and maintain comfort with an antiquated mechanical ventilation system (i.e., over 40 years old). It is also important to note that the function of the building has changed over the years. When the SCB was built in the 1960s, it was not designed to operate year-round and was not equipped with air conditioning (AC) capabilities. However, the building now operates year-round, which can make temperature/humidity control difficult.

Relative humidity measurements at the time of assessment ranged from 13 to 29 percent (Table 1), which were below the MDPH recommended comfort range in all areas surveyed. 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 on the top floor exhibited evidence of historic water penetration in the form of stains on concrete ceilings. Concrete is not a porous material, therefore it would not be prone to growing mold if wet. However, staff should report any current leaks to maintenance staff to prevent carpeting and or other porous materials stored in office space from getting wet.

A few areas had water-damaged ceiling tiles (Picture 6), which can indicate leaks from the roof or plumbing system. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a moisture source or leak is discovered and repaired.

Some areas had water coolers installed over carpeting (Picture 7). Water spillage or overflow of cooler catch basins can result in the wetting of the carpet. In addition some of the coolers had residue/build-up in the reservoir. These reservoirs are designed to catch excess water during operation and should be emptied/cleaned regularly to prevent microbial growth. The second floor faculty lounge had a refrigerator on carpeting, which was stained/damaged (Picture 8). In addition, visible mold growth was seen on the gaskets of the refrigerator (Pictures 9 and 10). Refrigerators should be cleaned on a regular schedule, including disinfection of gaskets and interior with a mild detergent or antimicrobial solution as needed.

Plants were observed in a few areas. Plants, soil and drip pans can serve as sources of mold growth. Plants should be properly maintained, over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should also be located away from ventilation sources to prevent 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, 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 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, 2011). 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 at the time of assessment ranged from non-detect (ND) to 2.4 ppm (Table 1), due to idling vehicles in the parking lot. No measurable 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 includes airborne solids that can be irritating to the eyes, nose, and throat. The NAAQS originally established exposure limits to PM with a diameter of 10 μm or less (PM10). In 1997, US EPA established a more protective standard for fine airborne particulate matter with a diameter of 2.5 μm or less (PM2.5). The NAAQS has subsequently been revised, and PM2.5 levels were reduced. 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 PM concentrations in the indoor environment.

Outdoor PM2.5 was measured at 6 μg/m^3 (Table 1). PM2.5 levels measured indoors ranged from 2 to 13 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 matter 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, the application of pesticides, the use of certain cleaning products or chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted.

Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were non-detect (ND; Table 1). At the time of assessment no measurable levels of TVOCs were detected in the vast majority of areas surveyed (Table 1). Slight levels of TVOCs ranging from 1.0 - 1.3 ppm were detected in the ground floor lobby/Dental Hygiene Area (Table 1), most likely due to materials (e.g., cleaners, polishes, rinses) used in the Dental Hygiene Lab.

In an effort to identify materials that can potentially increase indoor VOC concentrations, BEH/IAQ staff examined rooms for products containing these respiratory irritants; items typically used in a school/office environment were identified. Hand sanitizer was found in many offices and common areas (Table 1). Hand sanitizer products may contain ethyl alcohol and/or isopropyl alcohol, which are highly volatile and may be irritating to the eyes and nose and may contain fragrances to which some people may be sensitive.

Several areas contained dry erase boards and related materials. Materials such as 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.

Photocopiers were located in several areas. 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). Photocopiers should be used in well-ventilated areas or in areas with local exhaust ventilation to help reduce/remove excess heat, and odors.

Conclusions/Recommendations

The conditions noted at the SCB raise a number of IAQ issues. The general building design and the age/condition of ventilation equipment, considered individually, present conditions that could have an adverse impact on IAQ. When combined, these conditions can serve to further degrade air quality. Some of the conditions detailed in this report can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is recommended. The first consists of **short-term** measures to improve air quality and the second consists of **long-**

term measures that will require planning and resources to adequately address overall IAQ conditions.

Short-Term Recommendations

1. Operate mechanical ventilation systems continuously during periods of occupancy, make repairs as needed. Once weather permits increase outside air intake if mechanically possible.
2. Supplement airflow by using openable windows/fans to control for comfort (with the exception of periods of high outdoor relative humidity to avoid condensation problems). Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding (during winter months).
3. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
4. 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).
5. Consider placing refrigerators and water dispensers on non-carpeted areas or on waterproof mats.
6. Ensure refrigerators are cleaned out regularly. Clean moldy gaskets with a mild detergent or antimicrobial agent; if they cannot be adequately cleaned consider replacing.

7. Ensure plants have drip pans and avoid over-watering. Examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
8. Replace missing/water-damaged ceiling tiles.
9. Encourage staff to report building leaks to maintenance department for remediation.
10. Locate photocopiers in well-ventilated areas or examine the feasibility of installing local exhaust ventilation.
11. 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.

Long-Term Recommendations

1. Based on the age, physical deterioration, and availability of parts, the BEH recommends that an HVAC engineering firm evaluate options for providing adequate ventilation building-wide. Such an evaluation is necessary to determine the operability and feasibility of repairing/replacing the equipment.
2. Consult with HVAC engineering firm to examine the feasibility of installing mechanical ventilation to areas of the building without it.

References

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration, and Air Conditioning Engineers. ANSI/ASHRAE 62-1989.

ASHRAE. 1991. ASHRAE Applications Handbook, Chapter 33 "Owning and Operating Costs". American Society of Heating, Refrigeration and Air Conditioning Engineers, Atlanta, GA.

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

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 2011. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations, 8th edition. 780 CMR 1209.0

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

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

Sundell. 2011. Sundell, J., H. Levin, W. W. Nazaroff, W. S. Cain, W. J. Fisk, D. T. Grimsrud, F. Gyntelberg, Y. Li, A. K. Persily, A. C. Pickering, J. M. Samet, J. D. Spengler, S. T. Taylor, and C. J. Weschler. 2011. Ventilation rates and health: multidisciplinary review of the scientific literature. *Indoor Air*, Volume 21: pp 191–204.

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