INDOOR AIR QUALITY ASSESSMENT
ODOR INVESTIGATION

Mashpee High School
Guidance Suite
500 Old Barnstable Road
Mashpee, Massachusetts

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

In response to a request by Catherine Laurent, Mashpee Department of Public Works, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding a complaint of odors at Mashpee High School (MHS), 500 Old Barnstable Road, Mashpee, Massachusetts. On June 11, 2012, Cory Holmes, Environmental Analyst/Regional Inspector and Ruth Alfasso, Environmental Engineer/Inspector for BEH's Indoor Air Quality (IAQ) Program made a visit to MHS to conduct the IAQ assessment.

The request was prompted by concerns of pungent/musty odors in first floor guidance suite. BEH staff were accompanied by Brad Tripp, Town of Mashpee Facilities Supervisor, and Ms. Laurent during the assessment. The areas investigated were limited to rooms in the guidance suite and adjacent areas.

Methods

General IAQ tests for carbon dioxide, carbon monoxide, 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. To determine if a source of volatile organic compounds (VOCs) was responsible for the odors, testing for total volatile organic compounds (TVOCs) was conducted with a MiniRAE 2000 photoionization detector. BEH staff also performed visual inspection of building materials for water damage and/or microbial growth and examined the guidance suite and adjacent areas for the presence of odors and/or other environmental concerns.

Results

As mentioned, testing was conducted in the guidance area where the odor had been reported, and also in the hallway outside the guidance office, an office located across the hall (B-112) and the main school office for comparison in areas that were not impacted by the odor. The guidance area was not occupied at the time the evaluation was conducted, while the other areas were operating normally. Results appear in Table 1.

Discussion

Ventilation

Ms. Laurent reported that they have received complaints regarding the odor since January 2012, during the heating season. At the time of the MDPH assessment, the ventilation systems were operating in air conditioning (AC) mode. It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in the areas examined, indicating that the ventilation systems were operating adequately in the building. Conditioned air is circulated in the guidance suite via fan coil units (FCUs) located above the ceiling tiles. Fresh outside air is ducted from air intakes on the outside of the building to the FCUs where it is heated or cooled and distributed to the rooms by ceiling-mounted supply diffusers. Two FCUs serve the rooms in the guidance suite – one located in the center of the ceiling in the large main room, and one in the ceiling of one of the side rooms.

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 heating, ventilation and air conditioning (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 15 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, consult Appendix A.

The temperature in areas examined ranged from 71°F to 73°F, which was within the MDPH recommended range in all areas surveyed (Table 1). 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 is typical, even in a building with an adequate fresh air supply.

The relative humidity measured in areas investigated ranged from 55 to 59 percent; which was within 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 and Odor Investigation

In February 2012, wall-to-wall carpeting in the guidance office that had been water-damaged over the years was replaced by carpet squares in response to the initial odor complaints of January 2012. There is no backing/padding beneath the carpet squares and they are installed directly on the concrete slab, which would rule out moldy carpet/padding as the source of the odor in this area.

BEH staff examined the ceiling tiles and above the ceiling plenum and did not identify any mold growth or water-damaged materials which could serve as a source of odor. BEH staff also conducted moisture testing of all walls and carpeting in the guidance suite; all materials had low (i.e., normal) moisture content at the time of the assessment.

Upon entry into the guidance suite, BEH staff noted a slightly pungent/musty odor which was not detected in the adjacent offices examined during the visit. One building occupant described the odor as “dirty socks”. The odor was noticeably more potent towards the front portion of the area that shares a common wall with the mechanical room. This area contains a FCU above the ceiling. BEH staff identified the FCU as a possible odor source since the coils produce condensation during AC season. BEHs staff recommended to Mr. Tripp that the FCUs be opened up and examined. In subsequent correspondence Mr. Tripp, reported that the units were opened and inspected by town maintenance staff who found no obvious source of odors.

An IAQ staff review of available information indicates that "dirty sock" odors, sometimes called "dirty sock syndrome" can be caused by bacteria that collects and grows on the coils of heat pumps and ACs (ACHR News, 2006; FSC, 2012, Trane, 2009). Odors are created when heat pumps go into defrost or when systems operate in heating for a limited period and put back into cooling mode. The bacteria accumulate and grow on the coil during this heating time and odors are released when the indoor coil gets cool and damp. Heat pumps and air conditioners experience the problem when they are reactivated after heating has been used (FSC, 2012, Trane, 2009).

Other potential sources of odors could be scale/build-up of debris in the condensation drainage pipes. Drainage for the FCU in this area is provided by solid PVC pipe. Drainage pipes typically have a trap to prevent sewer odors (from the drainage system) from backing up into the FCU. A trap uses drainage water to create a liquid seal that prevents sewer gas odor from backing up the line. The trap system works during AC operation because the FCU is draining condensation collected by the AC. During the heating season, these traps dry out because no condensation drains from the FCU. As the heat pump operates, negative pressure is created, which can draw air from the drain system through these pipes and into the unit. This can be a means for odors from scale/debris build-up inside the condensate pipes to be drawn into the unit and be distributed by the HVAC system.

During the investigation holes/breaches were noted in the common wall between the mechanical room and guidance suite. These breaches in the wall can serve as pathways for particulates and/odors to migrate from the mechanical room into the guidance suite.

Another possible source of odor could be from soiled items within the space. At the time of assessment, Ms. Laurent mentioned removing all items from the space to see if the odor dissipated. If all the items were removed/relocated, for instance to the gym, it would serve a two-fold purpose: 1.) It would allow staff to eliminate stored items as the source of odor (if the odor does not change after the removal) and/or 2.) It could allow guidance staff the opportunity to thoroughly go through materials item by item to rule them out.

Finally, while examining the FCU in the front portion of the guidance suite BEH staff noted a number of air leaks from the unit. Although it is known that most ductwork leaks to some extent, these noticeable leaks in/around the FCU should be minimized to prevent the loss of heat and more importantly, loss of cool air during AC season, which can lead to condensation on cool metal surfaces in the ceiling plenum that can lead to mold 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 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. On the day of the assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). No measurable levels of carbon monoxide were detected in areas surveyed (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 9 $\mu g/m^3$ (Table 1). PM2.5 levels measured in areas surveyed were between 6 to 9 $\mu g/m^3$ (Table 1), all below the NAAQS PM2.5 level of 35 $\mu g/m^3$. There were no significant differences in particulate levels between the guidance suite and comparison areas. 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 particulates 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 VOCs. VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (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.

As mentioned previously, in order to determine if a source of VOCs was responsible for the odors, testing for VOCs was conducted. No measureable levels of VOCs were detected in background (outdoors), in the guidance office suite or in the other offices used for comparison (Table 1).

Conclusions/Recommendations

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

1. Contact an HVAC engineering firm that is familiar with this odor issue (i.e., dirty sock syndrome) to conduct a thorough examination of the HVAC system in the guidance suite to rule out as a source of odor. This may include, but not limited to:
    a. Full examination and cleaning of evaporator/cooling coils and cleaning with a non-acid cleaner and if necessary, coating of coils with a protective agent to prevent bacterial growth.

b. Possible replacement of coils with coated coils, which reportedly reduce the chances of bacterial growth and subsequent odors.

c. Removal and examination of condensate drain pipes to inspect for scale/build-up.

d. Ensure condensation/drain trap is installed and intact.

e. Inspect the interior of ductwork.

f. Inspect rubber/plastic gaskets/parts that can degrade and give off odors.

2. Have HVAC engineering firm inspect integrity of FCU/ductwork in the ceiling plenum for integrity, repair as needed to prevent leakage and condensation.

3. Consider removal all file cabinets/items from room and conduct thorough individual investigation to rule out stored items being a source of odors.

4. Seal all holes/breaches in wall between the guidance suite and adjacent mechanical room.

5. Consider opening up walls in select areas in each wall, to rule out the wall cavity as a source of odors.

6. Contact the BEH's IAQ Program if further advice/investigation is needed.

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Location: Mashpee High School **Indoor Air Results**

Address: 500 Old Barnstable Road, Mashpee **Date: 6/11/2012**

Table 1

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	TVOCs (ppm)	PM2.5 (ug/m^3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Intake	Exhaust	
Background	310	ND	66	60	ND	9					Mostly sunny, light breeze
Main Office	591	ND	71	59	ND	6	2	N	Y	Y	
Hallway Directly outside B-112/Guidance Suite	451	ND	72	56	ND	9	0	N	N	N	
B-112	489	ND	73	55	ND	8	8	N	Y	Y	DO
Guidance Suite	480	ND	73	57	ND	9	0	Y	Y	Y	Odors detected/musty/pungent, leaking air around FCU, walls & floors dry (i.e., normal) moisture content, no visible mold on building materials (walls, carpet, ceiling tiles), items or above ceiling plenum

ppm = parts per million FCU = fan coil unit $\mu g/m^3$ = micrograms per cubic meter DO = door open ND = non-detect

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems	Temperature: Relative Humidity:	70 - 78 °F 40 - 60%