INDOOR AIR QUALITY
FOLLOW UP ASSESSMENT

Needham Public Health Department
Needham Town Hall
1471 Highland Avenue
Needham, 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 Janice Berns, Director, Needham Public Health Department (NPHD), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) was asked to conduct a follow up indoor air quality (IAQ) assessment at the Needham Town Hall (NTH) located at 1471 Highland Avenue, Needham, Massachusetts. The BEH/IAQ Program had previously visited the building in January/February of 2013 to investigate IAQ concerns and issued a report based on observations made at that time, with recommendations to improve air quality (MDPH, 2013). Actions taken on recommendations made in the previous MDPH IAQ report are listed in Appendix A. The December 2013 follow up assessment was isolated to the NPHD offices and Powers Hall, where occupants also reported symptoms thought to be related to indoor air quality. The follow up assessment was prompted by intermittent odors, ongoing IAQ concerns and respiratory issues reported by NPHD staff.

On December 19, 2013, Michael Feeney, Director of BEH's Indoor Air Quality (IAQ) Program, conducted the assessment. Mr. Feeney was assisted by Cory Holmes, Environmental Analyst/Regional Inspector in BEH's IAQ Program.

Methods

BEH/IAQ staff performed visual inspection of building materials for water damage and/or microbial growth and examined the building for the presence of odors and/or other environmental concerns. Air testing for carbon monoxide, carbon dioxide, temperature and relative humidity was 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. Screening for total volatile organic compounds

(TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The NPHD has 11 staff members and can be visited by several members of the public on a daily basis. 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 seven of nine areas, indicating a lack of air exchange at the time of assessment. Note that the assessment occurred during the heating season on a cold day; therefore outdoor air was likely limited to maintain thermal comfort. Limiting outside air intake can contribute to an increase in carbon dioxide levels.

Fresh air in the NPHD offices is provided by ceiling-mounted air diffusers connected to an air handling unit (AHU) housed in an attic mechanical room. Heating and cooling in offices on the second floor is supplemented by the use of fan coil units (FCUs), which recirculate air but do not provide additional fresh air supply. BEH/IAQ staff examined blueprints related to the NTH renovation specifically related to NPHD offices. As noted previously, the duct and piping system plans, indicate interior rooms are to be heated/cooled using both ceiling-mounted air diffusers and FCUs. This configuration is unusual; interior areas typically use only ceiling-mounted air diffusers for heating, cooling and fresh air. All other spaces in the building have either FCUs located under windows or are configured to have the ceiling-mounted diffusers as the sole source of fresh air. Excessive airflow from the ceiling-mounted fresh air diffusers and FCUs in interior offices of the NPHD may decrease comfort for some occupants, as well as be a source of continuous noise.

Exhaust ventilation in the NPHD is provided by ceiling-mounted vents connected to ductwork. Without adequate exhaust ventilation, excess heat and normally-occurring indoor air pollutants can accumulate, leading to indoor air/comfort complaints.

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). Balancing of the ventilation system is tentatively scheduled for June 2014.

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 Board of Building Regulations and Standards (SBBRS), adopted the 2009 International Mechanical Code (IMC) to set minimum ventilation rates. **<u>Please note that the MSBC is a minimum standard that is not health-based</u>**. 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, J. 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).

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 B.

Indoor temperature measurements the day of assessment ranged from 72ºF to 74ºF, which were within the MDPH recommended comfort range (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70ºF to 78ºF 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.

The relative humidity in the building the day of assessment ranged from 17 to 25 percent, which was below 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 materials were not apparent in the NPHD office at the time of this assessment. Please review the previous IAQ assessment and Appendix A of this report regarding moisture issues that need to be addressed.

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 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).

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 1.0 to 3.0 ppm (Table 1), likely due to moderate/heavy traffic, idling vehicles and a number of restaurants that surround the building. Carbon monoxide levels measured inside the building ranged from ND to 1.0 ppm (Table 1), which were at or below outdoor levels.

Particulate Matter (PM2.5)

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 concentration the day of assessment was measured at 21 $\mu g/m^3$ (Table 1). PM2.5 levels measured inside the building ranged from 5 to 8 $\mu g/m^3$ (Table 1). Both indoor and outdoor PM2.5 levels 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 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, cooking in stoves and microwave ovens; 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 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. 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.

In an effort to determine whether VOCs were present in the building, particularly due to the reports of intermittent odors, air monitoring for TVOCs was conducted. Samples in outdoor air were taken for comparison to indoors. Outdoor TVOC concentrations were ND (Table 1). No measurable levels of TVOCs were detected in the building during the assessment (Table 1).

Conclusions/Recommendations

Based on measurements and observations during both assessments, indoor air quality issues in the NPHD appear to be related to the operation of the FCUs. The following recommendations are made to improve indoor air quality:

1. Discontinue the use of FCU fans in the NPHD interior offices.
2. Continue to implement recommendations made in the previous MDPH IAQ assessment.

3. 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).
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

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Location: Needham Town Hall **Indoor Air Results**

Address: 1471 Highland Ave., Needham, MA **Date: 12/19/2013**

Table 1

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	TVOCs (ppm)	PM2.5 (ug/m³)	UFP (1000p/cc)	Occupants in Room	Windows Openable	Ventilation		Remarks
										Intake	Exhaust	
Background	440	1.0-3.0	46	36	ND	21	17-73					Clear, sunny, moderate to heavy traffic, restaurant odors
Conference Room	1142	ND-1.0	72	25	ND	7	8.5-10		Y	Y	Y	
Dinell	1026	1.0	73	22	ND	6	7	0	Y	Y	Y	
Clark	1106	ND	73	22	ND	6	6	1	Y	Y	Y	
Gurge	977	ND	73	21	ND	6	6	1	Y	Y	Y	
Burns Office	905	ND	73	20	ND	6	6	2	Y	Y	N	
Reception	895	ND	73	20	ND	5	6	1	N	Y	N	
Read	833	ND	74	18	ND	6	7	0	N	Y	N	
Carmichael	784	ND-1.0	74	18	ND	8	8	0	N	Y	Y	
Powers Hall	501	ND	72	17	ND	6	8	0	Y	Y	Y	

ppm = parts per million   ND = non-detect   µg/ m³ = micrograms per cubic meter   UFP = ultrafine particulate

p/cc = particles per cubic centimeter

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%

Appendix A

Actions on MDPH Recommendations, Needham Town Hall, Needham, MA

The following is a status report of action(s) taken on MDPH recommendations made in the 2013 MDPH report (**in bold**) based on reports from maintenance staff, documents, photographs and MDPH staff observations.

- Discontinue the use of FCUs in the NPHD interior offices. Shut off the coolant supply to these units to prevent condensation generation in hot, humid weather and seal the drip pan.
- Action: **FCUs were cleaned with an antimicrobial agent and reactivated.**
- Ensure that FCU filters are installed properly. This may require reconfiguring the wiring of some FCUs or retrofitting filter racks so that filters can be installed in a manner to prevent drawn air by-passing filters.
- **Action:** This action was reportedly done.
- Seal all holes in the walls of the FCU cabinets to limit filter bypass. Double sided, foil-faced insulation with adhesive or aluminum insulation tape can be applied in a manner to create an airtight seal.
- **Action:** It is planned to seal holes with double-sided foil-faced insulation/aluminum insulation tape.
- Repair/install fan speed controls in FCUs.
- **Action:** A capital project is reportedly being arranged to rewire units (tentatively scheduled for August 2014); in the interim thermostats were lowered to 72 degrees for thermal comfort.
- Remove all blockages from FCUs to ensure adequate airflow. NTH staff should be encouraged not to deactivate FCUs and to report any complaints concerning temperature control to the facilities department.
- **Action:** This action has been completed.

Appendix A

- Determine if exhaust vents exist under/behind furniture/stored items as indicated on the plans. If so, ensure that the fans for these vents are functioning to remove stale air and associated pollutants. If no exhaust vents exist, consider discussing the installation of exhaust ventilation with an HVAC engineer.
- **Action:** Plans are being made with a ventilation engineer to add a return vent to the front office and conference room and add a register to Christopher Coleman's office.
- **Use openable windows in conjunction with mechanical ventilation to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding. Windows should not be opened when the HVAC system is in cooling mode, particularly during hot, humid weather conditions.**
- **Action:** This is reportedly done by staff as weather permits.
- Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
- Action: **Balancing to be scheduled for June 2014 by HVAC engineering firm.**
- 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).
- **Action:** HEPA filtered vacuum cleaners reportedly to be provided to custodial staff.
- **Consult with HVAC engineer/plumber to determine:**

Appendix A

    - **If traps can be retrofitted into FCU condensate drains; and**
    - **If FCU components can/should be insulated to prevent/reduce condensation.**

- **Action:** Traps were plugged and cleaned out; holes were sealed and exposed pipes were insulated.
- **Remove porous materials from beneath/within FCUs.**
- **Action:** Custodial staff are to ensure all FCUs are clear of paper/debris inside each unit during regular filter changes.
- **Clean/disinfect areas of water leaks/condensation within FCU cabinets with an appropriate antimicrobial, as needed.**
- **Action:** FCUs were reportedly cleaned with an antimicrobial agent.
- **Consult with a building engineering contractor to consider adding additional insulation or other modifications to the window systems to prevent energy loss, thermal bridging and related condensation problems.**
- **Action:** No action was taken.
- **Properly seal the edge of flooring in the atrium's second floor hallway to prevent mop water from moistening the space between the wood and cement decking. Consider other means of cleaning this floor in lieu of wet mopping.**
- **Action:** Spaces along floor edge in atrium corridor are reportedly planned to be sealed.
- **Consider relocating the parking space shown in Picture 13 to prevent products of combustion from being entrained into the HVAC system.**
- **Action:** A "No Idling" sign was posted at this parking spot. A hood is planned for installation over the grate to prevent rain/debris infiltration and routine monitoring of grates will be conducted.

Appendix A

- **Render airtight all sewer ejector pumps. If possible, install mechanical exhaust ventilation in mechanical rooms with such equipment.**
- **Action:** Pumps were reportedly sealed.
- **Consider installing local exhaust ventilation to remove photocopier pollutants from room 046.**
- **Action:** This recommendation is being evaluated.