INDOOR AIR QUALITY ASSESSMENT

Hanson Town Hall
542 Liberty Street
Hanson, Massachusetts 02341

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
October 2009

Background/Introduction

At the request of Mr. Richard Edgehill, Hanson Board of Health (HBOH), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality concerns at the Hanson Town Hall (HTH), located at 542 Liberty Street, Hanson, Massachusetts. The request was prompted by concerns of possible mold growth, primarily in the Planning & Conservation Department (PCD), related to a leaking ventilation unit in the attic. On August 19, 2009, Cory Holmes, Environmental Analyst/Inspector for BEH's Indoor Air Quality (IAQ) Program made a visit to the HTH to conduct an indoor air quality assessment. Mr. Holmes was accompanied by Building Maintenance Supervisor Brian Clemens during the assessment.

The HTH office is three-story office building constructed in 1872; additions were constructed in 1946 and 1999. At the time of the 1999 addition, older portions of the building also underwent interior renovations (e.g., painting, carpeting). Windows are openable throughout the building. Windows in the older sections of the building were reportedly replaced 2 years ago.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 7565. BEH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The HTH has an employee population of approximately 20 and can be visited by up to 100 individuals daily. 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 areas surveyed the day of the assessment indicating adequate air exchange. The heating, ventilation and air conditioning (HVAC) system consists of air-handling units (AHU) located in the attic (Picture 1) and on the flat roof (Picture 2). Conditioned air is distributed to ceiling-mounted air diffusers (Picture 3) and ducted back to the AHU via return vents (Picture 4). It is important to note, however, that the AHUs located in the attic did not appear to introduce fresh air and these units are limited to heating/cooling and circulating air. Therefore, the only means of introducing fresh, outside air to areas supported by attic AHUs is via openable windows. At the time of the assessment, one of the attic AHUs was inoperable and replacement of the unit was reportedly put out to bid.

The HVAC system is controlled by digital thermostats (Picture 5). Airflow is controlled using a fan switch that has two settings, *on* and *auto*. When the fan is set to *on,* the system provides a continuous source of air circulation and filtration. The *automatic* setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system. The MDPH recommends that digital thermostats be set to the fan "on" setting to provide continuous air circulation.

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 existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires that each room 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 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.

Temperature readings in occupied areas ranged from 73° F to 86° F, which were above the MDPH recommended comfort guidelines in several areas. 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. It is important to note that the attic temperature was measured at 90° F, which contains several of the buildings AHUs. Often times attics are equipped with an exhaust fan that is activated once a set temperature is reached during summer months to remove excess heat (Picture 6); no such fan exists at the HTH. A passive louvered vent that opens and introduces outside air into the attic exists (Picture 7). The day of the assessment the louvered vent was open and introducing hot, humid outside air (temp 85-90° F; RH 85-90%). The excess heat in the attic coupled with the fact that the duct work for the HVAC system is uninsulated, may be taxing the system beyond its capacity to cool and remove moisture, as evidenced by elevated temperature and relative humidity measurements taken in several areas on the second floor (Table 1).

Temperature complaints (excessive heat) were reported in meeting room A, particularly during meetings with high occupancy. This room is equipped with only one supply vent, which may result in a lack of airflow/circulation. In contrast, offices with minimal occupancy contain up to four supply vents.

The relative humidity measured in occupied areas ranged from 43 to 78 percent, which was above the MDPH recommended comfort range in a number of areas surveyed. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Moisture removal is important since the sensation of heat conditions increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperatures rise, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, comfort levels improve. While temperature is mainly a comfort issue, relative humidity in excess of 70 percent can provide an environment for mold and fungal growth (ASHRAE, 1989). 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

In order for building materials to support mold growth, a source of water exposure is necessary. As previously indicated, the assessment was prompted by mold concerns among PCD employees who are housed on the top floor directly below the attic AHU that had chronic leaks. Following the most recent leak; the AHU was disconnected, areas of leaks were dried out and damaged portions of the carpet had been removed. No current water damage, visible mold growth or associated odors were observed/detected in the PCD at the time of the MDPH/BEH assessment.

BEH staff examined conditions in the attic above the PCD in an effort to identify any water damaged building materials or mold growth. Evidence of water damage in the form of stained plywood around the AHUs was observed; however, no visible mold growth or associated odors were observed/detected. Mr. Clemens noted that no drip pans were installed beneath the attic AHUs (Picture 1), and that he would suggest installation of drip pans for the incoming unit and possible retrofit for existing units.

Water damaged ceiling tiles were seen in a number of areas, particulary beneath the flat roof of the 1946 addition (Pictures 8 through 10). Water-damaged ceiling tiles indicate leaks from either the roof or plumbing system and can provide a source for mold growth. These tiles should be replaced after a water leak is discovered and repaired.

Condensation can also provide a source of moisture in the attic. Condensation is the collection of moisture on a surface at or below the dew point. The dew point is the temperature that air must reach for saturation to occur. Over time, condensation can collect and form water droplets. As the AC system operates, water droplets form on the cool surface of uninsulated ductwork in the unconditioned attic. As mentioned previously, a louvered vent was observed in the attic allowing uncontrolled humid, outside air into the attic (Picture 7), which can greatly increase condensation during summer months.

BEH staff examined the outside perimeter of the building to identify breaches in the building envelope and/or other conditions that could provide a source of water penetration. A number of exterior sources for moisture infiltration were identified:

- Plants and trees were observed growing in close proximity to the foundation and building exterior (Pictures 11 and 12). Plants in close proximity to the building envelope can cause water damage to brickwork and mortar. Water can eventually penetrate the brick subsequently freezing and thawing during the winter. This freezing/thawing action can weaken bricks and mortar, resulting in damage.

- Plants and trees were observed growing in close proximity to HVAC equipment, which can hold moisture against metal surfaces accelerating deterioration (Picture 13).
- Damaged/rotted wooden windowsills were observed (Pictures 14 and 15).
- Damaged/rotted wood and open seems in exterior walls were observed (Pictures 16).
- Poor drainage/overflow from a stairwell drain and rotted wooden door at the rear of the building was also observed (Pictures 17 through 19). It is also important to note that there is no lip to the doorframe to prevent water penetration; directly inside the door is wall to wall carpeting that reportedly gets wet during heavy rain.

These conditions can undermine the integrity of the building envelope and provide a means of water entry by capillary action into the building through exterior walls, foundation concrete and masonry (Lstiburek & Brennan, 2001). In addition, these breaches in exterior areas can provide a means of drafts and pest entry into the building.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials (e.g., ceiling tiles, carpeting) 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.

Dehumidifiers were observed in a few areas for moisture removal during periods of increased relative humidity. Occupants and/or maintenance staff should periodically examine, clean and disinfect these units as per the manufacturer's instructions to prevent mold/bacterial growth and associated odors.

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 can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the building environment, BEH staff obtained measurements for 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 assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). No measurable levels of carbon monoxide levels were detected inside the building at the time of the assessment.

Several other conditions that can potentially affect indoor air quality were identified during the assessment. In a number of areas, items were observed on the floor, windowsills, tabletops, counters, bookcases and desks. The large number of items stored provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. In addition, these materials can accumulate on flat surfaces (e.g., desktops, windowsills and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

Several supply, exhaust and return vents were observed to have accumulated dust/debris (Pictures 3 and 4). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles. Supply vents can aerosolize accumulated dust once activated.

Finally, restrooms are equipped with exhaust vents that operate via a rooftop motor (Picture 20). The vents were not drawing air at the time of the assessment. Exhaust ventilation is necessary in restrooms to remove excess moisture and to prevent odors from penetrating into adjacent areas.

Conclusions/Recommendations

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

1. Continue with plans to replace faulty AHU in attic.
2. Operate the HVAC system continuously in the fan "on" mode during periods of occupancy to maximize air circulation and filtration.
3. Work with town officials to develop a preventive maintenance program for all HVAC equipment.
4. Consult with HVAC engineering firm for advice on proper attic ventilation and/or the insulation of attic ductwork to improve cooling/comfort. Determine whether the installation of an attic fan would be beneficial to reduce heat and excess humidity in the attic during summer months.
5. Install drip pans beneath attic AHUs to prevent water penetration into occupied areas.
6. Consider installing additional supply vents in meeting room A, or installing an additional wall-mounted AC unit for use during maximum occupancy.
7. 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 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).

8. Replace water damaged/rotted wooden window frames/sills.
9. Seal seams and replace water damaged/rotted wood on exterior walls.
10. Take measures to prevent water penetration through the exterior door at the base of rear stairwell, this may include several steps, which may include:
    - Re-grading the surface around rear stairwell drain to improve drainage;
    - Replacement of the wooden door with a steel-framed door with lip to prevent water penetration; and/or
    - Permanent removal of the door, if not an essential means of egress (in accordance with local fire codes).
11. Remove carpeting from interior of rear stairwell and replace with a non-porous flooring material.
12. Trim plant growth 3 to 5-feet away from exterior of building and HVAC equipment.
13. Ensure dehumidifiers are cleaned and maintained as per the manufacturer's instruction to prevent microbial growth.
14. Continue to make repairs of roof leaks on the flat roof over the 1946 portion of the building. Consideration should be made to replace the roof to prevent chronic roof leaks.
15. Remove/replace water damaged ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
16. Restore exhaust ventilation in restrooms to remove odors and moisture, make repairs as necessary.

17. Relocate or consider reducing the amount of stored materials to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

18. Clean supply, exhaust and return vents periodically of accumulated dust.

19. Clean carpeting annually or semi-annually in soiled high traffic areas as per the recommendations of the Institute of Inspection, Cleaning and Restoration Certification (IICRC). Copies of the IICRC fact sheet can be downloaded at: http://www.cleancareseminars.com/carpet_cleaning_faq4.htm (IICRC, 2005)

20. For more information on mold consult as "Mold Remediation in Schools and Commercial Buildings" published by the US Environmental Protection Agency (US EPA, 2001). Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html

21. 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.

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Picture 1

Attic AHUs, Note Water Damaged Plywood from Chronic Leakage and Lack of Drip Pans Installed beneath AHUs

Picture 2

Rooftop AHUs

Picture 3

Ceiling-Mounted Air Diffuser

Picture 4

Ceiling-Mounted Return Vents, Note Dust/Debris Accumulation

Picture 5

Digital Thermostat, Note Fan Switch to Auto (Bottom Left)

Picture 6

Example of Attic Fan (in Home), Triggered by Excessive Heat

Picture 7

Louvered Vent to the Outside in Attic

Picture 8

Water Damaged Ceiling Tiles

Picture 9

Water Damaged Ceiling Tiles

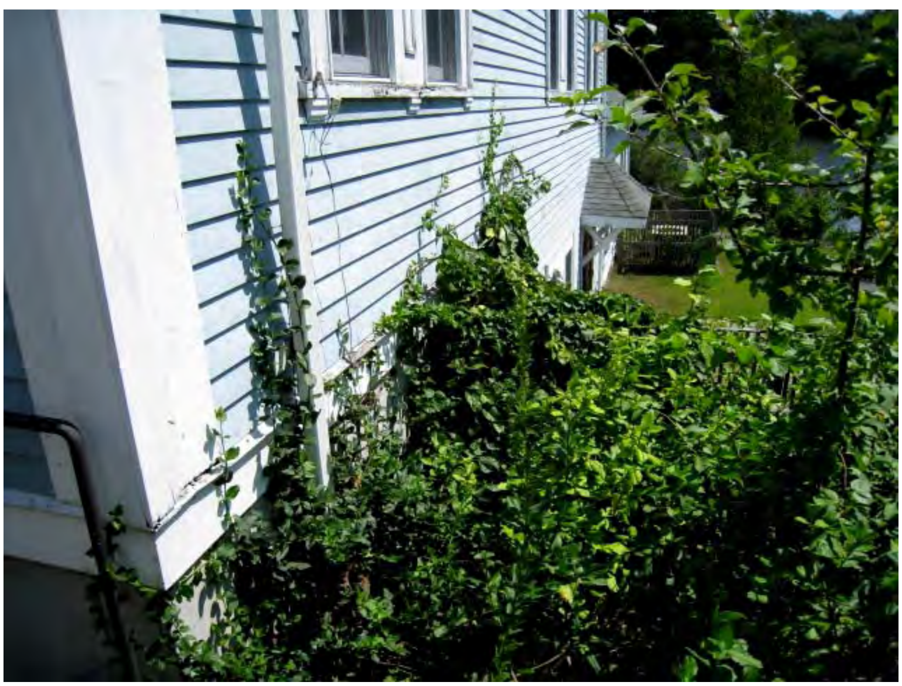
Picture 10

Flat Roof of 1946 Addition

Picture 11

Plant Growth against the Building

Picture 12



Plant Growth against the Building

Picture 13

Plant Growth in Close Proximity to HVAC Equipment

Picture 14

Damaged/Rotted Wooden Window Frame

Picture 15

Damaged/Rotted Wooden Windowsill

Picture 16

Wood Rot between Seams

Picture 17

Rear Stairwell Note Drain and Wooden Door at Bottom

Picture 18

Close-Up of Drain at Base of Stairwell, Note Rot/Damage to Bottom of Wooden Door

Picture 19

Note no Lip to Prevent Water Penetration and Carpet Directly inside Door

Picture 20

Rooftop Exhaust Vent/Motor for Restrooms

Hanson Town Hall **Indoor Air Results**

542 Liberty Street, Hanson, MA

Table 1

August 19, 2009

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Background (outdoors)	85-90	85-90	70	ND					Hot, humid, scattered clouds
Board of Health	75	78	720	ND	3	Y	Y	Y	DO, plant
Planning & Conservation	83	75	687	ND	2	Y	Y	Y	AC down, carpet removed from water damage, no visible mold growth, DO
Meeting Room A	75	60	595	ND	0	N	Y	Y	One supply vent, heat/comfort complaints, DO
Zoning Board of Appeals	86	39	607	ND	2	Y	Y	Y	DO
Attic	90	93		ND					Open louvered vent to outside, water stained plywood floor, no visible mold growth, AC units down
Town Planner	79	43	531	ND	0	Y	Y	Y	
Planning Board	77	49	580	ND	2	Y	Y	Y	DO, plant

ppm = parts per million parts of air
CT = ceiling tile

WD = water damage
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%

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542 Liberty Street, Hanson, MA **August 19, 2009**

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Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Building Dept	74	49	560	ND	1	Y	Y	Y	DO
Building Commishioner	74	52	545	ND	0	Y	Y	Y	DO
Veteran's Agent Registrar	74	53	587	ND	0	Y	Y	Y	
Town Clerk Main	74	54	569	ND	1	Y	Y	Y	DO
Town Clerk Office	75	55	602	ND	0	Y	Y	Y	DO, plants
Treasurer Collector	74	51	607	ND	2	Y	Y	Y	WD CTs from roof leaks
Treasures Office	74	52	630	ND	1	Y	Y	Y	WD CT
Mian Hallway									WD CTs

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							Supply	Exhaust	
Assessor's Office Main	74	49	655	ND	3	Y	Y	Y	DO
Assessor's Office	73	49	627	ND	0	Y	Y	Y	DO
Town Accountant	74	58	608	ND	0	Y	Y	Y	DO, plants
Mail Room	76	62	578	ND	0	Y	Y	Y	DO, computer network server-heat AC down
Executive Secretary	79	57	663	ND	1	Y	Y	Y	DO, fan operating, AC down
Town Administrator's Office	80	55	615	ND	0	Y	Y	Y	DO, plant
Cafeteria	77	76	448	ND	0	Y	Y	Y	Plants
Selectman's Meeting Room	74	63	479	ND	0	Y	Y	Y	

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