INDOOR AIR QUALITY ASSESSMENT

Westfield Athenaeum
6 Elm Street
Westfield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
January 2012

Background/Introduction

At the request of Christopher Linquist, Director, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality (IAQ) at the Westfield Athenaeum (WA), 6 Elm St, Westfield, Massachusetts. The request was prompted by concerns related to water damage and potential mold growth in basement of the building following Tropical Storm Irene (the tropical storm). The tropical storm arrived on August 28, 2011, resulting in an estimated 4.5 inches of rainfall with maximum gusts of wind of 39 mph in the Westfield area of Western Massachusetts. Concern related to the effects of the storm on the 1966 wing first floor of the building prompted this assessment. On September 14, 2011, Michael Feeney, Director of BEH's IAQ Program, made a visit to WA to conduct an assessment. He was accompanied by Kathleen Gilmore, Environmental Analyst/Regional Inspector in the IAQ Program. The WA facility manager, Christopher Trafficante, accompanied Mr. Feeney and Ms. Gilmore.

This assessment was limited to the 1966 wing first floor and the basement area below. As reported by Mr. Linquist, water had flooded the garage, which then entered the storage room area through a connecting door (Picture 1). Mr. Linquist also reported that conditions inside the building were extremely humid during the storm. As a result of the tropical storm, occupants on the 1966 wing first floor expressed concerns regarding odors.

The WA is a two-story structure constructed with multiple additions. The original structure was built as a residence in 1838. An addition, which serves as the main section of the library, was constructed in 1927. Two other additions were made in 1966, one to the north side of the 1927 wing and a second wing to the west wall of the 1838 residence. A garage was added in 1974 (Picture 2) that houses a bookmobile vehicle. As part of a renovation project in the late 1990s to address handicap access, a wall constructed in the basement area created a hallway allowing patrons to use the building elevator to access the basement-level community rooms while preventing access to the basement storage/work area.

The 1838 wing contains the administration office on the second floor, with the first floor containing part of the children's library. The 1927 wing contains the main library stacks with a multiple-tiered balcony at the rear of the wing. The north 1966 wing contains periodicals and reference material with a single balcony in the rear. The west 1966 wing contains a children's library and restrooms.

The basement contains a large storage/workroom (Picture 3), a mechanical ventilation room, an auditorium and several small rooms used for various community purposes. The garage is adjacent to the basement storage room on the north exterior wall of the 1966 wing. A double door connects the basement and garage (Picture 4). Windows in the building are openable with the exception of transom windows in the basement which were painted over and were not openable at the time of the assessment.

Methods

BEH staff performed visual inspection of building materials in the storage room area and the 1966 wing first floor for water damage and/or microbial growth as well as the exterior of the building. No other locations in the building were part of this assessment. Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The WA has a daily employee population of approximately 15-20, with up to several hundred individuals visiting on a daily basis. The tests were taken under normal operating conditions. Test results appear in Table 1.

Discussion

Ventilation

Table 1 shows that carbon dioxide levels were below 800 parts per million (ppm) parts of air in all areas surveyed, indicating adequate air exchange. These carbon dioxide levels are indicative of an adequate fresh air supply. The ventilation system in the 1966 north wing was located in a mechanical room in the storage room.

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 date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times when 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 (OSHA, 1997).

The Department of Public Health 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 ranged from 74 ^{o}F to 75 ^{o}F during the assessment, which were within the MDPH recommended comfort range (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70 ^{o}F to 78 ^{o}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.

The relative humidity measured in the 1966 wing first floor was 56 percent. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity in the basement ranged from 70 to 71 percent during the assessment, which was above the MDPH recommended comfort range. It is important to note that relative humidity measured indoors exceeded the outdoor measurement of 60 percent at the time of the assessment. This can indicate that sources of moisture exist in the storage room area. In addition to the water that flooded the basement, the storage room contains a sump pump with a heavily rusted lid (Picture 5), indicating repeated water vapor exposure. The lid is open and can readily allow for water vapor to enter the storage room, which from the storage room.

Moisture removal is important since increased water vapor concentrations in the storage room can lead to condensation[1] if an object has a temperature below the dew point. Therefore, any surface that had a temperature below the dew point would be prone to condensation under these temperature and relative humidity conditions.

Microbial/Moisture Concerns

As mentioned previously, the relative humidity conditions in the basement are of concern relative to moisture/mold growth. The basement storage room had a relative humidity of 71 percent. Prolonged relative humidity concentrations indoors above 60 percent can foster mold growth in susceptible porous materials such as cardboard, paper, books, cloth and other materials, which are present in the WA storage room. One indication of the presence of water-damaged materials was the detection of a musty odor upon entering the basement. This odor was due to the significant amount of books, paper products and other materials that were water-damaged and likely supporting mold growth. BEH staff identified a number of materials with evidence of moisture, water damage and mold colonization/growth including: missing or

[1] Condensation is the collection of moisture on a surface with a temperature below the dew point. The dew point is a temperature determined by air temperature and relative humidity. For example, at a temperature of 73^{o} F and relative humidity of 57 percent indoors, the dew point for water to collect on a surface is approximately 57^{o} F (IICRC, 2000).

damaged floor tiles (Picture 6), cardboard boxes, pipe insulation and books stored on shelves along the back wall (Picture 7). Of note are the books in Picture 7, which are stored on metal shelves located on the exterior foundation wall. While the flooding may have caused some of the mold growth on these books, the shelving also appears to be subject to condensation. Fasteners that affix the shelving to the foundation wall show signs of water damage (Picture 8). The wall where the shelving is attached is also the foundation for the building (Picture 9) located beneath the grass in Picture 1. Since this foundation wall is below grade and constructed in the 1950s, it is likely that the cement is not insulated. The wall would serve as a thermal bridge[2] which would lower the shelves' temperature below the dew point, resulting in condensation moistening any book stored along this wall during hot, humid weather. This process would occur during summer months and it is likely that the water damage and mold growth to the books on this shelf preceded the tropical storm damage.

It is noteworthy that reports of complaints of odors occurred in the 1966 wing first floor only, since there were no water-damaged materials noted in the occupied areas of that part of the building. The odors reported were likely due to basement air being forced into upper areas of the library by the tropical storm winds forcing air into the garage and through the storage room access doors. The tropical storm winds combined with the configuration of the garage and basement resulted in the migration of these odors into occupied space. The garage door opens to the west and was subjected to constant westerly winds in the storm. Since no means for air to escape the garage exists, the garage became pressurized, forcing air into the storage room via the garage access doors. Once the storage room became pressurized, it is likely odors traveled to the

[2] A thermal bridge is an object (usually metallic) in a wall space through which heat is transferred at a greater rate than materials surrounding it. During the heating season, the window comes in contact with heated air from the interior and chilled air from the outdoors, resulting in condensation formation if the windows temperature is below the dew point.

upper floor via the elevator shaft and through spaces in and around the air-handling unit (AHU) located in a mechanical room off the storage room. Once the storm subsided and the building was aired out, the basement odors receded. The mechanical room door was open to the basement when examined by BEH staff. No basement/storage room odors were detected in any location on the upper floors during the assessment.

In order to reduce the potential for further odor migration, a fan placed at the garage door was moving air from the garage into the basement (Picture 10). The fan in its original position pressurized the storage room and force odors into the occupied areas via the noted pathways. BEH staff recommended that the fan be reversed to draw air from the storage room into the garage, which would act to depressurize the storage room and prevent odor migration to occupied areas.

The configuration of the garage resulted in both flooding of the storage room and pressurization of the storage room. The driveway to the garage slopes downward from the parking lot (Picture 2). Rainwater flowed into an interceptor drain at the base of the building (Picture 11). Of note is that the interceptor drain does not span the garage door opening which allowed for water to penetrate into the garage. The garage floor was still moistened 16 days after the tropical storm (Picture 12), indicating poor drainage of the garage. With the fan in Picture 10 operating, moisture from the garage floor was directed into the storage room, increasing the relative humidity. The interceptor drain is connected to a sump pump located inside the storage room (Picture 5). Mr. Trafficante reported that the pump has backed up during severe storms causing water penetration and damage to the area surrounding the pumps.

BEH staff conducted a perimeter inspection of the building's exterior to identify potential sources of water penetration. Cracks and crevices exist in the building envelope which can undermine the integrity of the exterior walls and provide a means of water entry by capillary action into the building through the exterior wall system.

The roof of the garage is flat but slopes toward the 1996 north wing creating another means for water to migrate towards the building structure. The roof has one drain catch basin that leads to a grassy area but there are no rain gutters or downspouts allowing water to pool at the base of the foundation as evidenced by water damage along the exterior wall at the seam of the basement and garage (Picture 13). In this condition, water can penetrate through the garage walls to continue to moisten the garage floor.

Efflorescence was observed in bricks along the side of the building (Picture 14). Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar, brick or plaster, water-soluble compounds dissolve, creating a solution. As the solution moves to the surface of the material, the water evaporates, leaving behind white, powdery mineral deposits.

The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24-48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth.

Shrubbery and grassy areas are growing in close proximity to foundation walls (Pictures 15, 16). The growth of roots against exterior walls can bring moisture in contact with brick, eventually leading to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and/or masonry (Lstiburek & Brennan, 2001).

Other Concerns

Storage room odors observed in the occupied areas of the WA are directly related to the configuration of the garage and pressurization created by tropical storm winds. The garage door faces west (Picture 2). The WA garage is not equipped with either a mechanical exhaust system or openable windows to either remove emissions or provide cross ventilation. In a steady westerly wind, the garage may become pressurized forcing air into the storage room, which in turn may become pressurized, forcing odors from the storage room into occupied space via the elevator and HVAC system. If a window/passive vent/opening existed in the east wall of the garage, the pressurization would be relieved and impact to the occupied spaces in the WA by tropical storm winds would be reduced.

During the course of the assessment, a number of pipes exposing an insulation material (Picture 17) and water-damaged floor tiles were observed in the basement level of the WA. Due to the potential for these materials to contain asbestos, testing to should be done by a licensed contractor. If it is asbestos is present, it should be remediated in conformance with all applicable Massachusetts asbestos abatement and hazardous materials disposal laws.

Conclusions/Recommendations

In view of these findings at the time of the visit, the following conclusions and recommendations are provided:

1. Consider installing a passive or mechanical exhaust fan in the garage to vent vehicle exhaust from the building. If not feasible, remove bricks from the east wall of the garage to reduce pressurization during time of high westerly winds.
2. Consider replacing the sump pump for the garage drain inside the garage. If not feasible, render the sump pump as airtight as possible to prevent moisture evaporation into the storage room.
3. Examine the feasibility of installing a mechanical exhaust ventilation system for the basement storage/workroom.
4. Check the weather-stripping around the bookmobile interior door. Check for air-tightness by monitoring for light and/or drafts around doors. Ensure doors accessing the basement fit completely flush with threshold.
5. Remove any mold-contaminated materials (including stored items) in the basement.
6. Remove and replace any water-damaged/mold-colonized building materials (e.g., floor tiles). This measure will remove actively growing mold colonies that may be present. Remove mold contaminated materials in a manner consistent with recommendations found in “Mold Remediation in Schools and Commercial Buildings” published by the US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, DC. This document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.
7. Ensure that the HVAC system in the basement mechanical room have all door and access panels closed. Keep the door to the mechanical room closed.

8. Use dehumidifiers in below grade areas during hot, humid weather to reduce relative humidity. Ensure dehumidifiers are cleaned and maintained as per the manufacture's instruction to prevent microbial growth.
9. Seal utility holes and other potential pathways to eliminate pollutant paths of migration from the basement to the first floor.
10. Install gutters and downspouts on the garage roof to direct rainwater at least 5 feet away from the foundation. Remove foliage to no less than five feet from the foundation.
11. Examine the junction between the garage and the 1927 wing for degrading seals and repair as needed.
12. 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. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
13. Consult with a licensed asbestos inspector to ascertain whether pipe insulation and floor tiles contain asbestos and encapsulate or remove in conformance with Massachusetts law. Do not remove/replace water-damaged ceiling tiles until this issue is resolved.
14. 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

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1.

IICR. 2000. IICR S001 Reference Guideline for Professional On-Location Cleaning of Textile Floor Covering Materials Institute of Inspection, Cleaning and Restoration Certification. Institute of Inspection Cleaning and Restoration, Vancouver, WA.

Lstiburek, J. & Brennan, T. 2001. Read This Before You Design, Build or Renovate. Building Science Corporation, Westford, MA. U.S. Department of Housing and Urban Development, Region I, 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. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001.

Picture 1

Garage Access Door in Storeroom

Picture 2

Garage Entrance Facing West, Note Slope Downward towards the Garage Door

Picture 3

Basement Storage/Workroom

Picture 4

Door Connecting the Basement to Garage (arrow)

Picture 5

Sump Pump inside the Storeroom

Picture 6

Damaged/Missing Floor Tiles

Picture 7

Books Stored on Back Wall

Picture 8

Shelf Fastener with Signs of Dried Condensation on its Surface

Picture 9

Books on Shelf Attached to Foundation Wall

Picture 10

Open Garage Access: fan (arrow) was originally positioned to inject air into storeroom. BEH staff reversed fan direction to draw air and moisture from storeroom.

Picture 11

Interceptor Drain, Note Space between Wall and Drain, Moistened Concrete Floor Days after Storm

Picture 12

Garage Floor Moistened 16 Days after Tropical Storm

Picture 13

Water Damaged Exterior Wall

Picture 14

Efflorescence on Exterior Wall

Picture 15

Shrubs/Plants on and abutting Exterior Wall

Picture 16

Grass Area at Foundation

Picture 17

Exposed Pipe Insulation

Location: Westfield Athenaeum **Indoor Air Results**

Address: 3 Elm Street, Westfield, MA **Date: 7/14/2011**

Table 1

Location/ Room	Carbon Dioxide (ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Background	290	82	60					
Basement Storage Room	508	74	71	0	N*	N	N	DO * Windows Painted Shut
Hallway Outside storage room	325	74	71	0	N	N	N	
Mechanical ventilation room	319	74	70	0	N	Y	Y	DO
1996 North Wing Floor Level	473	74	56	3	Y	N	N	DO
Main Desk	492	75	56	2	Y	Y	Y	

ppm = parts per million

µg/m^3 = micrograms per cubic meter

DO = door open

ND = non detect

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3