INDOOR AIR QUALITY ASSESSMENT

HCAC Building
9 Russell Road
Huntington, Massachusetts 01050

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

Background/Introduction

At the request of the Huntington Board of Selectmen, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding mold concerns at the Hampshire Community Action Commission (HCAC) building, 9 Russell Road, Huntington, Massachusetts. The request was prompted by reports of possible crawlspace odors infiltrating the main section of the building.

On February 13, 2009, Michael Feeney, Director, and Lisa Hébert, Regional Inspector/Environmental Analyst, of BEH's Indoor Air Quality (IAQ) Program made a visit to the HCAC to conduct an assessment of the building. Selectman Robert Heath accompanied BEH staff during the assessment.

The building was constructed as a two-floor, wooden clapboard structure with an unfinished attic and cellar during the 1800s. Since 1998, the original building has undergone a number of renovations and an addition. The interior has been subdivided into offices, which contain a number of town offices. A wing was added to the rear of the building, which contains a day care center. Windows are openable throughout the building.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™. BEH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The HCAC has an employee population of five and is visited by approximately 40 to 50 people 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 of air (ppm) in all areas surveyed, which indicates adequate air exchange in the building. It is important to note, however, that some rooms had open windows and/or were empty/sparsely populated at the time of assessment, which can result in lower carbon dioxide levels. Carbon dioxide levels would be expected to be higher with increased occupancy and windows closed.

The heating, ventilating and air conditioning system consists of three air handling units (AHUs): one AHU in the attic serves the second floor (Picture 1); an AHU in the cellar serves the first floor (Picture 2); and the third AHU serves the day care center. Each AHU provides cooling and/or heating of air within the building to occupied areas through ceiling and wall-mounted air diffusers connected via ductwork. Air returns to the AHUs through ceiling or wall-mounted exhaust grilles via ductwork with the exception of the first floor, which has return vent in the floor (Picture 3). None of the AHUs at the HCAC have the ability to draw fresh air from outdoors or to exhaust stale air from the building.

The AHUs are controlled by thermostats. Thermostats have a fan setting that can be set to either “auto” or “on”. Setting the thermostat to “auto” activates the AHU at a preset temperature, and deactivates the system once the preset temperature is reached. The thermostat should be set to the "on" position during periods of occupancy in the building in order to provide continuous airflow to occupied areas.

To maximize air exchange, the MDPH typically recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. Generally, 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. However, in the case of the HCAC, the AHUs merely circulate and condition existing air as they have no capacity to bring in fresh air or exhaust stale air from the building.

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.

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 temperature readings ranged from 66^{o} F to 69^{o} F, which were below the MDPH recommended comfort guidelines (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 building ranged from 23 to 28 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. It is important to note, however, that relative humidity measured indoors exceeded outdoor measurements (range +11 – 16 percent). This increase in relative humidity can indicate that the exhaust system is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration). In the case of the HCAC, there is no means of exhaust so this condition can be expected to continue unless improvements to the HVAC system are made. Moisture removal is important since the sensation of heat conditions increase as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperature rises, the addition of more relative humidity will make occupants feel hotter. The sensation of dryness and irritation is common in a low relative humidity environment. Relative humidity levels in the building would be expected to drop during the winter months due to heating. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

As discussed previously, the building has a cellar. The first floor AHU is located in the cellar that consists of a furnace/forced hot air air-handing unit (AHU) (Picture 2). Floor-mounted heating vents and ducted return vents provide tempered air to the main section of the building. The location of the AHU in the cellar presents a number of water damage/mold concerns.

The cellar has a flagstone foundation with a dirt floor. The crawlspace appears to be subjected to significant water penetration as suggested by damp soil, water stains on wood support beams (Picture 4), wood rot around the bulkhead door (Picture 5), discoloration of a spray on insulation that was applied over the foundation wall (Picture 6) [and windows (Picture 7)] and water damaged cardboard (Picture 8). A significant amount of rotted wood and other discarded materials were observed in the crawlspace (Picture 9). If moistened for prolonged periods of times, these materials can serve as media for mold growth. Any water absorbent material (e.g., cardboard, paper, soil, cloth,) stored in the cellar, particularly in direct contact with the dirt floor, is likely chronically moistened and mold colonized. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials 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.

Three pathways exist for cellar air and its pollutants to migrate into the occupied first floor: (1) the HVAC system; (2) an open duct near the chimney; and (3) spaces and cracks that exist in the cellar ceiling/first floor boards created by damage to support timber. The AHU has a return vent that does not have its seams sealed. Since the return vent is depressurized as air is drawn from the first floor to the AHU, any seams that are not sealed can draw cellar air, water vapor and other pollutants into the duct, which may then be distributed to occupied areas.

The second pathway is an open duct near the chimney in the basement (Picture 10). The purpose of the duct is unknown, but seems to be used as a pipe/electric wire chase. Since this appears to be abandoned ductwork, it is likely that it ends in wall cavities in the upper floors. This duct opening in the basement should be sealed to prevent cellar air movement into the upper levels of the building.

The third pathway for cellar air, moisture and other pollutants to migrate into occupied areas is through spaces that exist in the cellar ceiling that have been opened due to damage to the support timbers. The first floor had noticeably uneven areas in the floor and the ceiling (Picture 11). This unevenness may be attributable to cracked beams (Picture 12), water damage to the support beams (Picture 13), poorly supported beams (Picture 14), or free, unsupported beams that exist in the cellar. Damage to the timbers supporting the floor can lead to spaces in the floor which would then expose the wall-to-wall carpet on the first floor to moisture.

Moisture is introduced into the cellar of the building through a number of means including the dirt floor and water penetration through the bulkhead door and through the flagstone foundation. As relative humidity levels increase indoors, porous building materials, such as wood and carpeting, can absorb moisture. The moisture content of wood and carpeting can fluctuate with increases/decreases in indoor relative humidity.

A number of conditions may have contributed to the accumulation of moisture between the floor and wall-to-wall carpeting:

- When an air conditioned space (first floor) is adjacent to a non-conditioned space (the dirt floor cellar), measures to separate each space using adequate insulation are necessary to prevent condensation on shared surfaces (e.g., the wood floor). The floor beneath the first floor offices has no insulation, exposing the underside of the floor, making it prone to condensation generation, particularly in hot, humid weather with the window-mounted air conditioner activated.

- The basement is subject to water penetration through its foundation, likely due to a lack of a gutter/downspout system for the roof edge at the front of the building (Picture 16) and the emptying of downspouts at the base of the foundation.
- The basement consists of flagstone walls with a dirt floor, which would allow accumulated surface water (pooling rain) on the exterior of the building to readily enter the basement.
- Moist air likely penetrates into the basement via the bulkhead door. Hot, humid air during summer months would tend to wet soil and foundation stone from accumulation of condensation. Condensation is the collection of moisture on a surface that has a temperature below the dew point. The dew point is a temperature that is determined by air temperature and relative humidity. For example, at a temperature of 85^{o}F and relative humidity of 90 percent, the dew point for water to collect on a surface is approximately 82^{o}F. Therefore, if a surface has a temperature under 83^{o}F, water vapor will form droplets on that surface. Surfaces below grade that are in contact with earth tend to be substantially cooler than the air temperature, making them prone to generating condensation. Once condensation moistens a material that can support fungal growth for an extended period of time, mold growth may occur.

Each of these conditions, in combination with high ambient temperatures during the summer, increased relative humidity and possible water sources within the basement, may contribute to moistening of porous materials. The American Conference of Governmental Industrial Hygienists (ACGIH) and the US Environmental Protection Agency (US EPA) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). 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. The application of a mildewcide to porous materials is not recommended.

Other Concerns

Bat waste was observed on the floor of the attic (Picture 16). Bats in a building raise concerns over diseases that may be caused by exposure to bat wastes. These conditions warrant clean up and appropriate disinfection. Certain molds (*Histoplasma capsulatum)* are associated with bat waste (CDC, 2001; NIOSH, 1997) and are of concern for immune compromised individuals. Diseases of the respiratory tract may also result from exposure to bat waste. While immune compromised individuals have an increased risk of health impacts following exposure to the materials in bat wastes, these impacts may also occur in healthy individuals exposed to these materials. Further, exposure to the saliva of a bat due to either a bite or a scratch poses a risk for rabies. Please see Appendix B for more information regarding the disease of rabies and rabies prevention methods. Although written for residential purposes, much of the information would nonetheless be helpful in addressing the situation in the building.

The methods to be employed in clean up of a bat waste problem depends on the amount of waste and the types of materials contaminated. The MDPH has been involved in several indoor air investigations where animal waste has accumulated within ventilation ductwork. Accumulation of bat wastes have required clean up of such buildings by a professional cleaning contractor. In less severe cases, the cleaning of the contaminated material with a solution of sodium hypochlorite has been an effective disinfectant (CDC, 1998). Disinfection of non-porous materials can be readily accomplished with this material. Porous materials contaminated with bat waste should be examined by a professional restoration contractor to determine if the material is salvageable. Where a porous material has been colonized with mold, it is recommended that the material be discarded (ACGIH, 1989).

The rotted fascia on the exterior of the building provides more than enough space for the entry of bats, birds and/or squirrels (Picture 17). These pathways into the building must be eliminated in order to eliminate the problem within the building.

Of note is the configuration of the exhaust ventilation for the attic AHU. The exhaust vent appears to be over 10 feet in length on the horizontal plane and has at least 270^{o} in bends (Picture 18). In general, exhaust ducts should minimize the numbers of horizontal pipes and turns. Increasing length and turns in exhaust ductwork can decrease the efficiency of products of combustion to the chimney. If this occurs, products of combustion can pool in the ducts, which can then enter into the attic space through spaces in the ductwork. In this configuration, all seams in the flue pipe should be sealed.

In the preschool, numerous cleaners as well as bleach and air fresheners were observed in the classroom. Cleaning products can be irritating to the eyes, nose and throat of sensitive individuals. Material Safety Data Sheets (MSDS) should be obtained for all cleaning products used within the HCAC and should be kept in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983). Additionally, many air fresheners contain 1,4-dichlorobenzene, a VOC which may cause reductions in lung function (NIH, 2006). Furthermore, deodorizing agents do not remove materials causing odors, but rather mask odors that may be present in the area.

Cracks were noted in drywall in the preschool and throughout the building, likely due to the structural issues in the basement discussed previously. These cracks may allow dusts and particulates to enter the occupied space. This condition could cause respiratory irritation to exposed individuals.

A pipe in the basement appears to have damaged insulation (Picture 19). This insulation may contain asbestos and, if so, should be remediated in conformance with all applicable State and Federal asbestos abatement and hazardous materials disposal laws.

Conclusions/Recommendations

Based on the observations made during this assessment, it appears that air from the cellar can readily be distributed to the first floor of the building since an AHU is in the cellar. The conditions within the crawlspace and attic are problematic, but readily repairable. In order to address the conditions listed, the recommendations made to improve indoor air quality in the building are divided into short-term and long-term corrective measures. The **short-term** recommendations can be implemented as soon as practicable. **Long-term** measures are more complex and will require planning and resources to adequately address the overall indoor air quality concerns.

Short-Term Recommendations

1. Remove carpet and padding from the first floor. Use a non-porous flooring material in the place of carpeting.
2. Consider removing as much wood/cardboard and other materials that can support mold growth from the floor of the crawlspace.
3. Contact a professional extermination firm to inspect the building for the presence of bats. Have the firm provide recommendations concerning the migration of bats into the

building. Particular attention should be made to seal pathways in the attic. Remediation of bat waste and elimination of entry pathways into the building should be conducted in accordance with MDPH and CDC guidelines (Appendices B and C).

4. Seal all spaces in the return ductwork for the attic and cellar AHUs.
5. Remove rotten timber and other accumulated debris from the basement.
6. To prevent moisture penetration into the basement, the following actions should be considered:
    a. Extend downspout to direct water away from the foundation wall.
    b. Remove foliage to no less than five feet from the foundation.
    c. Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek, J. & Brennan, T.; 2001).
    d. Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek, J. & Brennan, T.; 2001).
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 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).
8. Determine the purpose of the open duct in the cellar in Picture 10. If used as an electrical or pipe chase, seal the opening.
9. Repair cracks in drywall.

10. Discontinue use of air fresheners.

11. Store cleaning products out of reach of children.

12. Obtain Material Safety Data Sheets (MSDS) for all cleaning products used within the HCAC and store in an area that is accessible to all individuals during periods of building occupancy.

13. Repair rotted fascia on the exterior of the building. Attempt to identify additional entry points into the building and eliminate those pathways into the building as well.

Long-Term Recommendations

1. In order to address the attic furnace vent, examine the feasibility to install the exhaust vent at a location several feet higher in the chimney to provide a means for upward movement of combustion products to the chimney (Figure 1) or install a power vent to draw combustion products to the chimney.

2. Have the building inspector examine the various support beams in the cellar to determine their structural integrity and adequacy to support the floor load.

3. Have the building inspector examine the second floor porch (Picture 20) for adequacy to support the floor load.

4. Consult a licensed asbestos abatement contractor to identify and remove potential asbestos insulation noted in the crawlspace, basement and under the cabinets of the east wing. Remediate damaged floor tiles in conformance with State and Federal asbestos remediation and hazardous waste disposal laws.

References

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

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

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

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

CDC. 2008 Histoplasmosis. Centers for Disease Control and Prevention, Atlanta, GA . http://www.cdc.gov/nczved/dfbmd/disease_listing/histoplasmosis_gi.html

IICRC. 2000. IICRC 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

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.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

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

SMACNA. 1995. IAQ Guidelines for Occupied Buildings Under Construction. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

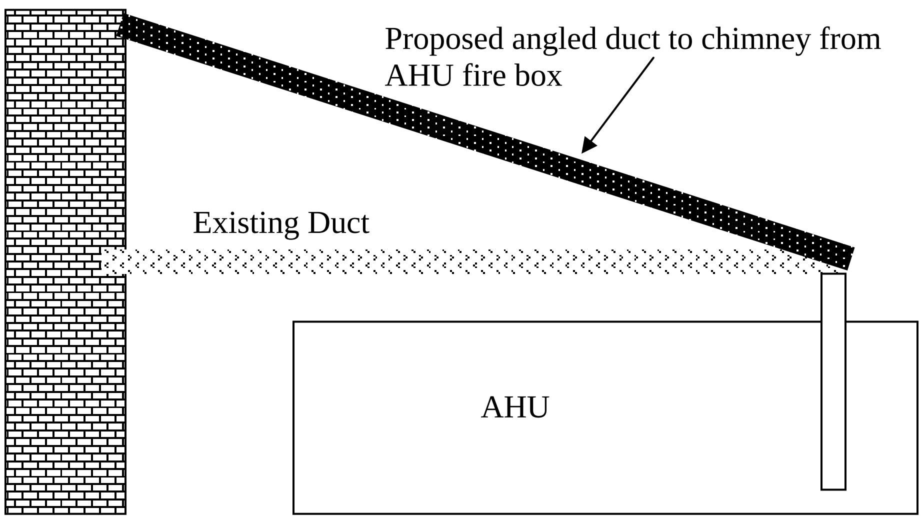
Thornburg, D. 2000. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

Trewartha, G.T. 1943. *An Introduction to Weather and Climate*. McGraw-Hill Book Company, New York, NY.

US EPA. 2001. "Mold Remediation in Schools and Commercial Buildings". Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001. Available at: http://www.epa.gov/iaq/molds/mold_remediation.html

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.

Figure 1
Reconfiguration of Combustion Product Vent to Chimney



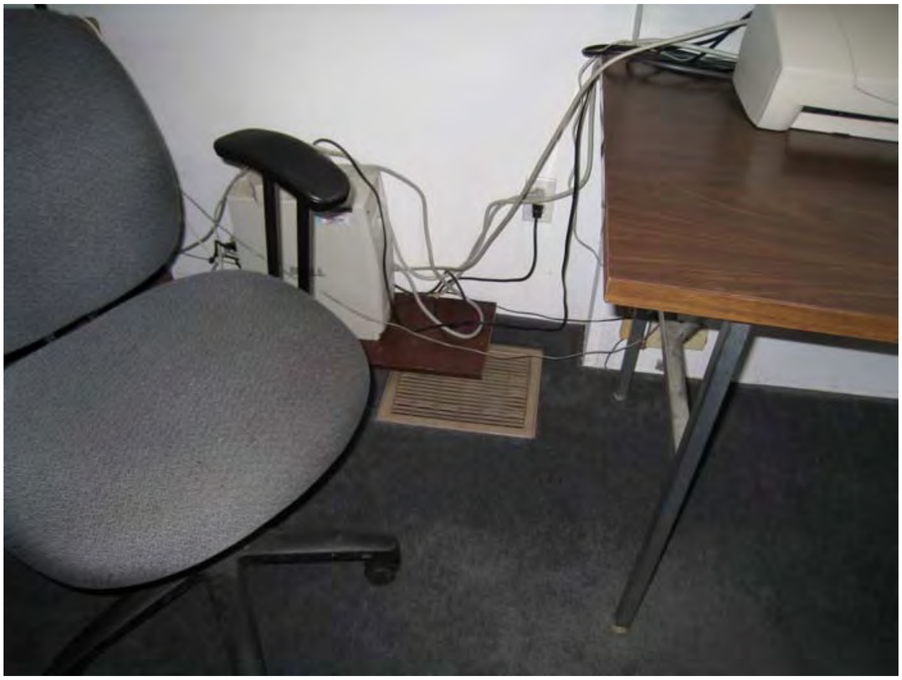
Picture 1

Attic AHU

Picture 2

Cellar AHU

Picture 3



Floor Return Vent

Picture 4

Rotted Wood near Bulkhead Door

Picture 5

Bulkhead Door, Note Moss and Water Stain

Picture 6

Discolored Spray on Insulation

Picture 7

Cellar Window Sealed Over Using Spray-On Insulation

Picture 8

Water Damaged Cardboard

Picture 9

Various Debris on Cellar Floor

Picture 10

Open Duct in Cellar

Picture 11

Uneven Ceiling
(The Light Fixture Bracketed By the Added Lines Should Be Parallel To the Rooms Wall/Ceiling, Not At an Angle)

Picture 12

Cracked Cellar Beam

Picture 13

Water Damaged Cellar Beam

Picture 14

Poorly Supported Cellar Beam

Picture 15

Roof Edge above Bulkhead without Gutter/Downspout

Picture 16

Bat Waste on AHU Duct in Attic

Picture 17

Hole In Roof That Is Likely Bat Access Point

Picture 18

Exhaust Pipe of AHU Running Parallel To the Attic Floor

Picture 19

Damaged Pipe Insulation

Picture 20

Second Floor Porch, Note Gap in Railing

Location: HCAC Building | **Indoor Air Results**

Address: 9 Russell Rd, Huntington, MA | **Date: 2/13/09**

Table 1

Location	Occupants in Room	Carbon Dioxide (ppm)	Temp (°F)	Relative Humidity (%)	Carbon Monoxide (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Outside (Background)		333	40	12	ND	3	-	-	-	
Nutrition	0	554	66	25	ND	3	Y	Y	N In hall	DO, DEM, deformed drywall
Pre School	0	715	68	25	ND	4	Y	Y	Y	DC, cracks in drywall, bottle of bleach, cleaners, air fresheners
Wellness	0	604	69	23	ND	2	Y	Y	Y	DC, bow in ceiling, ozone, floor slopes, exhaust partially blocked, gap when door is closed, telephone wire through portion of duct.
Hearing Screening	0	650	69	24	ND	2	Y	Y blocked	Y	DO, Blocked air supply, possible asbestos bottom to fireplace, water damage inside chimney
Front Hall	0	517	69	23	ND	2	Y	Y	Y	
Conference Room	0	730	66	28	ND	3	Y	Y	N In hall	DO

ppm = parts per million

AT = ajar ceiling tile
design = proximity to door
DO = door open

DEM = dry erase materials
GW = gypsum wallboard
MT = missing ceiling tile

ND = non detect
PC = photocopier
PF = personal fan

TB = tennis balls
VL = vent location
WD = water-damaged

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%