INDOOR AIR QUALITY ASSESSMENT

Holbrook Town Hall
50 North Franklin Street
Holbrook, Massachusetts 02343

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 Kathleen Moriarty, Health Agent for the Holbrook Board of Health, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality concerns at the Holbrook Town Hall (HTH), 50 North Franklin Street, Holbrook, Massachusetts. The request was prompted by employee concerns of poor indoor air quality and temperature/heat complaints in the building. On May 6, 2008, a visit to the HTH to conduct an indoor air quality assessment was made by Cory Holmes, an Indoor Air Quality (IAQ) Inspector in BEH's IAQ Program.

The HTH is a two-story, red brick building with an occupied basement. It was constructed in 1878. The building has undergone renovations over the years, most recently in 2007, which included a new slate roof, interior work and exterior windows along the front of the building. Windows are openable throughout the building; however, several of them are in disrepair and are reportedly difficult to open. The building contains town offices, common areas and public meeting rooms. At the time of the assessment, it was reported that the town of Holbrook had passed a capital improvement plan to install a central AC system to improve comfort in the building. In addition, the town is pursuing grant options to obtain funding for replacement of remaining windows.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted 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™

Aerosol Monitor Model 8520. MDPH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The HTH has an employee population of approximately 25 and is visited by up to 50 individuals daily. The 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 indicating adequate air exchange the day of the assessment. It is important to note, however, that the HTH does not have an operable means of mechanical ventilation but use windows to introduce fresh air and portable air-conditioning (AC) units for cooling. It appears that a mechanical ventilation system consisting of unit ventilators (univents) was retro-fitted; however, these units appeared to be of late vintage (as illustrated by hand controls) and to have not been used for some time (Pictures 1 and 2). A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building (Picture 3) and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to rooms through an air diffuser located in the top of the unit.

The animal control office and DPW meeting room located in the basement do not have mechanical ventilation or openable windows. BEH staff recommended that passive door vents be installed as a temporary means to provide air exchange.

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, consult Appendix A.

Temperature readings in the building ranged from 66^{o} F to 75^{o} F, which were within or slightly below the MDPH recommended comfort guidelines. 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. Heat complaints were expressed in offices along the front of the building. Window-mounted ACs cannot be installed in those areas due to the window configuration. This issue should be resolved once the mechanical AC system is installed; in the meantime occupants are attempting to maintain comfort using open windows and portable fans. BEH also suggests the application of a tinted film to windows as an alternative means to reduce solar glare and radiant heat.

The relative humidity measured in the building ranged from 34 to 43 percent, which was within or close to the lower end of the MDPH recommended comfort range in all areas surveyed. 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 wall plaster, peeling paint and efflorescence were observed in the board of health annex (Picture 4) and in the assessor's office (Picture 5). Water damage is most likely the result of water penetration through the building envelope, as evidenced by missing/damaged mortar around exterior brick (Pictures 6 through 9). 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. Also noted around the exterior of the building were open utility holes (Picture 10), which can provide a means of egress for drafts, moisture and/or pests into the building.

Several areas had water-damaged ceiling tiles (Table 1), most of which appeared to be from the historic building envelope or plumbing leaks (Pictures 11 through 13). Water-damaged ceiling tiles can provide a source of mold and should be replaced after a moisture source or leak is discovered and repaired.

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.

Window-mounted air conditioners (ACs) were observed in several areas. These units are normally equipped with filters, which should be cleaned or changed as per manufacturer's instructions to avoid the build-up and re-aerosolization of dirt, dust and particulate matter. Several of the units were missing filters and the cooling fins were occluded with dust and debris, which can provide a mold growth media when moistened. Musty odors were detected in the 1st floor meeting room, which appeared to be originating from the window AC unit (Picture 14). ACs that did have filters were found to be occluded with dust and debris (Pictures 15 and 16), which can be re-aerosolized when activated. Spaces were also noted around the AC in the 2nd floor hearing room (Picture 17), which can allow for uncontrolled drafts, moisture and pests into the building.

Dehumidifiers were observed in several 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 manufacture'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 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 building environment, BEH staff obtained measurements for carbon monoxide and PM2.5.

Carbon Monoxide

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health 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).

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). Carbon monoxide levels measured in the building were also ND.

Particulate Matter (PM2.5)

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter (μg/m^3) in a 24-hour average (US EPA, 2006). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA established a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 35 μg/m^3 over a 24-hour average (US EPA, 2006). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 21 μg/m^3 (Table 1). PM2.5 levels measured in the building ranged from 10 to 19 μg/m^3 (Table 1). Both indoor and outdoor PM2.5 levels were below the NAAQS of 35 μg/m^3 (Table 1). 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 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 the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

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 (Pictures 18 through 20). A number of personal fans were observed to have accumulated dust/debris (Pictures 21). Re-activated fans can also aerosolize dust accumulated on fan blades.

Lastly, curtains/drapes and carpeting in several areas was extremely worn and damaged (Pictures 22 through 24). Carpet in several areas was reported to be over 30 years old. Disintegrating textiles can be a source of airborne particulates, which can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

The conditions noted at the HTH raise a number of indoor air quality issues. The design/limitations of the original mechanical ventilation system and its components limits air exchange in the building. Lack of environmental pollutant dilution and/or removal by the ventilation system can result in the build-up and concentration of such pollutants in occupied areas. General building conditions, design and the operation (or lack) of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required. This approach consists of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Continue with plans to install central air conditioning to improve comfort.

2. Supplement airflow by using openable windows and fans to control for comfort.
3. Consider installing tinted film on windows to reduce solar glare and radiant heat.
4. Install passive door vents in the animal control office and basement meeting room.
5. 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).
6. Contact a masonry firm or general contractor to repair holes/breaches in exterior walls to prevent water penetration, drafts and pest entry.
7. Once leaks are repaired clean, prep and repaint water damaged areas.
8. 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.
9. Seal around air conditioners to prevent water penetration, drafts and pest entry.
10. Install filter media in portable air conditioners and clean cooling fins prior to use. Disinfect with an appropriate antimicrobial if necessary. Clean/change filters for ACs as per the manufacture's instructions or more frequently if needed. If filtration media cannot be acquired consider replacing AC units.
11. Ensure dehumidifiers are cleaned and maintained as per the manufacture's instruction to prevent microbial growth.

12. 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)
13. Replace damaged/worn carpeting and curtain/drapes to prevent the aerosolization of carpet/textile fibers.
14. Relocate or consider reducing the amount of materials stored in common areas to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
15. Clean personal fans/blades periodically of accumulated dust.
16. 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/indoor_air

The following **long-term measures** should be considered:

1. Have an HVAC engineering firm evaluate the buildings original ventilation system (univents) for proper operation and/or repair/replacement considerations.
2. Continue with plans to obtain funds for full window replacement throughout the building.
3. Examine the feasibility of providing mechanical ventilation to the animal control office and basement meeting room.
4. Consider having exterior walls re-pointed and waterproofed to prevent water intrusion. This measure should include a full building envelope evaluation.

References

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

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

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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.

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

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.

Picture 1

Vintage Unit Ventilator

Picture 2

Hand Control to Adjust Univent Air Intake Louvers

Picture 3

Fresh Air Intake for Univent

Picture 4

Water Damaged Wall Plaster, Efflorescence and Peeling Paint in Board of Health Annex

Picture 5

Water Damaged Wall Plaster, Efflorescence and Peeling Paint in the Assessor's Office

Picture 6

Northeast Corner of Building Corresponding to Water Damage in Board of Health Annex

Picture 7

Close-Up of Efflorescence and Missing/Damaged Mortar around Brickwork on Northeast Corner

Picture 8

Missing/Damaged Mortar around Brickwork

Picture 9

Missing/Damaged Mortar around Brickwork

Picture 10

Open Utility Hole on Exterior of Building

Picture 11

Water Damaged Ceiling Tile

Picture 12

Water Damaged Ceiling Tile

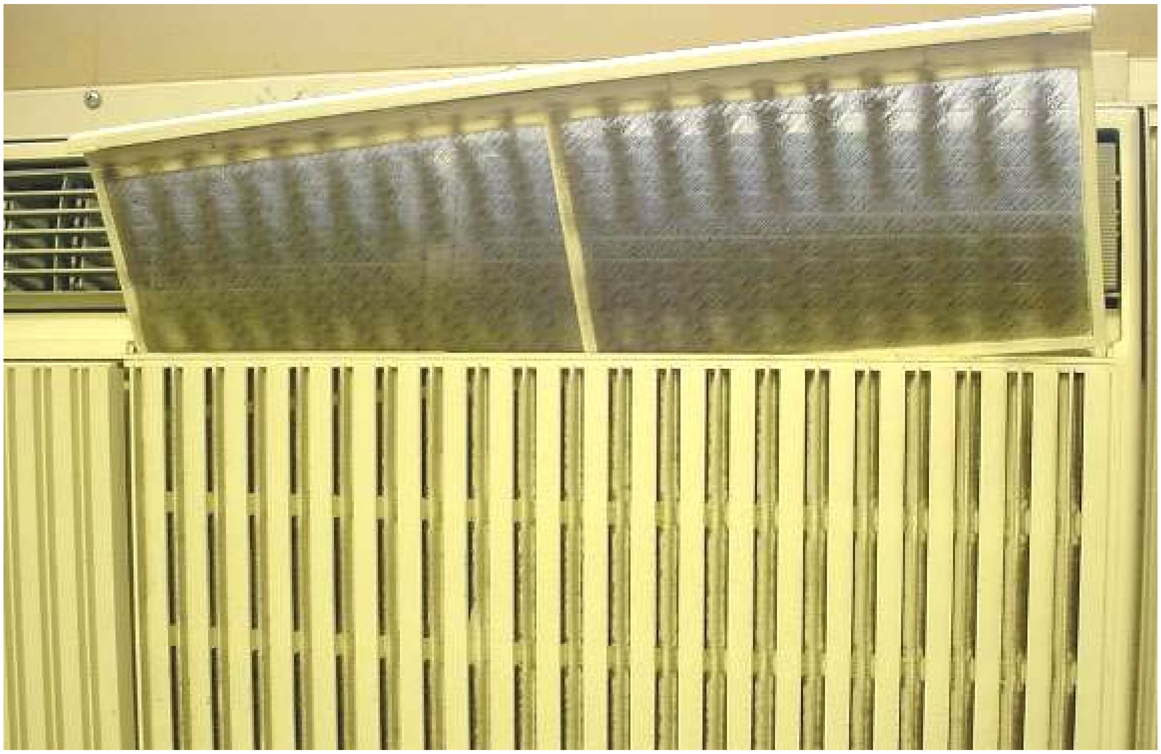
Picture 13

Water Damaged Ceiling Tiles near Air Conditioner

Picture 14

AC Unit in 1st Floor Meeting Room Missing Filter

Picture 15



AC Filter Occluded With Dust/Debris

Picture 16

Close-Up of AC Vent Occluded With Dust/Debris

Picture 17

Spaces around Window-Mounted AC in 2nd Floor Hearing Room

Picture 18

Cobwebs around Air Conditioner in 2nd Floor Meeting Room

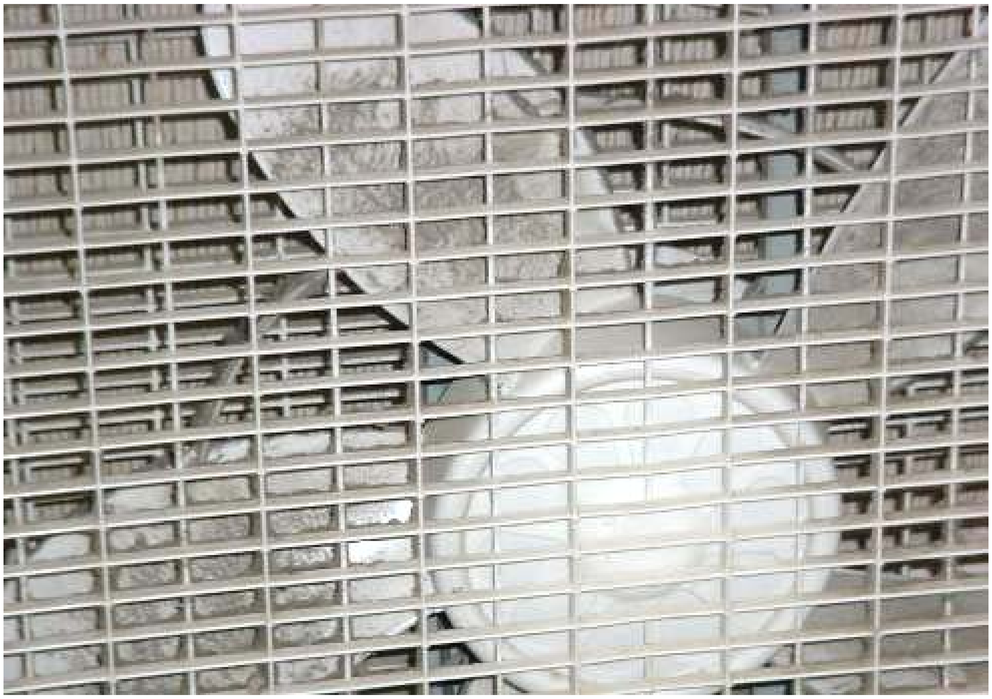
Picture 19

Dirt, Dust/Debris Accumulation on Windowsill in Office

Picture 20

Dirt, Dust/Debris Accumulation on Windowsill in Office

Picture 21



Accumulated Dust/Debris on Fan Blades

Picture 22

Damaged/Frayed Carpeting

Picture 23

Torn, Frayed Disintegrating Curtains/Drapes

Picture 24

Torn, Frayed Disintegrating Curtains/Drapes

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

Address: 50 North Franklin St. Holbrook, MA **Table 1** **Date: 05-06-2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
background		66	51	394	ND	21				Clear/sunny, winds light and variable, moderate traffic
Cable TV Room	0	67	39	555	ND	16	N	N	N	2 WD CT-corner/interior wall Open interior window into hearing room
Hearing Room	0	68	39	591	ND	16	Y	Y	N	Debris in UV, cobwebs, AC not sealed-drafts/pests
Historical Commission	3	68	40	741	ND	15	Y	Y	N	Dust/debris on flat surfaces, AC
Conservation Commission	0	68	38	539	ND	11	Y	N	N	AC, cobwebs/dust/debris
Building/Wiring Inspector	1	69	39	674	ND	18	Y	Y	N	Plants, AC, cobwebs/dust/debris
Planning Board	1	68	40	747	ND	19	Y	Y	N	WD CTs near AC/windows, cobwebs/dust/debris on flat surfaces and in AC/filter
Board of Health	0	68	39	593	ND	15	Y	Y	N	Window open, 1 WD CT near door
Board of Health Annex	0	68	39	595	ND	12	Y	N	N	WD plaster/peeling paint exterior wall adjacent to window, WD CT
Town Clerk	1	70	39	743	ND	10	Y	Y	N	Dusty/disintegrating drapes, cobwebs/dust/debris, old/damaged carpeting

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
DO = door open
AC = air conditioner
CT = ceiling tile
UV = univent
WD = water-damaged
PF = personal fan
PC = photocopier

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%
Particle matter 2.5 < 35 ug/m^3

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

Address: 50 North Franklin St. Holbrook, MA **Table 1 (continued)** **Date: 05-06-2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m³)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Collector's Office	3	71	38	540	ND	19	Y	Y	N	Window open, HEPA air purifier, dust/debris on flat surfaces and in AC/filter, 3 WD CT near AC, old/damaged carpeting
Copy Room	0	71	38	596	ND	16	Y	Y	N	PC-dust/debris on walls around unit
Treasurer/ Collector	1	72	37	642	ND	13	Y	Y	N	
Assessors	3	74	36	707	ND	13	Y	Y	N	Computer network-open CT-wiring, HEPA air purifier, dust/debris on flat surfaces, AC missing knobs, peeling paint and efflorescence rear wall/left corner
Town Administrator	1	75	35	709	ND	14	Y	Y	N	
Selectmen Secretary	2	74	35	715	ND	17	Y	Y	N	
Accountant	4	74	34	707	ND	15	Y	Y	N	Window open, humidifiers, 4 WD CT, plants, heat complaints
Meeting Room	0	71	35	585	ND	16	Y	Y	N	AC-old, no filter (musty odors)

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Address: 50 North Franklin St. Holbrook, MA **Table 1 (continued)** **Date: 05-06-2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m³)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
DPW	2	69	39	721	ND	15	Y	Y	N	Forced hot air vents
DPW Office	0	68	40	683	ND	12	Y	Y	N	AC
Basement Hallway										AC-dust/cobwebs
Animal Control	1	67	42	775	ND	14	N	N	N	AC, recommend passive door vent for airflow
Meeting Room	0	66	43	633	ND	16	N	N	N	AC-occluded with dust/debris
New DPW Area	3	68	41	602	ND	16	Y	N	N	Wall-mounted AC
New DPW Office	0	66	42	506	ND	14	Y	N	N	
Exterior/ Perimeter										Missing/damaged mortar-exterior brick Spaces around univent air intakes Open utility holes

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