INDOOR AIR QUALITY ASSESSMENT

Massachusetts Department of Recreation and Conservation
Bureau of Forest Fire Control, District 10 Headquarters
Bureau of Forestry
Moore House
7 Military Road
Amherst, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Donald Sacco, Transitional Manager, Connecticut Valley District of the Massachusetts Department of Recreation and Conservation (DCR), the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH), provided assistance and consultation regarding indoor air quality concerns at the DCR Moore House, 7 Military Road, Amherst, Massachusetts. On July 22, 2005, a visit to conduct an indoor air quality assessment was made to the Moore House by Michael Feeney, Director of CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. The assessment was prompted by respiratory irritation symptoms that occupants believed to be attributed to poor air quality in the building.

The Moore House is a two-level, wood frame building originally constructed as a residence in the 1970s. The building was obtained by the Commonwealth in 1986. The Moore House contains both the DCR District 10 Headquarters of the Bureau of Forest Fire Control and the DCR Bureau of Forestry, Forest Health Program. The first floor contains offices, a meeting room, two garage ports for the Forest Health Program and a storage closet. The lower level contains storerooms for both programs, the furnace room and a garage. Windows are openable in most rooms. No openable windows exist on the lower level.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor. Screening for total volatile organic compounds (TVOCs) was conducted using an HNu Photo Ionization Detector (PID).

Results

The building has an employee population of 7. The tests were taken under normal operating conditions. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that the carbon dioxide levels were above 800 parts per million (ppm) of air in all occupied areas sampled, despite having the front door opened during the air sampling, which indicates little air exchange. The air handling unit located in the basement does not have the capacity to introduce outside air or exhaust air from the building; it tempers and *recirculates* air only. Therefore, the sole source of fresh air in the Moore House is through open windows or doors. With a lack of fresh air supply or exhaust ventilation, normally occurring pollutants that exist in the interior space can build up and lead to indoor air quality/comfort complaints.

In addition, no mechanical means to remove carbon monoxide and other products of combustion produced during mechanical/vehicle operations exists in the garage. The return vent for the HVAC system is located in the hallway floor on the upper level. In this instance, pollutants produced in either the upper or lower level garages may be drawn into occupied space. Offices have window-mounted air conditioners (WACs), which were operating during the assessment. The WACs did not appear to have the means to introduce fresh air.

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 have openable windows in each room (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 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 in occupied areas were measured in a range of 78^{o} F to 86^{o} F, which were above the MDPH recommended comfort range in the majority of areas. Please note that all of the garage doors were open with an outdoor temperature of 80^{o} F on the day of the assessment. 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 measurements in the building ranged from 40 to 68 percent, with some areas above the MDPH recommended comfort range. 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

Upon entering the Moore House, a distinct musty odor was detected. The odor was traced to a moldy mop that was stored in a closet with the door closed (Picture 1). Both standing water and wet mops can serve as media for mold growth and associated odors. Mop buckets should be emptied and dried after use. Mop heads should be dried as soon as practicable to prevent mold growth.

Other Concerns

Building occupants expressed concerns about a possible chemical exposure from the use of a floor wax (Butcher's Bowling Alley Wax) in the hallway during the winter months of 2005. The Material Safety Data Sheet (MSDS) indicates that this product contains both turpentine and a naphtha compound, which are known to be eye and respiratory irritants (The Butcher's Co., 2004). In order to determine whether these or other chemicals were present within the DCR, air sampling for volatile organic compounds (VOCs) was conducted. VOCs are substances that have the ability to evaporate at room temperature. For example, turpentine and naphthas are chemicals that rapidly evaporate at room temperature and would likely contain VOCs. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals.

MDPH staff conducted TVOC sampling in offices, the garages, and all common areas (Table 1). Background (i.e., outdoor) TVOCs sampling was also conducted for comparison purposes. TVOCs were non-detectable (ND) outdoors. Upper story offices had a consistent measurement of 0.2 parts per million (ppm) of TVOCs. This concentration was recorded at floor level and within the breathing zone (3 to 5 feet above the floor) (the return vent for the heat system had slightly higher TVOC measurement of 0.3 ppm). Upon entering the basement, the TVOC concentration increased to 1.8 to 1.9 ppm. These results indicate that the source of TVOCs was likely within the basement and not the floor wax. Also, if the floor were the source, TVOC concentrations would be expected to *increase,* as the PID probe got closer to the floor. Because the TVOC measurements were generally uniform on the first floor regarding the height where measurements were taken, volatile chemicals in the wax likely had evaporated and were not the source of the measured TVOCs.

The basement level had a subdivided room that is used to store portable fire fighting equipment (Pictures 2 and 3). Many of these devices use gasoline as a fuel. Gasoline contains a number of VOCs that can rapidly evaporate at room temperature. Each fuel tank for gasoline-powered equipment can release gasoline vapors into the indoor environment, even those drained of fuel. The basement contains no means to exhaust gasoline vapors from the basement storage areas or garage. In an effort to provide some relief, a fan was placed during this assessment to draw air from the basement out through the lower level garage door. After 20 minutes of operating this fan, TVOC measurements dropped to 0.2 ppm in basement areas.

Three likely pathways for migration of TVOCs from the lower level up to the first floor were identified: 1) the stairwell, 2) the chimney (Pictures 4 and 5), and 3) the forced hot air heating system ductwork. Of particular note is the heating system, which uses an air handling unit (AHU) to deliver heated air and draws return air from the first floor via ductwork. Since the AHU cabinet and return vent are not airtight [e.g., no cover exists over the filter access opening (Picture 6)], air and other pollutants present in the basement can be drawn into the HVAC system and directed to the first floor. Even when deactivated, lower level air and VOCs can migrate upwards into the first floor hallway via the return air vent.

Firefighting equipment can also provide several sources of environmental pollutants. These sources of pollutants can include the following:

- Vehicle exhaust containing carbon monoxide and soot;
- Vapors from gasoline, motor oil and other vehicle liquids which contain VOCs;
- Water vapor from drying hose equipment;
- Rubber odors from new vehicle tires; and
- Residues from fires on vehicles, pump equipment, hoses and fire-turnout gear.

Of particular interest is vehicle exhaust. Neither of the garages is equipped with a mechanical exhaust system to remove exhaust during vehicle idling.

Also found were breaches in the exhaust vent for the AHU in the basement (Picture 7) as well as a hole in the chimney (Picture 8). Under certain conditions, products of combustion from the AHU and/or chimney can be released into the building through these breaches. Exhaust vents and chimneys should be airtight.

Conclusions/Recommendations

The Moore House is a building that was designed as a residence, which was converted into use as office space, but also for storage of various fire fighting equipment. The storage of this equipment inside the building provides a source of chemical exposure, which was migrating to the occupied areas on the first floor. These environmental pollutants can cause health symptoms (e.g., respiratory irritation) in individuals who occupy the building. In addition, the escape of gasoline vapors can pose a significant fire hazard. For these reasons, CEH staff recommends that all gasoline powered equipment should be removed from the basement and stored outside the building.

In view of the findings at the time of the visit, the following recommendations are made:

1. Remove moldy mop and mop bucket from the first floor storage closet. Discard moldy mop head.
2. Open windows to provide fresh air.
3. Remove all gasoline-powered equipment from the lower level. Examine the feasibility of providing appropriate storage facilities for the gasoline-powered fire fighting equipment outside.
4. Install a cover over the AHU filter rack.
5. Seal all return ductwork and the AHU cabinet with mastic or HVAC foil tape to prevent air entrainment. The remediation of the AHU and return ductwork will prevent the draw and distribution of basement air and associated odors to occupied floors.

6. Seal all holes in the AHU exhaust duct and chimney.
7. Install weather-stripping and a door sweep to render the door to the lower level garage as airtight as possible.
8. Seal all spaces that exist in the interior wall and the ceiling of the lower level garage with an appropriate, fire-rated sealant.
9. Install wire mesh/bird screens on chimney terminus to prevent entry of birds/bats.
10. Examine the feasibility of installing a dedicated exhaust fan for the garages.
11. Consideration should be given to retrofitting the HVAC system with a means to both introduce fresh air and exhaust pollutants from the building.
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. Install disposable filters with an increased dust spot efficiency in the AHU. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000;

MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the AHU by increased resistance. Prior to any increase of filtration, the AHU should be evaluated by a ventilation engineer as to whether the heat pump can maintain function with more efficient filters.

14. Clean or replace filter for window-mounted air conditioners as per the manufacture's instructions or more frequently if needed.

15. Refer to resource manuals and other related indoor air quality documents for additional building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website: http://mass.gov/dph/indoor_air.

References

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Picture 1

Mop and Bucket in Storage Closet

Picture 2

Gasoline-Powered Pumps

Picture 3

Gasoline Powered Equipment in Lower Level

Picture 4

Fireplace on Lower Floor

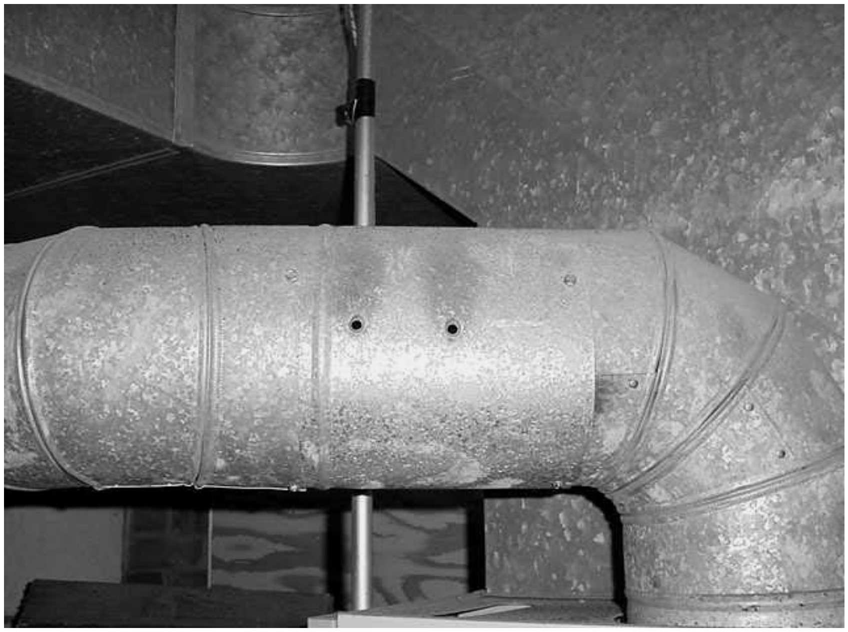
Picture 5

Fireplace on Upper Floor

Picture 6

Open Filter Access Panel

Picture 7



Holes in AHU Exhaust Vent

Picture 8

Hole in Chimney, Lower Level

TABLE 1
Indoor Air Test Results
Massachusetts Department of Conservation and Recreation, Moore House, 7 Military Road, Amherst, Massachusetts
July 22, 2005

Remarks	Carbon Dioxide (*ppm)	TVOC	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Outside (Background)	415	ND	82	70					
Meeting Room/Entrance	1519	0.2	86	60	10	Y	N	N	Fire place Exterior door open
Shade Tree Management	1352	0.2	80	67	1	Y	Y	N	Window-mounted air-conditioner Passive door vent Door open
Dist. 10 Dispatch	1271	0.2	82	66	0	Y	Y	N	Door open
Kitchen	1194	0.2	81	60	0	N	Y	N	Window-mounted air-conditioner
Bathroom	1307	0.2	81	68	0	Y	N	N	Door open
District 10 main office	908	0.2	78	40	0	Y	Y	N	Window-mounted air-conditioner
Hallway upper floor	1167	0.2	82	60	0	N	N	Y	TVOC level at return vent = 0.3 ppm TVOC level at return vent after fan placed in lower level garage= N.D to 0.1 ppm

*** ppm = parts per million parts of air**

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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							Supply	Exhaust	
Lower Level Pump storage	788	1.9	74	64	0	N	N	N	11 gasoline-powered pumps, leaf blowers TVOC level at return vent after fan placed in lower level garage= 0.2 ppm
Lower Level Uniform storage	805	1.9	74	65	0	N	N	N	Fireplace TVOC level at return vent after fan placed in lower level garage= 0.2 ppm
Lower Level Garage	681	1.8	74	68	0	N	N	N	Off-road vehicles TVOC level at return vent after fan placed in lower level garage= 0.2 ppm
Lower Level Tree warden storage	747	1.9	74	66	0	N	N	N	TVOC level at return vent after fan placed in lower level garage= 0.2 ppm
Upper floor garage	427	ND	85	63	0	Y	N	N	
Upper Floor Storeroom	1349	0.2	81	66	0	Y	N	N	Moldy mop

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