

INDOOR AIR QUALITY POST-OCCUPANCY ASSESSMENT

**Massachusetts Division of Standards
Metrology Laboratory
659/661 Highland Avenue
Needham, Massachusetts**



Prepared by:
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Bureau of Environmental Health
Indoor Air Quality Program
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Background/Introduction

In response to a request from Bruce Tebo, Project Manager, Division of Capital Asset Management (DCAM), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) conducted post-occupancy indoor air quality (IAQ) testing at the Massachusetts Division of Standards (DOS), Metrology Lab located at 659/661 Highland Avenue, Needham, Massachusetts. On September 29, 2011, a visit to conduct indoor air quality (IAQ) testing was made by Cory Holmes, Environmental Analyst/Regional Inspector in BEH's IAQ Program. Mr. Holmes was accompanied by Mr. Tebo during the assessment. This evaluation was conducted as part of enhanced efforts to assess the air quality of office space leased by Massachusetts state agencies pre- and post-occupancy.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 7565. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. BEH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The tests were taken during normal operations. Test 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 indicating optimal air exchange at the time of testing (Table 1). Mechanical ventilation is provided by a heating, ventilation and air conditioning (HVAC) system. The air handling unit (AHU) is located in a mechanical closet on the main floor (Picture 1). Fresh air is drawn through a vent on the exterior of the building. Ductwork connects the AHU to ceiling-mounted supply diffusers (Picture 2). By design, diffusers are equipped with fixed louvers that direct air along the ceiling to flow down the walls and create airflow. Air returns to the AHU through ceiling-mounted return vents via ductwork (Picture 3).

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 HVAC system balancing was reportedly balanced prior to occupancy.

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](#).

Indoor temperatures ranged from 68° F to 71° F, which were within or close to the MDPH recommended comfort range (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 66 to 76 percent, which was above the MDPH recommended comfort range in all areas surveyed during the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Higher humidity at a given temperature reduces the ability of the body to cool itself by sweating; “heat index” and “apparent temperature” are measures that take into account the impact of a

combination of heat and humidity on how hot it feels. At a given indoor temperature, the addition of humid air increases occupant discomfort and may generate heat complaints. If moisture levels are decreased, the comfort of the individuals increases. In addition, while temperature is mainly a comfort issue, relative humidity in excess of 70 percent for extended periods of time can provide an environment for mold and fungal growth (ASHRAE, 1989).

DCAM and DOS staff have been in discussion with their HVAC engineering firm to make possible adjustments/modifications to the mechanical ventilation system, which may include adding dehumidifiers to reduce 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

A file cabinet was noted directly against the wall in the training room (Picture 4). Cardboard boxes were noted directly against the wall in the training room and on the floor in the storage room (Pictures 5 and 6). File cabinets (and other office furniture) should be moved away from the wall to allow airspace and prevent the trapping of moisture, which can lead to mold growth on flat surfaces. Likewise, cardboard boxes should be elevated (e.g., stored on pallets) and away from walls.

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 and discarded.

Other Indoor Air 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 effects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating, Refrigerating 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. Outdoor carbon monoxide concentrations were non-detect (ND) the day of the assessment (Table 1). No measureable levels of carbon monoxide were detected in the building during the assessment (Table 1).

Particulate Matter

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 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) 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 PM_{2.5} standard requires outdoor air particle levels be maintained below 35 $\mu\text{g}/\text{m}^3$ 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.

The outdoor PM2.5 concentration was measured at 45 $\mu\text{g}/\text{m}^3$ (Table 1), which was above the NAAQS PM2.5 level of 35 $\mu\text{g}/\text{m}^3$. The most likely sources of elevated particulates in the area were elevated pollen conditions and moderate to heavy traffic nearby. PM2.5 levels measured indoors ranged from 4 to 12 $\mu\text{g}/\text{m}^3$ (Table 1), which were below the NAAQS PM2.5 level of 35 $\mu\text{g}/\text{m}^3$. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of activities that occur indoors and/or mechanical devices 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, use of stoves and/or microwave ovens in kitchen areas; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Conclusions/Recommendations

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

1. Continue with plans to adjust/modify HVAC system to reduce relative humidity conditions (e.g., dehumidification).
2. Ensure file cabinets (and other office furniture) are not directly against walls; allow one to two inches of space for airflow and to prevent trapping of moisture.
3. Porous items should not be stored directly on floors. Items on shelves should be at least one to two inches from walls to allow airflow.

4. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
5. 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

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Picture 1



Air Handling Unit for HVAC System in Mechanical Room

Picture 2



Ceiling-Mounted Supply Diffuser

Picture 3



Ceiling-Mounted Return Vent

Picture 4



File Cabinet Directly against Wall of Training Room

Picture 5



Cardboard Boxes Directly against Wall of Training Room

Picture 6



Cardboard Boxes Directly on Floor of Storeroom

Location: Division of Standards, Metrology Lab

Address: 659/661 Highland Ave., Needham, MA

Indoor Air Results

Date: 9/29/2011

Table 1

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m ³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Background	354	ND	69	100	45					Moderate to high traffic conditions, cloudy rainy
Garage(Front)	343	ND	69	72	12	1	N	Y	Y	
Garage (Rear)	364	ND	69	71	12	0	N	Y	Y	
Small Mass Lab	348	ND	68	66	9	0	N	Y	Y	
Small Volume Lab	378	ND	68	71	11	0	N	Y	Y	
Storage	375	ND	68	74	10	0	N	Y	N	Particle board shelving/odors
Kitchen	458	ND	70	76	6	0	N	Y	N	
Training Room	408	ND	70	76	6	0	N	Y	Y	Cardboard/file cabinet directly against wall
Storage Room							N	N	N	Cardboard directly on floor
Conference Room	431	ND	70	71	4	0	N	Y	Y	
Office	464	ND	71	69	4	0	N	Y	Y	

ppm = parts per million

µg/m³ = micrograms per cubic meter ND = non detect

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%