INDOOR AIR QUALITY ASSESSMENT

Essex Agricultural and Technical School
Gallant Hall
Berry Hall
Gymnasium
Expo Center
Horse Barn

562 Maple St,
Hathorne, MA

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
July 2013

Background/Introduction

At the request of Peter Mirandi, Director, Danvers Health Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) conducted indoor air quality (IAQ) assessments of several buildings at the Essex Agricultural and Technical School (EATS), 562 Maple Street in the Hathorne Village of Danvers, Massachusetts. On March 26, 2013, a visit was made to the campus by Michael Feeney, Director, BEH's IAQ Program, and Sharon Lee, Environmental Analyst/Inspector for BEH's IAQ Program. These indoor environmental assessments are part of a larger MDPH/BEH investigation of concerns associated with environmental factors and vocal tics among students at the EATS and the North Shore Vocational School in Middleton, Massachusetts. The IAQ Program conducted air-sampling for carbon monoxide, volatile organic compounds (VOCs) and mercury vapor, as well as general IAQ parameters in each building.

The EATS is a campus that consists of more than 20 buildings that are accessible to students (Picture 1). This assessment discusses conditions observed in buildings most frequently accessed by the majority of students. BEH's IAQ staff is planning to assess the remainder of the campus in late spring. The following buildings were assessed and are the subject of this report: Gallant Hall, Berry Hall, the gymnasium, the Expo Center and the horse barn. These buildings were constructed at various times, but for the most part construction is of brick. Classrooms have openable windows. The Expo Center is a steel-framed permanent tent-like structure with no windows or heating system. The horse barn is a stable with stalls for horses.

Methods

Air tests for carbon dioxide, carbon monoxide, 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. Air testing for total volatile organic compounds (TVOCs) was conducted using a MiniRAE 2000 photo ionization detector (PID). Air tests for mercury vapor was conducted using a Lumex Mercury analyzer RA-915+. BEH/IAQ staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school serves approximately 500 high-school-age students and has approximately 50 staff members. 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 above 800 parts per million (ppm) in 3 of 7 areas tested in Berry Hall and 10 of 14 areas tested in Gallant Hall, indicating poor air exchange in most areas at the time of assessment. Carbon dioxide levels in all areas of the gymnasium, Expo Center and horse barn were below 800 ppm. It is important to note that some areas were sparsely populated or had doors open to hallways or the outdoors, which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to increase with higher occupancy and closed windows and doors.

Fresh air to classrooms in Berry and Gallant Halls is supplied by unit ventilator (univent) systems (Picture 2). A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building (Picture 3). Return air from the classroom is drawn through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Many univents were found deactivated at the time of assessment (Table 1). In addition, some univents were found obstructed by furniture and other items on top of air diffusers and/or in front of return vents along the bottom of the units. Univents must remain free of obstructions and be allowed to operate while rooms are occupied.

Note that the univents are original equipment, more than 35 years old. Function of equipment of this age is difficult to maintain, since compatible replacement parts are often unavailable. According to the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), the service life[1] for a unit heater, hot water or steam is 20 years, assuming routine maintenance of the equipment (ASHRAE, 1991). Despite attempts to maintain the univents, the operational lifespan of the equipment has been exceeded. Maintaining the balance of fresh air to exhaust air will become more difficult as the equipment ages and as replacement parts become increasingly difficult to obtain.

Exhaust ventilation for classrooms in Berry and Gallant Halls is provided by wall-mounted exhaust vents ducted to rooftop motors. Some wall-mounted exhaust vents were blocked at the time of assessment. Further, no draw of air at all was detected from some exhaust vents in Berry Hall. As with supply ventilation, exhaust ventilation must be free of blockages and allowed to operate while the building is occupied.

---

[1] The service life is the median time during which a particular system or component of …[an HVAC]… system remains in its original service application and then is replaced. Replacement may occur for any reason, including, but not limited to, failure, general obsolescence, reduced reliability, excessive maintenance cost, and changed system requirements due to such influences as building characteristics or energy prices (ASHRAE, 1991).

Various types of equipment exist in the other buildings assessed during this visit. Mechanical ventilation for the gymnasium is provided a ducted air handling unit (AHU). The Expo Center has a set of exhaust fans near the peak of its roof (Picture 4), and fresh air is provided by from passive louvered vents near the opposite peak (Picture 5). The horse barn has no mechanical heating or ventilating system.

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 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.

Minimum design ventilation rates are mandated by the Massachusetts State Building Code (MSBC). Until 2011, the minimum ventilation rate in Massachusetts was higher for both occupied office spaces and general classrooms, with similar requirements for other occupied spaces (BOCA, 1993). The current version of the MSBC, promulgated in 2011 by the State Board of Building Regulations and Standards (SBBRS), adopted the 2009 International Mechanical Code (IMC) to set minimum ventilation rates. **Please note that the MSBC is a minimum standard that is not health-based**. At lower rates of cubic feet per minute (cfm) per occupant of fresh air, carbon dioxide levels would be expected to rise significantly. A ventilation rate of 20 cfm per occupant of fresh air provides optimal air exchange resulting in carbon dioxide levels at or below 800 ppm in the indoor environment in each area measured. MDPH recommends that carbon dioxide levels be maintained at 800 ppm or below. This is because most environmental and occupational health scientists involved with research on IAQ and health effects have documented significant increases in indoor air quality complaints and/or health effects when carbon dioxide levels rise above the MDPH guidelines of 800 ppm for schools, office buildings and other occupied spaces (Sundell et al., 2011). 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.

Temperatures ranged from 64°F to 69°F in Berry Hall; 72°F to 75°F in Gallant Hall; and 67°F to 74°F in the gymnasium; temperature ranges for these more traditional student areas were within or close to the MDPH recommended range. The Expo Center and horse barn have no heating systems and are reflective of ambient conditions on the day of the visit (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. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents/exhaust vents deactivated/obstructed).

Relative humidity measurements in the building ranged from 21 to 46 percent in Berry Hall; 17 to 34 percent in Gallant Hall; and 29 to 34 percent in the gymnasium. All of these were below the MDPH recommended comfort range in the majority of areas surveyed (Table 1). The Expo Center and horse barn had relative humidity measurements ranging from 40 to 51 percent. 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 leaks from the roof were reported in classrooms of Berry and Gallant Halls. Repairs to these areas should be made to prevent further water infiltration. Consideration should also be given to replacing the current roof on each building, which was installed over 15 years ago and is nearing its end of useful service life.

Water-stained and missing ceiling tiles were observed in classrooms of Gallant and Berry Halls. In some areas, water-damaged tiles were the interlocking mineral variety, which can be difficult to replace. These interlocking mineral tiles may also contain asbestos mastic. A determination should be made concerning whether these tiles contain asbestos. If they do, the tiles should be left in place until they can be removed by a licensed asbestos remediation contractor.

Plants were observed in some areas (Table 1). Plants should be properly maintained and equipped with drip pans. Plants should also be located away from ventilation sources to prevent aerosolization of dirt, pollen or mold. Plants should not be placed on porous materials, since water damage to porous materials may lead to microbial growth.

Some areas also had aquariums. Aquariums need to be properly maintained and cleaned so as not to emit odors. As with plants, these items should not be placed on or near univents.

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 indoor environment, BEH/IAQ 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 MSBC (SBBRS, 2011). 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) at the time of the assessment (Table 1). No measureable levels of carbon monoxide were detected inside any of the buildings during the assessment (Table 1).

Particulate Matter

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter includes airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to PM with a diameter of 10 μm or less (PM10). In 1997, US EPA established a more protective standard for fine airborne particulate matter with a diameter of 2.5 μm or less (PM2.5). The NAAQS has subsequently been revised, and PM2.5 levels were reduced. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 35 $\mu g/m^3$ 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 PM concentrations in the indoor environment.

Outdoor PM2.5 concentrations the day of the assessment were measured at 7 $\mu g/m^3$. PM2.5 levels measured inside all building ranged from 3 to 22 $\mu g/m^3$ (Table 1). Both indoor and outdoor PM 2.5 levels were below the NAAQS PM2.5 level of 35 $\mu g/m^3$. 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.

Volatile Organic Compounds

Indoor air concentrations can be greatly impacted by the use of products containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals and are associated with various neurological symptoms, such as headache, numbness and lethargy. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In order to determine if VOCs were present, testing for TVOCs was conducted. No measureable levels of TVOCs were detected in background/outdoors (Table 1). TVOCs were also non-detect in all but one area, the boy's locker room, on the day of assessment. The boy's locker room had an overwhelming odor of cologne, which contains VOCs. VOCs from excessive cologne use can be irritating to the eyes, nose and respiratory system. Odor and VOCs from such products can accumulate in a room when the exhaust ventilation system is deactivated.

There are several copy rooms in the building containing photocopiers. Photocopiers can be sources of pollutants such as VOCs, ozone, heat and odors, particularly if the equipment is older and in frequent use. Both VOCs and ozone are respiratory irritants (Schmidt Etkin, 1992). Photocopiers should be kept in well ventilated rooms, and should be located near windows or exhaust vents.

Many classrooms contained dry erase boards and related materials. In some areas, dry erase material debris was collected on the marker tray. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Air fresheners/deodorizers and scented candles were observed in some areas (Table 1). Air fresheners contain VOCs that can be irritating to the eyes, nose and throat of sensitive individuals. Many air fresheners contain 1,4-dichlorobenzene, a VOC which may cause reductions in lung function (NIH, 2006). Deodorant materials do not remove materials causing odors, but rather mask odors which may be present in the area.

Cleaning products were in some areas. Cleaning products contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. These products should be properly labeled and stored. Additionally, a Material Safety Data Sheet (MSDS) should be available at a central location for each product in the event of an emergency. Consideration should be given to providing teaching staff with school-issued cleaning products and supplies to prevent any potential for adverse chemical interactions between residues left from cleaners used by the schools facilities staff and those left by cleaners brought in by others.

Operable fume hoods are critical to providing control and removal of fumes and vapors from experiments that may produce airborne products. If the chemistry curriculum at the school requires the use of fume hoods, these fume hoods should be inspected and calibrated as per manufacturer's recommendation.

Mercury Vapor

Mercury (Hg) is a naturally occurring metal which has several forms. Elemental mercury (also known as metallic mercury) is a shiny, silver-white, odorless liquid at room temperature. If heated, it is a colorless, odorless vapor. When elemental mercury is spilled or a device containing mercury breaks, the spilled mercury can vaporize and become an invisible, odorless, toxic vapor. Exposure to elemental mercury primarily occurs by inhaling mercury vapors that are released into air. Although elemental mercury is not readily absorbed by the skin or stomach, people can also be exposed to elemental mercury vapors when mercury is handled. Sources of mercury in buildings can typically include exhaust from vehicles/furnaces; broken fluorescent light bulbs, thermometers, thermostats, barometers and sphygmomanometers (blood pressure cuffs). MDPH has also responded to spills of science chemicals or materials mentioned above. These types of materials can be found in classrooms/schools and public buildings across the state.

Mercury also occurs naturally in the environment and can be found at low levels in air. Mercury levels have been measured at levels between 0.010 and 0.020 $\mu g/m^3$ in the outdoor air in urban settings and 0.006 $\mu g/m^3$ in ambient, non-urban settings (ATSDR, 1999). Factors that may contribute to these background mercury levels include the fossil fueled agricultural equipment used at the Essex Agricultural Technical School (EATS), the local highway that bisects the campus, and construction equipment currently being used for the building project.

The US Agency for Toxic Substances and Disease Registry (ATSDR) has also established suggested action levels for mercury indoors (Appendix B). The MDPH recommends that buildings with mercury spills indoors be remediated/cleaned to where mercury air vapor levels are below 1 $\mu g/m^3$ within the relevant breathing zone of occupants based upon ATSDR guidance. Mercury levels in all buildings sampled were in a range of 0.005 to 0.030 $\mu g/m^3$, well below the ATSDR suggested action level of 1 $\mu g/m^3$ and reflective of background levels that can typically be found in indoor environments.

Short-term exposure to high levels of elemental mercury vapors may cause effects including, but not limited to: nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, eye irritation, metallic taste in the mouth, and irritant effects to the respiratory system and lung (such as coughing and sore throat). Longer term health effects depend on the amount and length of time of exposure to elemental mercury. Higher exposures to mercury can result in a range of health effects, including effects to the central nervous system and liver and kidney damage.

Other Conditions

In some classrooms and offices, items were observed on windowsills, tabletops, counters, bookcases and desks (Table 1). The large number of items stored in classrooms 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, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

A number of personal fans in classrooms and common areas were observed to have accumulated dust/debris. Re-activated fans can aerosolize dust accumulated on fan blades/housing.

Window-mounted or portable air-conditioning units are equipped with washable filters. These filters should be cleaned periodically as per manufacturer's instructions to avoid the build-up and re-aerosolization of dirt, dust and particulate matter. Air-conditioning units are often equipped with a "fan only" or "exhaust open" setting. In this mode of operation, the unit can provide air circulation by delivering fresh air without cooling.

Conclusions/Recommendations

Based on the observations and air measurements taken during this visit, substances that more likely to have neurological effect (e. g., carbon monoxide, VOCs, or mercury) were not found at levels associated with health impacts based upon the scientific/medical literature. However, BEH/IAQ staff did identify various conditions that can affect the comfort of building occupants and suggest a number of recommendations.

It is important to note that a new building is being constructed. Recommendations provided in this report are designed to improve the indoor environmental conditions in the existing buildings. The first consists of **short-term** measures to improve air quality and the second consists of **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

Short-Term Recommendations

1. Operate all ventilation systems throughout buildings, including univents and interior classroom HVAC systems, continuously during periods of occupancy to maximize air exchange. This is of critical importance given the high levels of carbon dioxide documented in numerous areas of the school.
2. Use openable windows to supplement fresh air in the classrooms during occupancy. If thermal comfort is a concern, consider opening windows between classes and during unoccupied periods. Care should be taken to ensure windows are closed at the day's end.
3. Consider operating window-mounted and portable air-conditioners in the "fan only" or "fresh air" mode to introduce outside air by mechanical means.

4. Ensure air-conditioning filters are cleaned as per manufacturer's recommendation, or more regularly as necessary.

5. Work with an HVAC engineering firm to adjust/repair univents and exhaust vents to improve air exchange in classrooms.

6. Remove all blockages/items from the surface of univent air diffusers and return vents (along front/bottom) as well as from exhaust vents to ensure adequate airflow.

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 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. Examine areas of leakage and ensure any water-damaged ceiling tiles and wall materials are repaired and/or replaced. Examine the area above ceiling tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial, as needed.

9. Ensure indoor plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial, as needed. Move plants away from the air stream of mechanical ventilation equipment.

10. Clean chalk and dry-erase marker trays of accumulated dust and debris regularly using a damp cloth.

11. Clean accumulated dust and debris periodically from the interior of univents, exhaust vents and blades of personal and ceiling fans.

12. Ensure chemical hoods are cleaned and calibrated as per manufacturer's recommendation if they are used in the school's curriculum.

13. Store cleaning products properly and out of reach of students. All cleaning products used at the facility should be approved by the school department with MSDS' available at a central location.

14. Refrain from using air fresheners or other air deodorizers to prevent exposure to VOCs.

15. Consider adopting the US EPA (2000) document, "Tools for Schools", as an instrument for maintaining a good indoor air quality environment in the building. This document is available at: http://www.epa.gov/iaq/schools/index.html

16. 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.

Long-Term Recommendations

1. Consult with an HVAC engineering firm for a plan to replace ventilation system components. Take into consideration the current and likely future uses of spaces to determine the placement of supply and exhaust ventilation to maximize airflow and removal of pollutants and odors, including dedicated exhaust ventilation in areas where copy machines, laminators, kilns, chemicals, and food preparation equipment are used.

2. Consult with an engineering firm to determine if all or portions of building roofs should be replaced.

References

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

ASHRAE. 1991. ASHRAE Applications Handbook, Chapter 33 "Owning and Operating Costs". American Society of Heating, Refrigeration and Air Conditioning Engineers, Atlanta, GA.

ATSDR. 1999. Toxicological Profile For Mercury. Agency for Toxic Substances and Disease Registry, Atlanta, Georgia.

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

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.

NIH. 2006. Chemical in Many Air Fresheners May Reduce Lung Function. NIH News. National Institute of Health. July 27, 2006. http://www.nih.gov/news/pr/jul2006/niehs-27.htm

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.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 2011. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations, 8th edition. 780 CMR 1209.0.

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

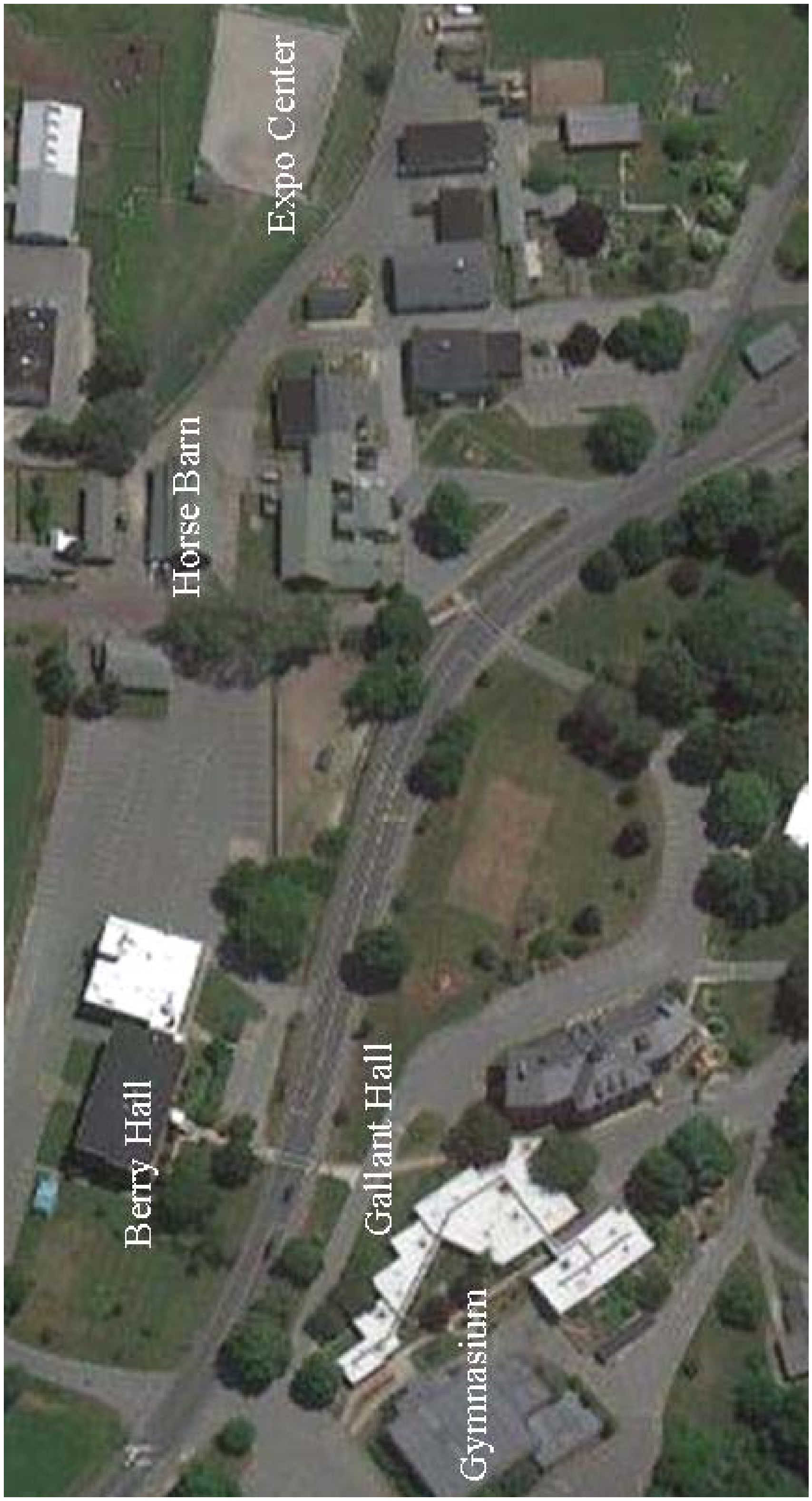
SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

Sundell. 2011. Sundell, J., H. Levin, W. W. Nazaroff, W. S. Cain, W. J. Fisk, D. T. Grimsrud, F. Gyntelberg, Y. Li, A. K. Persily, A. C. Pickering, J. M. Samet, J. D. Spengler, S. T. Taylor, and C. J. Weschler. Ventilation rates and health: multidisciplinary review of the scientific literature. *Indoor Air*, Volume 21: pp 191–204.

US EPA. 2000. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/actionkit.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

Picture 1



Buildings assessed on March 26, 2013 visit

Picture 2

Example of a univent

Picture 3

Example of univent fresh air intakes (arrows)

Picture 4

Exhaust fans in the Expo Center

Picture 5

Passive louvered vents In The Expo Center

Location: Essex Agricultural and Technical School

Address: 562 Maple St, Hathorne, MA

Indoor Air Results

Date: March 26, 2013

Table 1

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Hg ($\mu g/m^3$)	TVOCs (ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
										Intake	Exhaust	
Background	339	3	51	19	7	0.002	ND					Sunny, few clouds, slight wind; high traffic area; construction across street
Berry Hall												
BH 001	866	ND	68	27	6	0.009	ND	18	Y	Y	Y	3 WD-CT, DEM, DO,
BH 002	777	ND	67	27	5	0.009	ND	24	Y	Y	Y	Aquarium, chemical hood, DEM, floor draining
BH104	1012	ND	69	30	10	0.015	ND	0	Y	Y UV, off, items	Y Off	PF, PC, DEM, 5 WD-CT, aquariums
BH201	529	ND	66	21	4	0.007	ND	O	Y	Y UV	U Off	PF, CD, 3 WD-CTs
BH202	436	ND	65	25	3	0.006	ND	0	Y	Y UV	Y off	DEM, PF
BH203	652	ND	66	25	3	0.006	ND	0	Y	Y UV		Portable AC, PF
Cafeteria	1070	ND	64	46	12	0.005	ND	8	Y	Y UV	Y	WD-CTs

ppm = parts per million
µg/m3 = micrograms per cubic meter
ND = non-detect
AC = air-conditioner
AD = air deodorizer
CD = chalk dust
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
PC = photocopier
MT = missing ceiling tile
PF = personal fan
UV = univent
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%

Location: Essex Agricultural and Technical School **Indoor Air Results**

Address: 562 Maple St, Hathorne, MA **Date: March 26, 2013**

Table 1 (continued)

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Hg ($\mu g/m^3$)	TVOCs (ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
										Intake	Exhaust	
Gallant Hall												
GH 01	1444	ND	74	25	5	0.013	ND	17	Y	Y UV	Y	DEM, plants, AD/perfume, PF
GH 02	631	ND	74	17	4	0.012	ND	0	Y	Y	Y	DEM, CP, PF, scented candle
GH 03	725	ND	75	19	5	0.013	ND	14	Y	Y UV	Y	CD, DEM
GH 04	1393	ND	75	25	11	0.016	ND	13	Y	Y UV	Y	DEM, 4 WD-CTs
GH 05	1293	ND	74	26	10	0.019	ND	11	Y 2 open	Y	Y	CPs, PF, DEM, CD
GH 06	1569	ND	74	26	19	0.009	ND	9	Y	Y UV	Y	DEM, CD, WD-CTs
GH 14	2189	ND	75	34	12	0.017	ND	28	Y 4 open	Y UV, off	Y	WD-CTs, PF, CD
GH 15	1585	ND	75	29	9	0.016	ND	11	Y	Y UV, off	Y	
GH 19	484	ND	74	18	7	0.017	ND	1	Y 4 open	Y	Y	Scented candle, PF, plants

ppm = parts per million
μg/m3 = micrograms per cubic meter
ND = non-detect
AC = air-conditioner
AD = air deodorizer
CD = chalk dust
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
PC = photocopier
MT = missing ceiling tile
PF = personal fan
UV = univent
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%

Location: Essex Agricultural and Technical School **Indoor Air Results**

Address: 562 Maple St, Hathorne, MA **Date: March 26, 2013**

Table 1 (continued)

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Hg ($\mu g/m^3$)	TVOCs (ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
										Intake	Exhaust	
GH 20	1785	ND	75	20	6	0.019	ND	17	Y	Y UV	Y	DO, 4 WD-CTs, papers stored in sink, flame cabinet next to UV, PF, chemical hood
GH 21	1099	ND	74	22	6	0.030	ND	15	Y 2 open	Y UV, off	Y	DEM
GH B05	704	ND	74	28	5	0.019	ND	1	Y	Y Off	Y	CPs, DO, DEM
GH B06	806	ND	74	23	4	0.019	ND	1	Y	Y Off	Y	CPs, DEM, DO, PF, aquarium, flame cabinet
Main office	1402	ND	72	27	11	0.011	ND	6	Y	N	N	Window AC, plants, PF
Cole Gymnasium												
Gym	670	ND	67	32	10	0.012	ND	14	N	Y	Y	Musty, WD-ceiling
Boys locker room	532	ND	67	29	7	0.012	6.7	0	N	Y	Y	Strong body spray/scent
Girls locker room	705	ND	71	34	4	0.017	ND	0	N	Y	Y	
Gym office	592	ND	74	34	7	0.018	ND	1	Y	Passive		WD-CTs, washer/dryer, MT

ppm = parts per million
µg/m3 = micrograms per cubic meter
ND = non-detect
AC = air-conditioner
AD = air deodorizer
CD = chalk dust
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
PC = photocopier
MT = missing ceiling tile
PF = personal fan
UV = univent
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%

Location: Essex Agricultural and Technical School **Indoor Air Results**

Address: 562 Maple St, Hathorne, MA **Date: March 26, 2013**

Table 1 (continued)

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Hg ($\mu g/m^3$)	TVOCs (ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
										Intake	Exhaust	
Expo Center												
Center Area	409	ND	49	40	6	0.011	ND	0	N	Y	Y	
F	403	ND	48	43	6	0.010	ND	0	N	Y	Y	
K	446	ND	48	44	12	0.010	ND	0	N	Y	Y	
H	404	ND	47	47	5	0.011	ND	0	N	Y	Y	
M	402	ND	47	47	12	0.011	ND	0	N	Y	Y	
C	408	ND	47	47	12	0.011	ND	0	N	Y	Y	
Horse Barn												
East Side (entrance)	523	ND	48	43	12	0.015	ND	0				DO
West Side	467	ND	48	51	22	0.015	ND	0				

ppm = parts per million
µg/m3 = micrograms per cubic meter
ND = non-detect
AC = air-conditioner
AD = air deodorizer
CD = chalk dust
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
PC = photocopier
MT = missing ceiling tile
PF = personal fan
UV = univent
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%

Appendix B

ATSDR Chemical Specific Health Consultation – Mercury

Table 1: Suggested Action Levels for Residential Setting

Action Level (ug/m^3)	Use of Action Level	Rationale for Action Level	Sampling Suggestions and other Considerations	Consult Section
Less than 1	Acceptable level for normal occupancy for most sensitive persons. No further response action needed	Experience has shown that response actions to reach levels lower than 1 ug/m^3 can be disruptive enough to cause more harm than benefit. 1 ug/m^3 is within an order of magnitude of health guidance values and indoor background levels. This concentration is 25 times lower than the concentrations referenced in the development of health guidance values.	No visible mercury; highest quality data.* Sampling in breathing zone of most sensitive person under normal conditions for use.	See Sections 2.1 and 2.2.1
3–6	Acceptable level for unrestricted use of family vehicles under most conditions.	Exposure duration in most vehicles is short compared with other settings, allowing a higher concentration as the “floor” of this range. Requirement for no visible mercury means the source of vapors has been removed and concentrations should continue to fall The “ceiling” of the range is based on the presumption that liquid mercury may still be present but not yet discovered.	No visible mercury; highest quality data.* Sampling in the passenger compartment under normal use conditions. Unusual use of the vehicle in this case would be extended family vacations.	See Sections 2.1 and 2.5
3–6	Acceptable level to allow personal belongings to remain in owner’s possession.	The sampling point suggested in the column to the right tends to concentrate the vapors higher than typical exposure conditions. Exposure frequency should be intermittent and the duration should be short. The 6 ug/m^3 is based on the possibility that liquid mercury i is present but may not have been discovered.	Survey instrument data generally acceptable.+ Readings should be at the vents of appliances or headspace of bags. Bags should be warmed passively to ambient conditions and appliances/ electronics should be at operating temperatures.	See Section 2.2.3
Greater than 10	Isolation of contamination from residents or evacuation of residents	Indications are that 10 ug/m^3 may be the concentration at which urinary levels of mercury begin to increase. Other studies indicate this concentration may be the lowest toxic concentration (TCLo) for humans. Continued exposure may be harmful.	Survey instrument data acceptable. + Exposure to contaminant should be minimized.	See Section 2.2.2

***Highest quality data is NIOSH 6009 analytic results or equivalent (e.g., Lumex reading averaged over 8 hours)**
+Survey instrument data is considered any real-time monitoring equipment (e.g., Jerome, MVI, VM 300)

US EPA and ATSDR. 2012. Chemical-Specific Health Consultation for Joint EPA/ATSDR National Mercury Cleanup Policy Workgroup Action Levels For Elemental Mercury Spills. Accessed from http://www.atsdr.cdc.gov/emergency_response/Action_Levels_for_Elemental_Mercury_Spills_2012.pdf

Appendix B

ATSDR Chemical Specific Health Consultation – Mercury

Table 2: Suggested Action Level for Other Locations

Action Level (ug/m^3)	Use of Action Level	Rationale for Action Levels	Sampling Suggestions and other Considerations	Consult Section/ Reference
Less than 3	Normal Occupancy for commercial settings where mercury exposure is not expected in normal course of work. (e.g., 29 CFR 1910 Subpart Z does not apply)	Concentration is based on residential action level of 1 ug/m^3 adjusted for a work day (i.e., 24/7 exposure reduced to 8/5 or 40 hour workweek). Persons exposed in these settings would not expect the presence of mercury as part of their normal employment.	No visible mercury; highest quality data.* Taken in breathing zone of most sensitive person under normal conditions for use. Pregnant workers should be offered alternate worksite.	See Section 2.1 and 2.3.2
1–3	Acceptable level for schools to resume normal operations.	Concentration is based on residential action level of 1 ug/m^3 adjusted for a typical school day.	No visible mercury; highest quality data.* Taken in breathing zone of most sensitive person under normal conditions for use. Pregnant workers and students should be offered temporary alternatives to working or attending the school..	See Section 2.1 and 2.4
3–6	Acceptable level for unrestricted use of vehicles under most conditions.	Exposure duration in most vehicles is short compared with other settings, allowing a higher concentration as the “floor” of this range. Requirement for no visible mercury means the source of vapors has been removed and concentrations should continue to fall The “ceiling” of the range is based on the presumption that liquid mercury may still be present but not yet discovered.	No visible mercury; highest quality data.* Sampling in passenger compartment under normal use conditions. Unusual use of the vehicle in this case would be situations where the vehicle is the workplace.	See Sections 2.1 and 2.5
Greater than 10	Isolation of contamination or evacuation of workers not covered by a health and safety program addressing exposure to mercury.	Indications are that 10 ug/m^3 may be the concentration at which urinary levels of mercury begin to increase. Other studies indicate this concentration may be the lowest concentration toxic to humans.	Survey instrument data acceptable.+ Exposure to contaminant should be minimized.	See Section 2.3.2
25	Normal Occupancy for industrial settings where mercury exposure is expected in normal course of work. (e.g., 29 CFR 1910 Subpart Z does apply).	Based on the 1996 ACGIH TLV. Assumes hazard communications programs as required by OSHA; engineering controls as recommended by NIOSH; and medical monitoring as recommended by NIOSH and ACGIH are in place.	Survey instrument data acceptable.+ Workers in these settings should be subject to OSHA standards for mercury (e.g., medical records, Subpart Z, HCS, HAZWOPER).	See Section 2.3.1
25	Upgrade responder protective ensemble to Level C during uncontrolled releases of mercury	For response, workers subject to requirements of 29 CFR 1910.120, based on the ACGIH TLV, as recommended by the 1987 NIOSH/OSHA/USCG/EPA Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities (the” 4 agency guidance manual”).	Survey instrument data acceptable.+ Uncontrolled release refers to the absence of positive engineering controls on the material.	Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities (NIOSH, 1987)

***Highest quality data is NIOSH 6009 analytic results or equivalent (e.g., Lumex reading averaged over 8 hours)**
+Survey instrument data is considered any real-time monitoring equipment (e.g., Jerome, MVI, VM 300, etc)

US EPA and ATSDR. 2012. Chemical-Specific Health Consultation for Joint EPA/ATSDR National Mercury Cleanup Policy Workgroup Action Levels For Elemental Mercury Spills. Accessed from http://www.atsdr.cdc.gov/emergency_response/Action_Levels_for_Elemental_Mercury_Spills_2012.pdf