INDOOR AIR QUALITY ASSESSMENT

Barnstable High School
744 West Main Street
Barnstable, MA

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

July 2014

Background/Introduction

At the request of the Barnstable School Department (BSD), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality (IAQ) at the Barnstable High School (BHS) located at 744 West Main Street, Barnstable, Massachusetts. On May 6, 2014, a visit to the BHS was made by Cory Holmes, Sharon Lee and Jason Dustin, Environmental Analysts/Inspectors; and Ruth Alfasso, Environmental Engineer/Inspector with BEH's IAQ Program. The assessment was a part of an overall plan to inspect all of the Barnstable schools.

The BHS is an interconnected complex comprised of several buildings that were constructed at different times with separate heating, ventilation and air conditioning (HVAC) components. Note, only select areas (some offices, media center) are equipped with air-conditioning (AC). Most classrooms do not have air-conditioning. The original building was constructed in 1954; additions were made in 1970 and 1997. The school contains an art wing, shop wing, kitchen/cafeteria, gymnasium, field house, auditorium, science classrooms, band/music rooms, media center, office space and storage. Also on the grounds is a free-standing building (building M) that is used for weight/training. Windows are openable throughout the building. Facilities Director David Kanyock reported that replacement windows are on order for installation in two science rooms where occupants have reported chronic heat complaints.

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 Models 8520 and 8532. Moisture content of porous building materials (i.e., gypsum wallboard/ceilings) was measured using a Delmhorst, BD-2000 Model Moisture Detector. BEH/IAQ staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 1,200 students in grades 8 to 12 with a staff of approximately 250. Tests were taken during normal operations at the school. 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 167 of 219 areas at the time of assessment, including Building M, indicating adequate air exchange in roughly three quarters of areas surveyed. Please note that some areas were empty or sparsely populated and several areas had open windows at the time tests were taken, which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with full occupancy and windows closed.

Fresh air in most classrooms is supplied by unit ventilators (univents) (Picture 1). Some univents are ceiling-mounted with ducted air diffusers (Picture 2). A univent is designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building (Picture

3) or in the case of ceiling-mounted univents, through rooftop intakes (Picture 4). Return air is drawn through an air intake located at the base of each unit where fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit (Figure 1). Univents have fan settings of "low", "med" and "high" (Picture 5). Univents were found deactivated or obstructed with items in several areas. In many cases, air diffusers were systematically obstructed by books to prevent airflow (Picture 1; Table 1). Not only does such practice inhibit the introduction of fresh air to occupants, but it can also be detrimental to the machinery. In order for univents to provide fresh air as designed, they must remain free of obstructions. Importantly, these units must remain on and be allowed to operate while rooms are occupied. Noise complaints from the univent in classroom 2718 were reported, which may indicate a mechanical problem. The occupant reports that often times the unit has to be temporarily deactivated in order to allow for class instruction.

Exhaust ventilation in classrooms is provided by wall or ceiling-mounted vents (Picture 6) ducted to rooftop motors (Picture 7). A number of these exhaust vents were not operating at the time of assessment. It is also important to note that some exhaust vents are located near hallway doors, which are often left open (Picture 8). With the hallway doors open, the exhaust vents will tend to draw air from the hallway *instead of* drawing stale air *from the classroom*. It is recommended that classroom doors remain closed while exhaust vents are operating to function as designed. Exhaust vents must be activated and remain free of obstructions. Without adequate supply and exhaust ventilation, excess heat and environmental pollutants can build up and lead to indoor air/comfort complaints.

Restrooms are equipped with exhausts that vent directly to the outside via the roof. On the day of assessment, it was observed that many of these exhausts were not drawing air and odors were prevalent, particularly in restrooms in the nurse's offices. Dedicated exhaust ventilation for restrooms is required to remove moisture and odors from these areas; this ventilation should remain on during occupied hours. The fans/ductwork for the restroom exhaust vents should be examined to determine why they are not functioning, and repaired as needed.

Outside air for interior and common areas (e.g., auditorium, offices, media center, gymnasium) is provided by air handling units (AHUs) located on the roof (Picture 9) and ducted to fresh air supply diffusers (Picture 10). Return air is drawn in through wall or ceiling-mounted return vents and ducted back to AHUs. It is important to note that the Barnstable School Department has its own HVAC engineer on staff to maintain BPS buildings district-wide. However, with over 21 rooftop AHUs, more than 200 exhaust fans and close to 100 univents at BHS alone, the sheer number of HVAC units is difficult to maintain.

In addition, several of the rooftop units are original to the building's construction (1970s addition), which makes them over 40 years old. Efficient function of such aged equipment is difficult, since compatible replacement parts are often unavailable. According to the American Society of Heating, Refrigeration and Air-Conditioning Engineering (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 equipment, the operational lifespan of this equipment has been exceeded.

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

[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).

provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that heating, ventilating and air conditioning (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 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. **<u>Please note that the MSBC is a minimum standard that is not health-based</u>**. 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.

Indoor temperature measurements the day of assessment ranged from 69 °F to 77 °F (Table 1), which were within or very close to the MDPH recommended comfort range. 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. Temperature control complaints were expressed in a number of areas. In several areas, occupants covered univent air diffusers with books and other items in an attempt to alter airflow (Table 1; Picture 1). 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., exhaust vents and univents obstructed/not operating).

The relative humidity measured in the building during the assessment ranged from 29 to 44 percent, which was below the MDPH recommended comfort range in the majority of areas surveyed (Table 1). The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. However, like many public buildings on Cape Cod, the BHS has issues with elevated relative humidity and chronic dampness during summer months, making it more difficult to control due to lack of central/school-wide AC capabilities. 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

In order for building materials to support mold growth, a source of water exposure is necessary. Identification and elimination of the source of water moistening building materials is necessary to control mold growth. According to Mr. Kanyock, several areas of the building are known to have leaks due to roof/flashing issues. Areas with known problems have been identified (e.g., library, room 1410) and repairs are reportedly on a capital repair list.

Musty odors were detected in first floor classrooms where carpeting is directly adhered to the concrete slab (e.g., 1213 area). As mentioned previously, Cape Cod is a region susceptible to periods of extended high humidity. Condensation issues can occur as a result of moisture collecting on the slab. Carpeting adhered to the slab can absorb this moisture and subsequently grow mold over summer months. In some areas, peeling floor tiles and mastic were observed (Table 1), suggesting that condensation/water accumulation issues occur regularly.

Water-damaged ceiling tiles were observed in a number of areas (Pictures 11 and 12; Table 1). These indicate current/historic roof leaks, plumbing leaks or other water infiltration. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

Staff reported a leak around a skylight in room 1505. Visible mold growth was observed on the damaged gypsum wallboard (GW) ceiling/wall (Picture 13). At the time of assessment, the GW was determined to be slightly moist (Table 1), likely as a result of rain in the days prior to the BEH assessment. This issue was subsequently communicated to BSD Facilities staff for remediation.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials (e.g., carpeting, GW) 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.

Music/band rooms have been reported to have a history of mold growth on stored items due to lack of air circulation and temperature/humidity control. Instrument cases are constructed of leather, cardboard, glue and a plush lining, which are all porous materials that can support mold colonization. Other porous items, such as clothing/uniforms, are also stored in these areas and have been reportedly damaged due to mold growth. Closets and storerooms do not have air circulation or dehumidification that would aid drying of items that may be moistened due to high humidity. Without adequate temperature and relative humidity control, materials susceptible to mold growth will become moistened in hot, humid weather. Materials moistened for a prolonged period can be a source of mold growth.

Refrigerators in several rooms (e.g., 1717, 2705) had visible mold growth and staining of gaskets (Picture 14). The gaskets are composed of non-porous material that should be cleaned and disinfected using an appropriate antimicrobial.

Science rooms are equipped with safety showers and floor drains (Table 1). This can lead to dry drain traps if water is not poured into the traps occasionally. Dry traps can allow moisture and odorous gases to enter occupied spaces.

In some areas, such as data rooms, ductless AC units were in use (Table 1). These units are equipped with condensation drain hoses, which need to be directed to an appropriate drain and inspected regularly for leaks and blockages that can lead to microbial growth or odors.

Breaches were observed between countertops and sink backsplashes in a number of classrooms (Picture 15; Table 1). Water can penetrate through backsplash seams if they are not watertight. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage. Porous materials were found stored under many sinks (Table 1). Materials stored under sinks may make leaks harder to detect and repeated moistening of porous materials can result in mold growth. Several sinks were also found to be dripping and could not be turned completely off, providing additional moisture. As discussed, moistened materials that are not dried within 24 to 48 hours can become potential sources for mold growth.

Several rooms had aquariums/terrariums, some of which contained debris/residue and appeared to have not been active for some time (Picture 16; Table 1). Aquariums and terrariums should be properly maintained to prevent bacterial/mold/algal growth and associated nuisance odors. If not in use, these items should be properly cleaned and stowed.

Plants and cut flowers were noted in some classrooms (Table 1). Plants can be a source of pollen and mold which can be respiratory irritants to some individuals. Plants should be properly maintained and equipped with drip pans and should be located away from air supplies to prevent the aerosolization of dirt, pollen and mold.

Water dispensing equipment and refrigerators were located in carpeted areas. Carpeting may be moistened from leaks or spills from this equipment which may lead to microbial growth. These appliances should be located on non-porous flooring or a waterproof mat.

BEH/IAQ staff examined the exterior of the building to identify breaches in the building envelope and/or other issues that could provide a source of water penetration. Several potential sources were identified. A number of areas had exterior doors (e.g., gym) that were damaged and/or had missing/damaged weather-stripping, where light could be seen penetrating through the spaces underneath/around the doors (Pictures 17 and 18). Spaces around exterior doors can serve as sources of drafts and/or water penetration into the building, causing water damage and potentially leading to mold growth. In addition, these spaces can serve as pathways for insects, rodents and other pests into the building.

Trees and overhanging branches were observed in some areas. It is recommended that trees/shrubbery should be located at least five feet from the building to avoid impingement of moisture on exterior walls/foundation, in addition overhanging branches should be cut back to prevent debris from clogging roof drains.

Birds/nesting materials were observed inside air intake louvers along the exterior of the building/Performing Arts area (Picture 19). Birds can be a source of disease, and bird wastes and feathers can contain mold and mildew, which can be irritating to the respiratory system. In subsequent correspondence with BPS officials/Facilities Department, it was recommended that these vents be cleaned/disinfected after school hours.

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 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 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, 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. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). No measurable levels of carbon monoxide were detected inside the building (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). 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 PM concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 2 μg/m^3 (Table 1). PM2.5 levels measured in the building ranged from 1 to 29 μg/m^3 (Table 1), which were below the NAAQS PM2.5 level of 35 μg/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 matter 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.

Note that the highest PM2.5 reading was in classroom 1325, where an electric fryer was being operated; all other readings were significantly lower (Table 1). Regular classrooms do not have appropriate dedicated exhaust ventilation to remove odors and particulates from cooking.

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. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to identify materials that can potentially increase indoor VOC concentrations, BEH/IAQ staff examined rooms for products containing these respiratory irritants.

Classrooms contained dry erase boards and related materials. 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.

Cleaning products were found in some classrooms. 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 in an area inaccessible to children. Additionally, an MSDS should be available at a central location for each product in the event of an emergency. It was reported by Mr. Kanyock that MSDS for school-issued products are kept on-site in the custodial office.

Air deodorizers were observed in several areas (Table 1). Air deodorizers contain chemicals 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). Furthermore, deodorizing agents do not remove materials causing odors, but rather mask odors that may be present in the area.

In correspondence with Marina Brock, Environmental Specialist, Barnstable County Health Department (BCHD), BHS Science curriculum staff perform regular chemical storage audits and cleanouts working with both the BCHD and local Fire Department.

Science rooms and the chemical storage area were examined. Fire-rated cabinets were present for storage of flammable and corrosive materials, although some materials were found in unlocked classroom cabinets/shelves (Picture 20). Fire-rated cabinets did not appear to have appropriate venting to the outside, which is necessary to prevent a build-up of flammable or hazardous vapors from the cabinets. The storeroom itself had only a small exhaust vent. Based on discussions during the assessment, it may be possible that a dedicated exhaust vent for the cabinets can be built through the wall of the storeroom, allowing for appropriate venting. In addition, at the time of the visit, the BHS was in the process of cleaning and removing chemical products from the facility; there were a variety of jars and items contained in cardboard boxes (Picture 21). Regular cleanouts of chemical storage areas is recommended. Storage of these items in boxes should be only used as a temporary solution prior to appropriate disposal. Attached as Appendix B is “Guidance Concerning Proper Use and Storage of Chemicals in Schools to Protect Public Health” for additional reference.

Other Conditions

Other conditions that can affect IAQ were observed during the assessment. There were several kilns located in a separate room off the pottery arts room. These kilns appeared to have exhaust ventilation directed to the outside. It is important that exhaust ventilation be turned on and operating prior to the operation of any kilns and it should remain operating until the kiln cycle has completed and the kilns have cooled down. The ceiling tile system in the kiln room was observed to be in poor condition, including water-damaged ceiling tiles, missing ceiling tiles, and gaps around ductwork for the exhaust system (Pictures 22 and 23). Lack of an intact ceiling tile system can impair the ability of the exhaust system to remove kiln-generated pollutants and heat, and allow pollutants from the kiln room to migrate to other parts of the building.

The type of filter medium for air handling equipment used by the school comes in a bulk roll and must be cut to size before it is inserted into a metal lattice “cage” (Picture 24). This method is extremely time intensive, and the results are variable. If the filter medium is not properly fitted, gaps can allow unfiltered air into the room and/or reduce the useful life of the unit. The feasibility of installing disposable filters with an appropriate dust spot efficiency should be determined. 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 many airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Pleated filters with a Minimum Efficiency Reporting Value dust-spot efficiency of 9 or higher are recommended. Note that increasing filtration can reduce airflow (called pressure drop), which can subsequently reduce the efficiency of the unit due to increased resistance. Prior to any increase of filtration, each AHU/univent should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters. The filters were also found to be loaded with dust/debris, suggesting that the frequency of filter changes should be increased, which will be easier with disposable univent filters.

In many classrooms, large numbers of items were on floors, windowsills, tabletops, counters, bookcases and desks, which provide a source for dusts to accumulate (Picture 25). 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, dust and debris 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 air diffusers, exhaust/return vents, personal fans and in particular, the interior of univents, were found to have accumulated dust/debris (Pictures 24, 26 and 27; Table 1). Re-activated supply vents and fans can aerosolize dust/materials accumulated in equipment or on vents/fan blades. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles.

Accumulations of pencil shavings were observed in several classrooms (Table 1). Pencil shavings were also observed in a univent air diffuser due to the placement of an electric pencil sharpener in close proximity to a univent. These materials can also be aerosolized by air movement from the ventilation system or opening/closing of doors; aerosolized materials may present an eye or respiratory irritant.

Conclusions/Recommendations

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

1. Operate all supply and exhaust ventilation systems throughout the building (e.g., gym, cafeteria, classrooms) continuously during periods of occupancy to maximize air exchange. Make repairs to AHUs/univents and exhaust motors as necessary.
2. Remove all obstructions from univent air diffusers. Any temperature control complaints should be directed to building administration and/or the Facilities Department.
3. Adjust the percentage of fresh air supplied to and/or exhausted by the HVAC system to improve air exchange. If more airflow by occupants is desired adjust fan speed to "high".
4. Investigate "buzzing" noise from univent in classroom 2718, make repairs as needed.
5. Close classroom doors for proper operation of mechanical ventilation system/air exchange.
6. Openable windows may be used to increase fresh air when needed, but ensure that windows are closed tightly at the end of the day.
7. Continue with plans to install windows for the two science rooms where occupants have made chronic heat complaints.
8. Determine why exhaust vents in restrooms are not drawing air and repair as needed.

9. Continue with capital plans to replace air handling equipment that are past their useful service life (e.g., rooftop AHUs).
10. Due to the extremely large number of air handling units throughout the building (e.g., AHUs, univents, exhaust motors), a comprehensive preventative maintenance plan should be developed to maintain/repair/restore all (supply/exhaust) units to proper working order.
11. Change filters for air handling equipment (univents and AHUs) 2-4 times a year. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.
12. Consider replacing metal filter racks with properly fitting disposable filters with an equal or greater dust-spot efficiency to eliminate the time needed to replace filters from bulk material rolls. Prior to any increase of filtration, each piece of air handling equipment should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.
13. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
14. Work with an HVAC engineering firm to evaluate controls/settings for summer use of the building to prevent excessive moisture/condensation. Attached as Appendix C is MDPH "Preventing Mold Growth in Massachusetts Schools during Hot, Humid Weather".
15. During summer months, monitor conditions in classrooms to avoid elevated relative humidity (>70%) for extended periods of time, which can create conditions for condensation generation and/or mold growth.

- Continue to supplement the mechanical ventilation system, as needed, in susceptible/problem areas with portable dehumidifiers during humid months.
- Ensure that dehumidifiers are cleaned and maintained per the manufacturer's instructions, to prevent standing water and mold growth.
- Do not open windows in classrooms if air-conditioning (where installed) and/or dehumidifiers are operating.

16. Consider installing climate control HVAC equipment in band storage rooms. If not feasible store band items in alternate climate controlled area.
17. 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).
18. Continue with capital plans to make repairs to roof/exterior flashing.
19. Ensure roof/plumbing leaks are repaired (e.g., skylight room 1505, art/kiln rooms) and replace any remaining water-damaged ceiling tiles and other building materials such as GW. Disinfect areas of water leaks with an appropriate antimicrobial, as needed.
20. Ensure birds/nesting materials are removed from vents/louvers on exterior of building (Performing Arts). Clean and disinfect with an appropriate antimicrobial. Install bird screens on the *outside* of these vents to prevent further roosting.

21. Make repairs to exterior doors (seal and/or replace missing/damaged weather-stripping) (e.g., gymnasium/field house) to prevent drafts, moisture infiltration and pest entry. Ensure tightness of doors by monitoring for light penetration and drafts around doorframes. Replace if necessary.

22. Seal spaces/breaches and/or open utility holes around exterior of the building.

23. Consider replacing carpeting in areas susceptible to moisture (e.g., first floor on slab) with a non-porous flooring material.

24. Consider removing/replacing loose/damaged floor tiles in rooms on-slab with a non-slip floor system consistent with the type that has been installed in other portions of the school.

25. The storage areas in the band and chorus rooms should be examined and thoroughly cleaned out to remove mold-contaminated and water-damaged items. Discard mold-contaminated items including leather, paper, cloth and instrument cases. If materials are of significant value, a professional restoration contractor should be consulted about potential for cleaning.

26. Address storage issues for vulnerable items such as those kept in the chorus and band rooms, including sealing in plastic before the end of the year or storage in areas with sufficient air circulation to allow for drying.

27. Clean and disinfect mold-colonized refrigerator/freezer gaskets with a mild detergent or antimicrobial agent; if they cannot be adequately cleaned, replace.

28. Ensure that drains on laboratory sinks and safety shower floor drains are kept wet by pouring water into them at least twice a week (or as needed).

29. Regularly inspect the condensation drains on ductless AC units for leaks and stagnant water.

30. Seal areas between sink countertops and backsplashes to prevent water damage to the interior of cabinets and adjacent materials. Have leaking sink faucets repaired.

31. Do not store porous or significant amounts of items under sinks.

32. Ensure that aquariums and terrariums are maintained to prevent mold growth/odors. If not in use, properly clean, dry and store.

33. 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.

34. Trees/shrubbery should be located at least 5-feet from the building to avoid impingement of moisture on exterior walls/foundation. Trim back overhanging branches to prevent debris from clogging roof drains.

35. Place water dispensers in an area with non-porous flooring or on a waterproof mat.

36. Consider providing school-issued cleaning products when they are needed in classrooms to ensure the availability of MSDS information and to prevent chemical interactions. Keep all cleaners out of the reach of children.

37. Ensure that the kilns are inspected on a regular basis and that exhaust ventilation operates every time the kilns are used. Remove clutter from kiln rooms before they are operated.

38. Ensure that the ceiling tile system in the kiln room is continuous (e.g., repair spaces around vents, replace missing ceiling tiles) to prevent odor/particulate migration to adjacent areas.

39. Store any needed science chemicals/flammable materials in a properly approved storage cabinet. Consider adding exhaust ventilation to the hazardous material storage cabinets. Ensure that MSDSs are available for science chemicals and that outdated and unneeded chemicals are identified and properly discarded through regular inspections.

40. Refrain from using air fresheners and deodorizers to prevent exposure to VOCs.

41. Clean air diffusers, personal fans and exhaust/return vents of accumulated dust regularly.

42. Clean chalk and dry erase marker trays and pencil sharpening areas regularly with a wet cloth or sponge to prevent excessive build-up of dusts. Relocate pencil sharpeners away from univents.

43. Replace missing/damaged ceiling tiles throughout the building (e.g., Building M weight room).

44. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

45. 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, 2012).

46. 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/actionkit.html.

47. 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

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

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

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

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

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

IICRC. 2012. Institute of Inspection, Cleaning and Restoration Certification. *Carpet Cleaning: FAQ*. Retrieved from http://www.iicrc.org/consumers/care/carpet-cleaning/#faq.

MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

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

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

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

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. 2011. Ventilation rates and health: multidisciplinary review of the scientific literature. *Indoor Air*, Volume 21: pp 191–204.

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

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. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, D.C. EPA 402-K-01-001. March 2001.

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

Classroom unit ventilator (univent), note books on top obstructing air diffuser

Picture 2

Ceiling-mounted univent with ducted air diffusers

Picture 3

Univent fresh air intakes

Picture 4

Rooftop air intake for classroom univent

Picture 5

Univent fan speed control

Picture 6

Ceiling-mounted exhaust vent, note dust/debris accumulation

Picture 7

Rooftop exhaust motors

Picture 8

Proximity of exhaust vent to open hallway door (arrows)

Picture 9

Rooftop air handling units

Picture 10

Ceiling-mounted supply diffuser

Picture 11

Water-damaged ceiling tiles

Picture 12

Water-damaged ceiling tiles

Picture 13

Water-damaged/mold-colonized gypsum wallboard ceiling in classroom 1505

Picture 14

Visible mold growth/staining of refrigerator gasket

Picture 15

Spaces between sink countertop/backsplash, also note delamination

Picture 16

Disused aquarium on countertop in classroom, note film on glass and debris inside

Picture 17

Space/light beneath exterior door

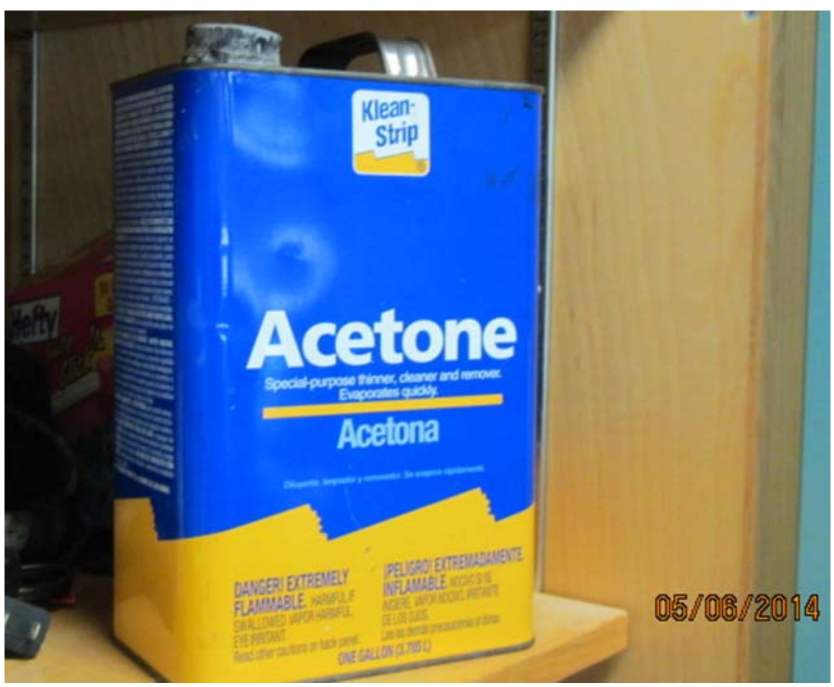
Picture 18

Damaged/corroded exterior door frame

Picture 19

Bird waste and nesting material in exterior intake vent

Picture 20



Flammable material on shelf of unlocked cabinet in classroom 2705

Picture 21

Chemical storage cleanout in progress

Picture 22

Kiln vents, with missing ceiling tiles and gaps in the ceiling tile system

Picture 23

Water-damaged ceiling tiles and gaps around kiln exhaust system

Picture 24

Univent filter medium in metal cage, note corrosion, dust accumulation on filter

Picture 25

Papers and other items in a classroom

Picture 26

Dusty personal fan

Picture 27

Dust accumulation inside a univent

Location: Barnstable High School **Indoor Air Results**

Address: 744 West Main St. Barnstable, MA **Date: 5/6/2014**

Table 1

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Background	391	ND	61	38	2					Clear, light wind
Auditorium	479	ND	73	38	3	0	N	Y Off	Y Off	
Auditorium (Upstairs)	479	ND	73	38	4	0	N	Y	Y	Light around back door, partly carpeted
Boys' Restroom							N	Y	Y Weak	
Cafeteria	811	ND	73	35	4	300	N	Y	Y Off	
Custodian near Auditorium	600	ND	73	32	5	3	N	Y	Y	Microwave, rear entrance door, partly open
Field House	691	ND	70	39	2	17	N	Y	Y	Doors need new gaskets/sealing-light penetration around most
Girls Locker Room	415	ND	72	30	4	0	N	Y	Y	
Greenhouse	609	ND	76	38	6	0	Y	Y	Y	Plants, solar gain
Gym	487	ND	70	33	2	0	N	Y	Y	WD ceiling

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
House E	606	ND	74	33	3	0	N	Y	Y	DO
Intervention	719	ND	72	37	4	0	Y	Y	Y	Plants
Intervention Room (in Cafeteria)	519	ND	73	37	4	0	Y	N	Y Off	Plants
IRC	768	ND	73	35	4	0	Y	Y	N	
Library director	438	ND	70	32	3	0	N	Y	Y	Items/clutter, carpet
Library Mezzanine	413	ND	72	30	3	0	N	Y	Y	
Library: Office off mezzanine	429	ND	70	32	3	0	N	Y	Y	Many WD CT, carpet, holes in wall
Main Cafeteria	929	ND	72	36	4	~300	Y Door	Y	Y	
Main Office – A (Principal's Office)	665	ND	73	35	5	2	Y Open	Y	Y	DO

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems	Temperature: Relative Humidity: Particle matter 2.5	70 - 78 °F 40 - 60% < 35 ug/m³

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Main Office - Admin kitchen	662	ND	73	36	6	0	N	Y	N	Breach/sink counter top, old appliances
Main Office – B	732	ND	73	36	5	2	Y	Y	Y	Plants, DO
Main Office – C	736	ND	73	36	6	0	Y	Y	Y	DO, PC, odors
Main office – D	749	ND	74	35	5	1	Y	Y	Y Near door	DO, items hanging from ceiling, accumulated items
Main office – Telephone Storage										Water cooler on floor
Men's Dressing Room	390	ND	71	31	4	0	N	Y	Y Off	2 WD CT
Music Info Center	490	ND	71	35	3	1	N	Y	Y	8 computers, stained carpets
Music Library	493	ND	71	38	4	0	N	Y	Y	Paper products stored on floor; humidity/condensation
Senior Cafeteria	823	ND	73	36	4	150	N	Y	Y	

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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: Barnstable High School **Indoor Air Results**

Address: 744 West Main St. Barnstable, MA **Table 1 (continued)** **Date: 5/6/2014**

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Senior Cafeteria Office	915	ND	72	36	3	0	N	N	Y	DO
Taylor's Office Library Mezz	374	ND	71	32	4	0	N	Y	Y	8 WD CTs, breach/sink counter top
Weight Room	559	ND	73	34	4	0	N	Y	Y	5 AT
Women's Dressing Room									Y (in restroom) Off	Furniture, accumulated items
Wood Shop	495	ND	73	32	3	0	N	Y	Y	Dedicated exhaust
1100 Main Office	912	ND	72	39	6	2	N	Y	Y	Computers, DEM, carpet
1100 C Copy	775	ND	72	37	7	0	Y	Y	Y	Carpet, PC, DO
1100 D	749	ND	73	37	9	0	Y	Y	Y	DO, printers, accumulated items, HS
1100 Mail	850	ND	73	38	6	1	N	Y	N	
1100 E	825	ND	74	35	7	1	Y	Y	Y	

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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: Barnstable High School **Indoor Air Results**

Address: 744 West Main St. Barnstable, MA **Table 1 (continued)** **Date: 5/6/2014**

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1100 H	693	ND	73	35	5	0	N	Y	Y	Plants
1100 G	708	ND	73	34	4	1	Y 2 Open	Y	Y	Boxes on floor
1102 Music	984	ND	71	38	6	20	N	Y	Y	Porous items, instruments, DEM, PFs
1102 Music Office	884	ND	71	38	5	1	N	Y	Y	Plants, fridge, items under sink, carpet
1102 Practice Room 1	707	ND	71	38	3	0	N	Y	Y	Storage of items, WD CT
1103 Band	545	ND	70	40	3	0	Y	Y	Y	Carpet, DEM, instruments, light visible under outside door
1102 Practice Room 2	627	ND	70	37	4	0	N	Y	Y	Storage of uniforms and other items, reported mold growth on items stored here before
1105	532	ND	73	30	2	1	N	Y	Y	PC, plant, DO
1201	566	ND	73	42	2	1	Y ½ Open	Y	Y Off	1 Broken CT, breach/sink counter top, PF, bowing CTs
1202	550	ND	70	32	3	0	Y Open	Y	Y	Trees near windows outside

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1203	655	ND	73	35	2	2	Y	Y	Y Off	PF, DEM, DO
1204	557	ND	73	34	2	17	Y Open	Y	Y	Plant, DEM, AT, HS
1205	570	ND	73	34	3	1	Y ¾ Open	Y Blocked	Y Off	Plants, DO, DEM
1206	819	ND	72	35	3	16	Y	Y	Y	Items on UV, bowed CTs, DEM, NC
1207	630	ND			2	2	N	Y	Y	NC, plants, WD CT, sink
1208 A	700	ND	72	36	2	2	Y	Y	N	2 WD CT, DO, NC
1210	692	ND	71	39	2	13	Y	Y	Y	DEM
1213 House C	702	ND	73	34	4	3	N	Y	Y Off	Musty carpet odors
1213 House B	598	ND	74	33	3	0	Y	Y	Y Off	DO
1213 C	776	ND	75	34	4	2	Y	Y	Y Dusty	Plants

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems	Temperature: Relative Humidity: Particle matter 2.5	70 - 78 °F 40 - 60% < 35 ug/m^3

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1213 D	609	ND	73	34	2	1	Y	Y	Y	AT, dust/cobwebs-exhaust vent
1214	705	ND	73	33	3	4	Y	Y Items	Y	DEM, DO, 2 WD CT
1214 Small Auditorium	564	ND	71	34	4	0	N	Y	Y	Carpet
1215	636	ND	71	31	2	0	N	Y	Y	DEM
1215 Custodian		ND					N	Y	Y	AT, WD CT
1217	555	ND	73	31	3	8	N	Y	Y	DEM, DO
1218	1057	ND	71	38	2	20	Y	Y	Y	
1220	872	ND	72	36	4	13	Y	Y	Y Blocked	
1221	889		71	38	2	11	Y	Y	Y	DEM
1222	937	ND	73	31	3	14	Y	Y	Y Off	PF

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1223	788	ND	71	38	2	0	Y	Y	Y	Accumulated items, DEM, WD CT, bowed tiles
1224	984	ND	72	37	4	16	Y	Y	Y	DEM, CPs
1225	853	ND	72	39	2	0	Y	Y	Y	Accumulated items, DEM, PF
1226	838	ND	73	37	3	19	Y	Y	Y Blocked	Plants, microwave
1227	796	ND	72	36	2	20	Y	Y	Y	Bowed CTs, DEM
1228	826	ND	73	37	4	28	Y	Y	Y	DO
1229	687	ND	71	36	2	6	Y	Y	Y	Fridge, microwave, items on UV
1230	652	ND	73	35	4	0	Y	Y	Y	Plant
Boys and Girls Restrooms (near 1230)							Y	N	Y Off	
1231	675	ND	72	31	2	3	Y	Y	Y Blocked	UV on, backsplash open, CP under sink

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1301	401	ND	69	32	3	0	Y 7/8	Y	Y	Breach/sink counter top, CPs, 8 WD CTs
1301 Office	387	ND	69	38	3	0	Y	Y	Y Dusty	
1302	607	ND	70	38	3	0	Y ¼	Y	Y	
1303	622	ND	72	38	4	1	Y 3 Open	Y	Y	Plants on UV, ductless air conditioner
1303 Observation	584	ND	73	35	1	0	N	Y	N	Accumulated items
1304	594	ND	72	35	1	1	Y	Y		Stove, toaster, refrigerator (clean), food, PF
1305	593	ND	72	34	2	1	Y	Y		Sink, WD CT, carpet, ductless air conditioner
1306 Nurse	507	ND	72	33	2	3	N	Y	Y	Air Purifier
1306 Restrooms							N	Y	Y Off	Strong restroom odors
1306 E	700	ND	74	34	2	0	Y Open	Y	Y	Fridge, plants, accumulated items

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems	Temperature: Relative Humidity: Particle matter 2.5	70 - 78 °F 40 - 60% < 35 ug/m^3

Location: Barnstable High School **Indoor Air Results**

Address: 744 West Main St. Barnstable, MA **Table 1 (continued)** **Date: 5/6/2014**

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1306 F	532	ND	74	32	2	0	Y Open	Y	Y	Sink
1307	649	ND	74	33	2	5	Y	Y	Y	PF, DO, breach/sink counter top, dehumidifier, stained carpet
1308	821	ND	74	35	3	6	Y	Y Blocked	Y	2 WD CTs
1310	789	ND	70	39	4	14	Y	Y	Y	Door to outside, PF dusty, WD CT, DEM
1311	960	ND	74	40	3	23	Y	Y	Y	Plant, DEM
1313	673	ND	73	34	3	0	Y	Y Blocked	Y	
1314	574	ND	72	31	2	1	Y	Y	Y	
1314 Storage									Y	DO
1315	630	ND	72	39	2	0	Y	Y Blocked	Y	PFs, DEM, AT
1316	487	ND	73	33	2	14	N	Y	Y	WD carpet, 2 levels, upholstered furniture

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems	Temperature: Relative Humidity: Particle matter 2.5	70 - 78 °F 40 - 60% < 35 ug/m^3

Location: Barnstable High School **Indoor Air Results**

Address: 744 West Main St. Barnstable, MA **Date: 5/6/2014**

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
1316 C	487	ND	72	32	3	1	N	Y	Y	Carpet, food
1316 E	552	ND	72	32	4	0	N	Y	Y	Carpet
1316 main	443	ND	71	32	2	10	N Door to outside	Y	Y	
1316 F	682	ND	73	34	3	2	N	Y	Y	Computers, carpet, sink breach/sink counter top
1316 H	656	ND	74	32	2	1	N	Y	Y	PC, PF, carpet, microwave, boxes on floor, water cooler on carpet
1317	637	ND	73	36	5	5	N	Y	Y	PC, fridge
1318	820	ND	74	36	3	0	Y	Y Off	Y Off	29 computers, 12 WD CTs
1319 Technology	647	ND	73	33	4	0	N	Y	Y	Computers, NC, DEM, PF
1320	742	ND	73	31	2	0	N	Y	Y	Strong odor (plastic or rubber-like)
1321	707	ND	73	33	4	14	N	Y	Y	WD CT, NC, DEM

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
1322	878	ND	74	34	5	21	Y	Y	Y	2 WD CTs
1323	1182	ND	74	40	5	16	N	Y	Y	DEM, DO
1324	1347	ND	74	40	4	15	Y	Y	Y	DEM, DO
1325	747	ND	72	36	29	14	Y	Y	Y	UV on, elevated PM2.5 due to operation of fryer in classroom, debris in UV, DEM
1326 House B	582	ND	73	42	4	1	Y ½ Open	Y	N	DO, PC, PF, plants
1326 B								Y	N	Broken CT
1326 C	560	ND	73	41	3	0	Y	Y	N	DO, PF
1326 D	487	ND	73	31	3	0	Y	Y	N	CPs
1326 E	630	ND	73	35	4	2	Y ½ Open	Y	N	2 WD CTs, DO

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1400s Staff Lounge	666	ND	73	34	6	0	N	Y	Y	
1400s Staff Restroom									Y Off	
1401	639	ND	72	35	3	0	N	Y	Y	DO
1402 Coffee/Copy	694	ND	74	34	2	0	N	Y	Y	Food preparation, PC, ductless air conditioner
1403	609	ND	74	31	4	1	Y	Y	Y Dusty	Air conditioned/computer servers
1404	590	ND	73	32	2	5	Y Open	Y	Y	DEM, items on UV, DEM, dusty ceiling
1405	522	ND	73	34	3	1	Y ½ Open	Y	Y	PCs, ADs
1406	633	ND	73	34	4	2	N	Y	Y Dusty	Stove tops, ATs, breach/sink counter top
1407	1048	ND	72	41	4	26	N	Y	Y	WD CT– mold, toaster
1408	797	ND	73	37	4	0	N	Y	Y	Many WD CT, AF odor, DEM, PF dusty, PS

ppm = parts per million
μg/m³ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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/m³

Location: Barnstable High School **Indoor Air Results**

Address: 744 West Main St. Barnstable, MA **Table 1 (continued)** **Date: 5/6/2014**

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1409	982	ND	77	40	12	20	N	Y	Y	CPs, stoves in in use
1410	662	ND	74	34	3	0	Y	Y	Y Dusty	AD, 2 MT
1411	696	ND	73	35	3	0	Y	Y	Y	PF, DO, CPs
1412	560	ND	73	34	4	0	Y ¼ Open	Y	Y Dusty	PF, DO
1414	605	ND	72	36	3	0	N	Y	Y	Low ceiling, bowed CTs
1414 Spinning Room	576	ND	71	38	3	0	N	Y	Y	MT, carpet
1419 Gym Staff	579	ND	71	36	2	0	N	Y	Y	Restroom inside, exhaust low/off
1500	641	ND	71	36	2	0	Y	Y	Y	Items on ceiling, PF, porous items under sink, emergency shower and floor drain
1501 Inner	711	ND	73	44	10	1	Y ½ Open	Y	Y W	3 broken CTs, DO, PF, HS
1501 Main	604	ND	73	35	4	0	N	Y	N	Food appliances, DO

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m^3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1502	625	ND	73	36	3	7	Y 1/3 Open	Y	Y	CPs, PF
1503	1095	ND	71	40	5	20	Y	Y Blocked	Y	Aqua, plants, cabinets of items
1504	405	ND	71	32	3	0	N	Y	N	CPs
1505	404	ND	71	36	3	0	N	Y	Y	WD-skylight, GW had med moisture/visible microbial growth
1506	452	ND	71	36	3	1	Y	Y Blocked	Y	Skylight, WD CT, WF FT, door (light visible beneath), plants, aquas, DEM, items
1508 Coastal Library	536	ND	71	34	2	0	Y	Y	Y	DEM, CP, accumulated items, several aqua
1509	623	ND	72	35	4	0	N	Y	Y Ajar	Beds, NC, Air Purifier
1510	526	ND	70	35	2	0	Y	Y	Y	Sinks, DEM, emergency shower/floor drain
1511	552	ND	70	34	2	0	Y	Y	Y	Plants, DEM, chemical storage, aqua
1514	698	ND	71	35	3	20	Y	Y	Y	Chemical hood-no date, drain, WD/moldy CT

ppm = parts per million
μg/m^3 = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1515	815	ND	70	37	3	28	Y	Y	Y	Plants, aqua
1521	777	ND	75	33	2	20				Aqua, AT
1522	826	ND	74	34	4	26	Y	Y Blocked	N	PF, CPs, sci. hood, fridge-items
1523	385	NB	70	33	3	0	Y ¾ Open	Y	Y Off	4 aquas., 2 WD CTs, plants on UV
1600	1451	ND	73	41	2	29	Y	Y	Y	UV-diffuser covered with books, PF
1601	859	ND	72	43	5	23	Y	Y	Y	DEM, plant, CP
1602	1052	ND	72	38	2	15	Y	Y	Y	
1603	486	ND	72	40	4	1	Y Open	Y	Y On	
1604	1012	ND	71	37	2	13	Y	Y	Y	Exhaust near open door, ATs, PF
1605	736	ND	72	41	5	13	Y Open	Y	Y	DEM, DO, HS

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1606	958	ND	71	39	1	20	Y	Y	Y	Broken CT near exhaust vent
1607	729	ND	72	40	3	15	Y Open	Y	Y Off-dusty	DEM, DO
1608	1065	ND	71	39	1	13	Y	Y	Y	PF, Air Purifier
1609	602	ND	72	39	2	2	Y	Y	Y Near door	DEM, accumulated items on surfaces
1700	573	ND	71	39	5	1	N	Y	Y	House A suite, PC
1700 A		ND								Storage
1700 B Conference	621	ND	72	37	4	0	Y	Y	Y	PF
1700 D	605	ND	73	36	3	1	Y	Y	Y	Plant, DO, carpet
1700 E	624	ND	73	36	5	1	N	Y		DO, microwave and fridge, NC
1701	401	ND	69	37	3	2	Y ¾ Open	Y	Y	DO, DEM

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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: Barnstable High School **Indoor Air Results**

Address: 744 West Main St. Barnstable, MA **Date: 5/6/2014**

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1702	481	ND	69	39	3	1	Y	Y	Y Blocked	DEM, AT, CPs, PS near UV
1703	502	ND	72	32	3	1	Y	Y	Y	Boxes on floor, NC, DO, science chemicals, bowed CT
1703 Prep Room										Accumulated items
1704	543	ND	71	32	3	0	Y	Y	Y	Bowed CTs, plants, NC
1705	1213	ND	71	43	4	19	Y ¼ Open	Y on	Y Dusty	PF-dusty, DEM
1706	932	ND	71	37	1	26	Y	Y	Y	DEM
1707	634	ND	71	38	4	0	Y ½ Open	Y Off	Y Off	DEM, PF-dusty, 2 AT
1708 Computer Room	714	ND	70	34	2	0	Y	Y	Y	DEM, bowed CTs, computers
1708 Storage										Clothing stored on shelves
1709	679	ND	71	38	3	20	Y	Y	Y	DO, breach/sink counter top, CP under sink

ppm = parts per million
μg/m³ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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/m³

Location: Barnstable High School **Indoor Air Results**

Address: 744 West Main St. Barnstable, MA **Table 1 (continued)** **Date: 5/6/2014**

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1710	566	ND	72	36	4	5	Y 2/6 Open	Y Blocked Off	Y Off	PF, laminators, cooling equip
1712	980	ND	73	39	5	20	Y	Y Blocked Off	Y Off	ADs, DEM
1713	462	ND	71	35	3	0	Y	Y	Y	Pottery items, clay, non toxic labeled glaze bottles
1713 Kiln Room		ND								Ventilation equipment, holes in ceiling tile system, AT/MT, WD CT
1715	607	ND	72	37	4	12	Y Open	Y	Y	Plants, DEM,
1717 Technology	586	ND	72	36	3	4	Y	Y	Y	PC, DEM, fridge gasket moldy
1718	707	ND	72	35	4	5	Y	Y	Y	Bowed CTs, carpet, DEM
1719	473	ND	73	32	3	0	N	Y	Y	Breach/sink counter top, PF, CPs, 2 WD CTs
1720	497	ND	73	32	3	0	N	Y	Y	3 PC, DO

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

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: Barnstable High School **Indoor Air Results**

Address: 744 West Main St. Barnstable, MA **Date: 5/6/2014**

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2112	632	ND	76	34	3	2	N	Y	Y	Copier near supply vent
2200	576	ND	76	33	4	2	Y	Y	Y	DEM, 30+ computers, cooling units on outside wall
2201	442	ND	73	32	2	1	Y Open	Y	Y	
2202	954	ND	75	38	5	22	Y Open	Y	Y	DEM, items on surfaces
2203	845	ND	73	36	3	29	Y Open	Y	Y	
2204	1184	ND	75	42	4	25	Y ¼ Open	Y	Y	DEM, items on surfaces
2205	419	ND	72	31	2	0	Y Open	Y	Y	Exhaust near open door
2206	834	ND	73	33	4	14	Y Open	Y Off	Y	DEM
2207 Nurse	774	ND	75	35	5	3	N	Y	Y	Copier, sink, storage room
2208	658	ND	73	37	2	6	Y	Y	Y	DEM, CP, PS

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2209 Main	637	ND	74	33	2	1	N	Y	Y	PC, 2 WD CT, WTW, DO
2209 A	774	ND	74	35	2	1	Y	Y	N	DO, MT, WTW
2209 B	627	ND	74	33	3	1	Y Open	Y	N	DO, WTW
2209 C	583	ND	74	33	2	1	Y Open	Y	N	PF, plants, WTW, DO
2209 D	555	ND	74	32	2	0	N	Y	N	WTW
2210	934	ND	74	33	3	27	Y	Y	Y	
2300 D	441	ND	72	31	3	0	N	Y	Y	Laminator
2300 TGA	437	ND	71	32	3	1	N	Y	Y Dusty	Reported loud exhaust, NC, WD CT
2301	945	ND	72	38	5	3	N	Y	Y	Items, DEM
2302 staff	717	ND	72	34	3	0	Y Open	Y	Y	Carpet, fridge and water cooler on carpet

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2305	754	ND	73	35	4	0	N	Y	Y	
2307	657	ND	73	32	5	3	Y	Y	Y	Dusty ceiling, DEM, NC, DO
2308 G	703	ND	72	34	4	6	Y Open	Y	Y	CP, carpet, dusty ceiling
2601	614	ND	74	35	2	7	Y Open	Y	Y Off	DEM, plant
2604	1608	ND	74	37	2	18	Y	Y On	Y Off	DEM
2605	857	ND	73	36	3	24	Y Open	Y On	Y On	DEM, plant
2606	1263	ND	74	40	1	27	Y	Y	Y	DEM
2607	524	ND	73	32	3	2	Y Open	Y Off	Y On	DEM, PF-dusty, upholstered furniture
2608	660	ND	72	33	3	3	Y Open	Y	Y On	DEM, surplus items on surfaces, boxes
2609	690	ND	72	35	2	4	Y Open	Y Blocked	Y On -near door	DEM, DO, plants, utility hole in wall

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Location: Barnstable High School **Indoor Air Results**

Address: 744 West Main St. Barnstable, MA **Table 1 (continued)** **Date: 5/6/2014**

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2700 A	608	ND	72	33	3	3	Y Open	Y	N	Plants, PC-odor
2701	575	ND	73	31	1	2	Y Open	Y	Y Off	DO, DEM, lab hood, eye wash, floor drain
2702	886	ND	75	36	2	6	Y	Y	Y	DO, Plants, complaint uninvent is loud (set to Medium), class just ended
2703	746	ND	73	35	5	17	Y Open	Y	Y	DO, PF-on, plants
2705 Science	562	ND	73	29	3	2	Y	Y Off	Y Off	DEM, eye wash, floor drain, terrarium, mini fridge w/mold, acetone, bleach, formaldehyde, Draino, etc.
2706	1031	ND	75	36	5	23	Y Open	Y	Y	DEM, PF (x2)-dusty
2707	1160	ND	75	37	3	19	Y	Y	Y	DEM, accumulated items on surfaces
2710	822	ND	75	33	3	24	Y Open	Y On	Y	
2711	817	ND	76	33	3	22	Y Open	Y Off	Y Near door	PF, DO, Items on UV

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Table 1 (continued)

Location/ Room	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2713 D	671	ND	76	32	4	4	Y Open	Y	N	DO
2713 B	700	ND	75	33	3	2	Y ¼ Open	Y	N	WTW
2713 Reception	762	ND	76	32	4	5	N	Y	N	WTW
2715	453	ND	73	29	3	2	Y	Y	Y	PS, dust & debris, MT, PF-on
2716	565	ND	74	33	3	3	Y Open	Y Off	Y	1 hr since class ended, comfort complaints room gets too hot, DO, DEM
2718	533	ND	72	31	4	5	Y	Y Noisy	Y	Hood, art supplies, DO, breach/sink counter top
2723 Art	853	ND	74	40	5	17	Y Open	Y Off	Y On	Glue, art supplies, paint, exhaust hood, DEM, DO, MT
Building M										
Out building - Weight room	491	ND	68	40	3	0	N	Y	Y	Breach/sink counter top, MTs, WD-CTs, exposed fiberglass insulation

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
WD = water-damaged
ADs = air deodorizers
aqua. = aquarium
AT = ajar tile
CPs = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
MT = missing ceiling tile
NC = non-carpeted
PC = photocopier
PF = personal fan
PS = pencil shavings
WTW = wall to wall carpet
GW = gypsum wallboard
HS= hand sanitizer
UV = univent

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Commonwealth of Massachusetts
Department of Public Health
Helping People Lead Healthy Lives In Healthy Communities

BUREAU OF ENVIRONMENTAL HEALTH
Indoor Air Quality Program

Guidance Concerning Proper Use and Storage of Chemicals in Schools to Protect Public Health

November 2006

The improper use and storage of chemicals in schools can lead to irritant symptoms related to indoor air quality, particularly in buildings with poor exhaust ventilation. The safety of students, faculty and school staff as well as emergency responders can all be adversely affected by the improper use and storage of chemicals. Due to the inherent danger from chemicals used in science curriculum and the variety of materials used by custodial staff, appropriate measures for proper use and storage of these materials are needed to prevent/reduce exposure. The municipal fire department in each municipality in Massachusetts has the exclusive authority to regulate the storage of flammable materials (527 CMR 14.00). The fire safety office of your municipal fire department should be consulted for assistance in compliance with these regulations.

The following guidelines are intended to serve as recommendations for the proper use and storage of these hazardous materials.

Chemical Identification

Container Labeling

Each container must be labeled with the chemical *name* of the material stored within (not chemical formula solely). Chemical names must be consistent with M.G.L. c. 111F (Hazardous Substances Disclosure By Employers, also known as the Massachusetts Right-To-Know Law) in order to facilitate the identification of the chemical(s) in case of a spill.

Material Safety Data Sheets (MSDS)

An appropriate MSDS for custodial supplies and chemicals used in science, art, photography and other programs should be obtained from the chemical supplier/manufacturer and kept in an area that is accessible to all individuals during periods of building operations in conformance with M.G.L. c. 111F. If no MSDS is available for a product because 1) the manufacturer no longer exists; 2) the manufacturer cannot be identified from the label or 3) the chemical was obtained prior to the promulgation of M.G.L. c. 111F, that material should be considered hazardous waste and disposed of in a manner consistent with Massachusetts hazardous waste regulations.

Appendix B

Proper Chemical Storage and Handling

Storage Cabinets

Flammable materials

All cabinets for storage of flammable materials must be in compliance with Massachusetts statutes, regulations and local ordinances promulgated pursuant to M.G.L. c. 148, § 13. In addition, all flameproof cabinets must meet the design and installation criteria set forth in the National Fire Prevention Association's (NFPA) latest version of NFPA 30: Flammable and Combustible Liquids Code.

Acids

Acids must be stored in a cabinet that is constructed from corrosion-resistant materials. Each acid cabinet should be vented to reduce acid vapor build up.

Chemical Storeroom Ventilation

Rooms that are designated for use as chemical storage areas must have a functioning exhaust ventilation system that operates continuously to remove fugitive chemical vapors. The local exhaust system should be ducted to the outdoors independent of the general ventilation system. Each room must also have an appropriate source of transfer (or make-up) air allowing for exhaust vents to operate efficiently. Such chemical storage ventilation systems must be in conformance with the applicable fire and building codes. Chemical storeroom exhaust vents must be inspected annually by appropriately trained individuals to ensure proper function.

Shelving

If chemicals are stored on shelving:

1. Shelving must be constructed of appropriate materials that will resist corrosion resulting from leaking materials stored on or around the shelves. For example, chemicals that are oxidizers should not be stored on wood and acids should not be stored on or near steel.
2. The shelving must be able to support the weight of stored materials.
3. Guardrails should be installed along the edge of shelving to prevent accidental slippage.

Chemical Hoods

Chemical hoods used in science programs as part of experiment preparation must be maintained in an appropriate manner in accordance with manufacturers' recommendations. Chemical hoods must be recalibrated annually by appropriately trained individuals to ensure proper function. Documentation of annual recalibration should be assessable to all building occupants. If an area is designed so the chemical hood is the sole exhaust vent for an area, the chemical hood must operate continuously during occupied hours. Chemical hoods should not be used to store unattended chemicals.

Prohibited Activities

The following chemical storage/handling practices should be prohibited to provide for the health and safety of school occupants.

- No shock sensitive material should be present in the school and should only be removed after consultation with the local fire safety office.
- No flammable materials should be stored outside flameproof cabinets.
- No non-flammable materials should be stored inside flameproof cabinets.
- Chemically incompatible materials must be separated and stored in an appropriate manner according to the manufacturer's recommendations.
- No flameproof cabinet should be vented in a manner to allow for backflow of air into the cabinet.
- No cabinet should share venting with the chemical hood.
- Acids should not be stored in cabinets made of or shelves supported by materials made of steel.
- Carpeting should not be used as floor covering in laboratories.
- Schools should not store more flammables or other liquid chemicals than are necessary to meet curriculum needs, and in no event more than a two year supply.
- No water reactive materials should be stored within 10 feet of a water source.
- Chemicals must not be stored in recycled food storage containers.

Appendix B

Chemical Spill Response Plan

Schools should have a chemical inventory and emergency response plan to ensure the safety of building occupants and emergency responders. The elements of an emergency response plan should include the following topics:

1. Procedures for evacuation of the building in the case of a spill that may to result in exposure to building occupants.
2. Contact number (911) for emergency response to a chemical spill.
3. Emergency procedures to contain the material in the location of the spill.
4. Closing of doors
5. Deactivation of the ventilation system
6. Routing of evacuation away from the spill location
7. Contact information for remediation services
8. Procedures for proper disposal of hazardous material in compliance with Massachusetts hazardous waste disposal laws.

Questions

If you have any questions concerning these guidelines, please contact:

Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
250 Washington Street, 7th Floor
Boston, MA 02108

Phone: (617) 624-5757 Fax: (617) 624-5777

Document Reviewed: August 2008

Appendix C

Commonwealth of Massachusetts
Department of Public Health
Helping People Lead Healthy Lives In Healthy Communities

BUREAU OF ENVIRONMENTAL HEALTH
Indoor Air Quality Program

Preventing Mold Growth in Massachusetts Schools during Hot, Humid Weather

June 2004

Background/Statement of the Problem

During the summers of 2002 and 2003, schools and other municipal buildings experienced significant mold problems. As a result, at least thirty school systems have experienced delayed school openings and/or have spent substantial funds on cleaning and remediating mold growth in schools. These mold growth problems are directly related to unusual weather patterns in New England (e.g., extended periods of hot, humid weather).

Mold growth in a building can produce eye, nose, throat and respiratory irritation. Mold may also exacerbate pre-existing respiratory problems (e.g., asthma) and cause symptoms in hypersensitive individuals. For these reasons, it is recommended that mold contaminated materials be removed or cleaned, where feasible (US EPA, 2001).

This document provides guidance on preventing or minimizing mold growth within a building. Most mold prevention steps can be employed in any building. However, certain steps involving dehumidification can only be achieved with dehumidifiers and/or heating, ventilating, and air-conditioning (HVAC) equipment

Understanding Dew Point

In general, two water phases - liquid and vapor - can create conditions conducive to fungal colonization of vulnerable materials. Leaks through the building envelope (e.g., roof, exterior wall components, foundation) or plumbing problems are obvious water sources. If the indoor environment is improperly managed, high relative humidity combined with hot weather can also cause damage. Under certain conditions, condensation can accumulate and moisten materials, especially porous, carbon-containing items (e.g., gypsum wallboard, carpeting, cloth, paper, cardboard).

The key to managing condensation within a building is understanding dew point. When warm, moist air passes over a cooler surface, condensation can form. Condensation is the collection of moisture on a surface at or below the dew point. The dew point is the temperature that air must reach for saturation to occur. If a building material/component has a temperature **below the dew**

point, condensation will accumulate on that material. Over time, condensation can collect and form water droplets.

For example, at a temperature of 76^{o}F and relative humidity of 30%, the dew point temperature at which condensation can collect on a surface is approximately 42^{o}F. At temperatures less than 43^{o}F, water vapor can condense and form droplets on a surface. During humid weather, when the temperature is 85^{o}F and relative humidity is 90%, the dew point is approximately 82^{o}F. Therefore, surfaces with a temperature below 83^{o}F are prone to condensation formation.

According to American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), if relative humidity exceeds 70%, mold growth may occur due to wetting of building materials (ASHRAE, 1989). It is recommended that porous material be dried with fans and heating within **24 to 48 hours of becoming wet** (US EPA, 2001, ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water damaged porous materials cannot be adequately cleaned to remove mold growth. To prevent condensation formation, the following points are recommended:

> **Action Step:** Monitor weather through extended weathercasts to determine if hot, humid weather for more than 2 days is predicted. Many web-based weather services will provide a dew point listing.

> **Action Step:** Monitor temperature of condensation prone building components with a laser thermometer. If the temperature of the building component is below the dew point during hot, humid weather, steps should be taken to decrease humidity levels.

Reducing Relative Humidity through Mechanical Means

Cooling

Cooling air is the easiest method to reducing airborne water vapor. Window-mounted air conditioners and most HVAC systems are equipped with cooling coils. Each of these cooling efforts operates by drawing air over cooling coils that are set to a temperature below the dew point. As a result, condensation forms. In this manner, moisture is removed, before air is provided to a room. Although this method is the easiest for reducing indoor relative humidity, two disadvantages exist. First, drainage for condensation must be adequate to remove water at a sufficient rate. If a significant amount of water accumulates and lingers in the drip pan, the operation of HVAC system fans can reintroduce the moisture into the air stream. In addition, stagnant water can provide a medium for mold growth and associated odors.

> **Action Step:** If systems equipped with cooling coils are used to remove moisture, ensure drain pans are operating as designed. Drain pans should not rely on evaporation to remove condensation; rather, water should drain rapidly. If pans are draining improperly, the drainage should be repaired. If proper drainage cannot be provided, this method of relative humidity reduction should be avoided.

Appendix C

Another problem associated with using cooling coils to reduce relative humidity is the potential for condensation generation on building components. This occurs when the HVAC system chills building components below the dew point. Most problems experienced in schools occurred in August 2003, when the buildings were unoccupied. HVAC systems are typically configured for occupied rooms, where room occupants generate heat. However, lack of building occupancy reduces the waste heat in a room. If the HVAC system operates at settings for occupied rooms during extended periods of vacancy, the chilling system operates at a temperature below the design. In this manner, building components are chilled below the dew point, causing condensation to form. Under these circumstances, monitoring of building component temperatures is vital to preventing/ minimizing condensation development.

> **Action Step:** Monitor temperature of condensation prone building components with a laser thermometer. If the temperature of building components is below the dew point, raise the HVAC system set point to elevate the temperature of building materials above the dew point. The temperature of insulated chilled water pipes and HVAC components in contact with chilled air should also be monitored.

Dehumidifying

As with window-mounted air conditioners and HVAC systems, dehumidifiers also remove moisture from an indoor environment by cooling air drawn into the system. Although this method is effective, the dehumidification process also has limitations. Condensation usually drips into a collection well. If the water in the collection well becomes stagnant, it can provide the potential for mold growth.

> **Action Step:** Clean and maintain dehumidifiers as per manufacturer's instructions. Some dehumidifiers are also equipped with condensation drain hoses. Measures should be taken to ensure water is draining out of hoses when dehumidifiers are operating.

> **Action Step:** Ensure drain hoses are pointed downwards into a suitable receptacle (e.g., sink) and away from porous materials. Monitor draining when the dehumidifier is actively operating.

Heating

Although counterintuitive, the application of heat to building components (e.g., slab floors and foundation in contact with soil, below grade areas) can reduce condensation generation and prevent mold growth. This method is typically employed in areas lacking mechanical ventilation (e.g. storage rooms).

> **Action Step:** Use carpet-drying fans to apply heat to slab floors with carpeting and below grade occupied areas with carpeting, gypsum wallboard, particleboard, plywood or ceiling tiles.

Appendix C

Increasing airflow

By increasing the airflow of a building, accumulation of hot, moist air can be reduced, decreasing the opportunity for porous materials to become wet. Areas particularly prone to elevated moisture include storage closets and occupied spaces without mechanical ventilation.

Action Step: Implement the following methods to promote increased airflow:

1. Open all interior doors between rooms and closets.

2. Operate HVAC systems not equipped with chilling components (e.g., unit ventilators, or univents) with the fresh air intake vents closed.

3. Operate general exhaust ventilation system normally.

4. Arrange floor fans in hallways to circulate air.

Operating specialized exhaust ventilation

Activities in some non-classroom areas can generate water vapor. These areas include pools, kitchens, restrooms and locker rooms/showers. Specially designed exhaust ventilation systems in these areas should be provided to remove both odors and water vapor. This equipment is designed to prevent migration of odors and water vapor to other areas of a building.

Action Step: Operate exhaust vents in restrooms and locker rooms/showers during hot, humid weather to remove water vapor. The pool exhaust ventilation should be operating at all times.

Removing Porous Materials from Exposure to Water Vapor

To prevent mold growth in buildings, a number of mitigation steps can be taken. Measures may include the removal of porous materials from areas likely to be in contact with surfaces that have a temperature below the dew point, or removal of porous materials from hot, humid areas.

Action Step: The following measures can be used to reduce fungal growth of porous materials.

1. Avoid placing wall-to-wall carpeting or other porous materials on slab in contact with soil or on floors in below grade areas.

2. Avoid placing porous materials on temperature bridges. A temperature bridge is a structure that allows cooler temperatures to transfer between two areas. Furniture made of metal is more likely to be susceptible to temperature fluctuations. Avoid storing porous materials on metal objects that are low and in contact with floor or foundation walls.

3. Store porous materials in airtight, hard plastic containers.

4. Avoid placing porous materials between fresh air supply vents and exhaust vents. The air between this equipment is likely to hold moisture, since these systems are used to remove water vapor from a building interior.

Preventing Moisture Intrusion

Separating occupied areas from unoccupied areas

A crawlspace is an unoccupied area that typically consists of a dirt floor, which holds moisture. As a result, this area is prone to high relative humidity and mold growth. The crawlspace is often used as a chase way to run pipes and electrical services to rooms through a building. Crawlspaces are usually present in schools that are equipped with univents connected to heating pipes. Spaces and holes in walls and floors provide a pathway for crawlspace air to penetrate classrooms. Breaches around pipes also provide a means for crawlspace air and associated odors/particles to be drawn and distributed to classrooms via univents. In order to prevent moisture and potential fungal pollutant migration from the crawlspace to occupied areas, penetrations should be rendered airtight.

> **Action Step:** Seal holes/breaches with an appropriate fire-rated sealant compound to prevent air draw from the crawlspace.

Reducing the Water Load on the Building Envelope

Breaches in the building envelope or water pooling on/against a building structure can also result in water penetration and subsequent mold growth. Buildings are typically designed for minimal water impingement via building envelope components, including the roof, exterior walls, foundation and other penetration points through the structures. For example, exterior wall systems should be designed weep holes and drainage plans to prevent moisture accumulation penetration.

An exterior wall system of many buildings contains an exterior curtain wall. Behind the curtain wall is an air space that allows for water to drain downward and for the exterior cladding system to dry. At the base of the curtain wall should be weep holes that allow for water drainage. Opposite the exterior wall and across the air space is a continuous, water-resistant material adhered to the back up wall that forms the drainage plane.

The purpose of the drainage plane is to prevent moisture that crosses the air space from penetrating the interior building system. The plane also directs moisture downwards toward the weep holes. The drainage plane can consist of a number of water-resistant materials, such as tarpaper or, in newer buildings, plastic wraps. The drainage plane should be continuous. Where breaks exist in the drainage plane (e.g., window systems, door systems and univent fresh air intakes), additional materials (e.g., copper flashing) are installed as transitional surfaces to direct water to weep holes. If the drainage plane is discontinuous, missing flashing or lacking air space, rainwater may accumulate inside the wall cavity and lead to water vapor/moisture penetration into the building.

In order to allow water to drain from the exterior brick wall system, a series of weep holes is customarily installed at or near the foundation slab/exterior wall system junction. Weep holes allow for accumulated water to drain from a wall system (Dalzell, 1955). Lack of weep holes in brickwork or burial of weep holes below grade will allow water to accumulate in the base of walls, resulting in seepage and possible moistening of building components.

Unless a structure is **designed** to be in contact with pooling water, efforts should be made to prevent water from pooling for extended periods. For example, standing water on flat roofs as well as water in contact with foundations and floor slabs should be removed. Mitigation efforts may include modifications to the building design and construction.

> **Action Step:** Reduce pooling water around the building envelope and around the exterior wall system through the following methods:

1. Install gutters and downspouts to direct rainwater at least five feet away from the foundation. Gutters should extend along the entire roof edge.
2. Remove foliage and wood chips to no less than five feet from the foundation.
3. Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek & Brennan, 2001).
4. Install a water impermeable layer (e.g., clay cap) on ground surface to prevent water saturation of ground near foundation (Lstiburek & Brennan, 2001).
5. Remove trees in close proximity to building to increase drying of exterior walls.
6. Ensure weep holes in exterior walls are not blocked with wicks or buried below grade. Weep holes must be free of blockage and located above grade to allow water to drain and air to penetrate and aid in drying into the drainage plane. Configure the weep hole opening to prevent insect entry into the drainage plane.

Questions

If you have any questions concerning these guidelines, please contact:

Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
250 Washington Street, 7th Floor
Boston, MA 02108
Phone: (617) 624-5757 Fax: (617) 624-5777

Document Reviewed: August 2008

Appendix C

References

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

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

Dalzell, J.R. 1955. *Simplified Masonry Planning and Building*. McGraw-Hill Book Company, Inc. New York, NY.

Lstiburek, J. & Brennan, T. 2001. Read This Before You Design, Build or Renovate. Building Science Corporation, Westford, MA. U.S. Department of Housing and Urban Development, Region I, Boston, MA

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