INDOOR AIR QUALITY ASSESSMENT

Agassiz Elementary School
20 Child Street
Jamaica Plain, MA

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

At the request of Jeffrey Lane, Environmental Division Chief of Boston Public Schools' Facilities Management, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality concerns at the Agassiz Elementary School (AES), 20 Child Street, Jamaica Plain in Boston, Massachusetts. At the time of the request, environmental health officials from the Boston Public Health Commission were notified of the city's request for MDPH assistance. Concerns relative to general indoor environmental conditions/air quality and chronic respiratory disease prompted the assessment.

BEH staff visited the AES several times over the course of the school year to observe conditions in both the heating and cooling seasons. The heating season is typically during the period from October 15 to May 15. On July 14, 2008, Sharon Lee and James Tobin, Environmental Analysts/Inspectors from BEH's Indoor Air Quality (IAQ) Program visited the building to take temperature and relative humidity measurements while the heating, ventilating and air-conditioning (HVAC) system was operating in its cooling mode. Ms. Lee and Mr. Tobin returned on December 11, 2008 to conduct general IAQ testing while the building was occupied during the heating season. During the December 2008 visit, IAQ staff were accompanied by Christine Gorwood and Julie Lemay, Environmental Analysts/Risk Assessors in BEH's Community Assessment Program (CAP), who conducted personal interviews with several employees. On January 21, 2009, Michael Feeney, Director of the IAQ Program, visited the AES to conduct temperature measurements of windows and walls; Ms. Gorwood returned with Mr. Feeney on the January 2009 assessment to conduct a second round of interviews with building occupants. Ms. Lee and Mr. Tobin returned to examine the roof of the building on April 22, 2009.

The AES is a three-story, cement and brick building that was constructed in 1973. The first floor contains general classrooms and the main office. A descending staircase on the first floor opens to a split lower level, consisting of an auditorium, gymnasium, child care center, office space and locker rooms. The second and third floors contain general classrooms. Windows are openable throughout the building. Windows throughout the building are scheduled to be replaced prior to the 2009-2010 school year.

Methods

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

As mentioned earlier, BEH's CAP staff conducted personal interviews with AES staff aimed at better understanding health concerns. In addition, BEH's physician consultant reviewed medical records for those employees that provided signed consent forms.

Results

The school houses a student population of approximately 900 and a staff of approximately 75. The tests on December 11, 2008 were taken during normal operations of the school; results appear in Table 1. Surface temperature measurements of windows and walls taken on January 21, 2009 appear in Table 2. Temperature and relative humidity measurements were taken during the cooling season on July 14, 2008. Results of these measurements as well as dew point calculations appear in Table 3.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in 6 of 71 areas surveyed on December 11, 2008, indicating adequate air exchange in the majority of the building at the time of the assessment. It is important to note, however, that a number of classrooms were empty/sparsely populated, which can typically result in reduced carbon dioxide levels. Carbon dioxide levels would be expected to be higher with full occupancy.

Mechanical ventilation to all rooms is provided by nine air-handling units (AHUs) with heat exchangers that are located in closets on the 3rd floor (Picture 1). Each heat exchanger introduces fresh air supplied by the AHUs via ceiling-mounted air diffusers ducted to various classrooms (Picture 2). Exhaust air is drawn through ceiling mounted vents and ducted back to the AHUs (Picture 3). Both supply and exhaust systems were functioning at the time of assessment. In some classrooms, the exhaust vents were located near hallway doors (Picture 4). When a classroom door is open in these areas, exhaust vents will draw air from both the hallway and the classroom. The open door reduces the effectiveness of the exhaust vent to remove stale air from classrooms.

Fan coil units (FCU) in each classroom facilitate airflow and provide temperature control (Picture 5). FCUs do not provide fresh air to rooms; rather, they re-circulate air and provide auxiliary heating and cooling as needed. A FCU draws air from the room through an intake located at the base of the unit. Air is filtered and conditioned by a coil, then distributed back to the room through an air diffuser atop the unit (Figure 1). Each FCU is controlled by a switch with settings for "low", "medium", "high", and "off" (Picture 6). Filters for a number of FCUs were occluded with dust (Picture 7); many filters were also falling out from the bottom of FCUs due to missing/damaged brackets (Picture 8). Filters that cannot be placed into brackets cannot provide adequate filtration. In a number of areas, FCUs were found deactivated and/or obstructed by furniture, books and other stored materials (Picture 9). In order for FCUs to facilitate airflow as designed, air diffusers and return vents must remain free of obstructions. Importantly, these units must remain "on" and be allowed to operate while rooms are occupied.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows

(SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 ppm. Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, consult Appendix A.

Temperature measurements in the school ranged from 68^{o} F to 74^{o} F during the December 11, 2008 visit, which were within or close to the lower end of the MDPH recommended comfort range (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

A lack of temperature control in the building was expressed by a number of AES staff. The excess heat or cold complaints can be attributed to the following conditions:

- The building's location in a thickly settled neighborhood subjects it to uneven heating. The majority of the classrooms contain exterior walls and windows, which are shadowed by triple-decker homes that surround the building (Map 1). The shade reduces the amount of solar heat that would warm exterior walls and windows in some areas.
- The window system configuration makes the building highly susceptible to uneven heating. The window system of the building consists of a single pane of glass installed inside a metal frame. When exposed to direct sunlight, the glass and metal of the windows become a significant source of heat. BEH staff measured the temperature of window glass in classrooms throughout the building on January 21, 2009 (Table 2). Window glass and frames of the AES were in direct sunlight, partial sunlight or in shade. Window frame temperature measured in a range from 0^{o}F to 103^{o}F, while the outdoor temperature was 25°F (Table 2). Windows on the south exterior walls in direct sunlight had the highest temperature readings; whereas, windows on north and west facing exterior walls had the lowest temperatures. The difference in temperature indicates that the windows are not energy efficient and can serve as thermal bridges[1]. Where a thermal bridge exists, condensation[2] is likely to form on the warm side of the cold object which can moisten materials, such as wooden window sills. This repeated exposure to

[1] A thermal bridge is an object (usually metallic) in a wall space through which heat is transferred at a greater rate than materials surrounding it. During the heating season, the window comes in contact with heated air from the interior and chilled air from the outdoors, resulting in condensation formation if the windows temperature is below the dew point.

[2] Condensation is the collection of moisture on a surface with a temperature below the dew point. The dew point is a temperature determined by air temperature and relative humidity. For example, at a temperature of 73^{o} F and relative humidity of 57 percent indoors, the dew point for water to collect on a surface is approximately 57^{o} F (IICRC, 2000).

moisture/condensation can lead to mold growth and wood rot as seen on some sills on the 3rd floor.

- Temperature in all of Boston's public schools is controlled by a central computer system located off-site at the school department's facility maintenance office. The temperature in all schools is preset to 68° F; therefore, the HVAC system at the AES would be expected to maintain a room temperature of 68° F. If the exterior walls of the building were properly insulated, the temperature of the interior side of exterior walls would be roughly equal to 68° F. The temperature of the doorframe around exterior doors for ground floor classrooms ranged from 0° F to 26° F (Table 2). Given proper insulation, all walls for interior classrooms (i.e., classrooms in the center of the building) would be expected to have a temperature equal to 68° F. The temperature for classroom hallway walls ranged from 37° F to 69° F, and those of interior walls separating classroom ranged from 35° F to 67° F (Table 2). These temperatures suggest the exterior walls of the AES have minimal or non-existent insulation to prevent heat loss.
- Each room contains a FCU. The pipes that provide heat for the coils are more typically installed along the length of the exterior wall, parallel to the floor to maintain heat in the classrooms. The FCU heating pipes at the AES were installed perpendicular to the floor, running from the FCU into the ceiling (Pictures 10 and 11). In this configuration, classroom exterior walls are heated during the winter, which can contribute to condensation generation on windows. Chilling of walls during the summer can also contribute to condensation generation.

- Insulation in the FCU cabinets is minimal and in disrepair (Pictures 12 and 13). It is likely that the heated air provided by FCUs is chilled rapidly, since the FCUs are installed on exterior walls with minimal or no insulation.

These aforementioned conditions can contribute to the wide range of cold temperature complaints in the winter. During summer months, the converse would be true in that the AES would be difficult to cool due to solar gain of the exterior walls and window systems from radiant sunlight. In addition, it is difficult to control temperature and maintain comfort without operating ventilation equipment as designed (e.g., FCUs obstructed/deactivated).

As previously discussed, the HVAC system at the AES is designed to use heat exchangers to optimize energy efficiency by transferring heat (Picture 14). However, the savings are minimized due to the cost of heating/cooling a building that does not appear to possess an energy efficient structure and window system.

The relative humidity measured in the building on December 11, 2008 ranged from 12 to 25 percent, which was below the MDPH recommended comfort range in all areas surveyed at the time of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity would be expected to drop below comfort levels during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. "Extremely low (below 20%) relative humidity may be associated with eye irritation [and]…may affect the mucous membranes of individuals with bronchial constriction, rhinitis, or cold and influenza related symptoms" (Arundel et al., 1986). Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

BEH staff examined building components and materials for water damage and/or microbial growth. Under certain conditions (i.e., temperature, humidity/moisture) mold and microbes can grow rapidly on available nutrients (i.e., organic matter). Therefore, in order to control mold growth, it is necessary to identify and eliminate water moistening building components and materials.

FCU cabinets appeared to be rusting and degrading (Picture 15), indicating frequent exposure to moisture. During the July 14, 2008 assessment, BEH staff observed condensation collected on the surfaces of a number of FCUs in classrooms (Picture 16), which can damage the exterior of the cabinet. Condensation generated on the surface can indicate that the FCU is operating at a temperature below the dew point. Raising the FCU temperature would reduce condensation generated on the FCU surface.

The floor below FCUs located in the stairwells appeared to have water staining, indicating that water had pooled on the floor as a result of condensation generated during hot, humid weather (Picture 17). As previously discussed, insulation within the FCUs was observed to be damaged and deteriorated, which can result in the formation of condensation within the units. This can result in damage to the interior of the FCU cabinet.

As discussed, condensation is the collection of moisture on a surface with a temperature below the dew point. The dew point is a temperature determined by air temperature and relative humidity. The dew points in various locations within the AES were in a range of 59^{o} F to 69^{o} F (Table 3). Therefore, any surface that had a temperature below this range would be prone to condensation generation under the temperature and relative humidity conditions at the time of the assessment. Condensation generated on the housing unit and within the FCU can result in damage and deterioration of the unit and its components (i.e., insulation, piping, metal housing). Opening windows while the FCU is operating in cooling mode is also discouraged, as condensation can also be generated on building materials (i.e., walls, floors, windows). Accumulated debris within the FCU can become moistened over time, resulting in mold growth and related odors.

Several AES employees reported to BEH staff that musty odors emanated from the FCUs when the units were activated. BEH staff found accumulated debris in drip pans, which serves as a source of microbial growth and suggests that the units are not routinely cleaned (Pictures 18 and 19). When a FCU operates in the cooling mode, drip pans collect and drain the condensation that accumulates on the coils. A drip pan below the coils directs water through a drain pipe to an auxiliary drain pan (Picture 19). Over time, drip pans can collect debris. Lack of/or damaged insulation in turn, causes condensation, which has resulted in moistening and rusting of the cabinet interior. Drip pans should be cleaned regularly to prevent accumulation of debris and ensure proper drainage; they should also be properly insulated. This type of on-going maintenance serves to prevent deterioration and ensure integrity of the drainage system.

The building's exterior wall consists of metal window frames with stone panels secured to a steel frame. A space was observed between the window frames and panel joints where water can collect (Picture 20). Over time, water pooling in these joints have corroded the window frames, evident by water staining below the windows (Pictures 21 and 22). In some areas, the window frame exterior appeared damaged, allowing moisture-laden air to move into the building and further contributing to water penetration (Picture 23). Water intrusion through the building exterior coupled with the aforementioned condensation produced as a result of the window configuration (i.e., single-pane glass framed in metal) has resulted in the deterioration of the window system. As discussed previously, wooden window sills showed signs of rot due to chronic exposure to moisture. Where wooden window sills have been removed, spaces could be observed in the window’s metal frame, window glass was cracked/broken, and caulking was missing/damaged (Pictures 24 and 25); these conditions can be attributed to water penetration to the building as well as creating another pathway for water to enter the building. During the December 11, 2008 assessment, precipitation was observed to be penetrating into the building through window frames.

Furthermore, under certain weather conditions (i.e., wind-driven rain), water can penetrate through the panel joints into the building. Ceiling tiles along the exterior wall were water damaged (Picture 26), and walls along the exterior exhibited water staining and efflorescence (Pictures 26 to 28). Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar, brick or plaster, water-soluble compounds dissolve, creating a solution. As the solution moves to the surface of the material, the water evaporates, leaving behind white, powdery mineral deposits. Such water related damage was observed primarily in west-facing classrooms (i.e., kindergarten areas).

During the July 14, 2008 assessment, BEH staff observed a number of water stained and displaced floor tiles in first floor kindergarten classrooms (Pictures 29), located at the western side of the building. Standing water was observed in one classroom (Picture 30). Water is often reported to appear around floor plugs in this area (Picture 31), suggesting that this area may have a high water table. Along the exterior, water staining around the building apron indicates that water may be pooling against this side of the building (Picture 32). Since this portion of the building resides on a cement slab foundation, it is likely that water pooling against the building filtrates through the slab and ultimately enters the classrooms.

Water-damaged/missing ceiling tiles were observed throughout the school, indicating leaks from either the roof or the plumbing system. Water-damaged ceiling tiles can provide a source for mold growth and should be replaced after a water leak is discovered and repaired. According to school officials, there was a supply pipe leak in 2003. The pipe was reportedly repaired, and no further leaks from the pipe were reported. Sporadic roof leaks, as evidenced by water-damaged ceiling tiles, occur particularly on the third floor in both A and C wings.

An examination of the roof conducted on April 22, 2009 revealed pooling water in a number of areas, including areas around clogged roof drains (Picture 33) and areas lacking drainage, especially near the sloped roofs of stairwells (Picture 34). Where water was pooling at the base of the sloped stairwell roofs, BEH staff observed peeling paint, efflorescence, and cracks to ceiling and wall plaster in stairwells within the building (Picture 35). Accumulated dirt/debris on the roof (Picture 36) has also resulted in plant growth. It appears that attempts have been made to reseal/tape holes/tears to the roof; however, some roof patches did not appear to be adhering (Picture 37). Freezing and thawing of pooling water during winter months can further damage the roof, causing leaks and subsequent water penetration to the interior of the building. Pooling water can also become stagnant, which can lead to mold and bacterial growth or serve as a breeding ground for mosquitoes.

Open seams between sink countertops and walls were observed in several rooms (Picture 38). If not watertight, water can penetrate through the seam, causing water damage. Improper drainage or sink overflow can lead to water penetration into the countertop, cabinet interior and areas behind cabinets. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage. Repeated moistening of porous materials can result in mold growth.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed/discarded.

A humidifier was observed in one classroom. If not properly maintained, the water reservoir can provide a source for mold growth. Once activated, a humidifier can aerosolize particles and odors. The water reservoir for the humidifier should be cleaned as per manufacturer's directions to prevent microbial growth and odors. In addition, the air diffuser should also be cleaned periodically to prevent dust collection and aerosolization of materials.

A dehumidifier was observed in classroom 101 (Picture 39). The occupant and/or maintenance staff should periodically examine, clean, and disinfect the unit as per the manufacturer's instructions to prevent mold/bacterial growth and associated odors, especially in the dehumidifier's condensation collection bucket. This dehumidifier was found operating with the classroom window *open*. Dehumidifiers should not be operating with the windows open since the moisture would be drawn *into* the classroom from the outdoors. Having windows open defeats the purpose of removing moisture from the room.

Several classrooms had a number of plants. Moistened plant soil and drip pans can be a source of mold growth. Plants should be equipped with drip pans; the lack of drip pans can lead to water pooling and mold growth on windowsills. Plants are also a source of pollen. Plants should be located away from the air stream of ventilation sources to prevent the aerosolization of mold, pollen or particulate matter throughout the classroom.

A classroom aquarium appeared green with algae growth (Picture 40). Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors. Similarly, terrariums should be properly maintained to ensure soil does not become a source for mold growth.

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 and acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEH staff obtained measurements for carbon monoxide and PM2.5.

Carbon Monoxide

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. An operator of an indoor ice must take actions to reduce carbon monoxide levels, if those levels exceed 30 ppm, 20 minutes after resurfacing within a rink (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2006). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2006).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations on December 11, 2008 were non-detect (ND) (Table 1). Carbon monoxide levels measured in the school were also ND at the time of the assessment.

Particulate Matter (PM2.5)

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

The outdoor PM2.5 concentration on December 11, 2008 was 17 μg/m^3. PM2.5 levels measured inside the school ranged from 7 to 15 μg/m^3 (Table 1). Both indoor and outdoor PM2.5 levels 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 mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Tobacco smoke odors were detected in the smaller cafeteria at the time of the December 2008 assessment. M.G.L. Chapter 270, Section 22 prohibits smoking in public buildings (M.G.L., 2004). BEH staff did not observe smoking or evidence of smoking within the building.

Volatile Organic Compounds (VOCs)

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 staff examined classrooms for products containing these respiratory irritants.

Air deodorizing sprays and plug-in deodorizers were observed in a number of classrooms throughout the AES. Air deodorizers contain chemicals that can be irritating to the eyes, nose and throats 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.

Many classrooms contained dry erase boards and related materials. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (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 on countertops and in unlocked cabinets beneath sinks in a number of classrooms. Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat and should be kept of out reach of children. Unlabeled/poorly labeled spray bottles were also noted in several classrooms throughout the building. Products should be kept in their original containers, or should be clearly labeled as to their contents, for identification purposes in the event of an emergency. Further, material safety data sheets (MSDS) for all cleaning products must be available at a central location in the building. Consideration should be given to providing teaching staff with school issued cleaning products and supplies to prevent any potential for adverse chemical interactions between residues left from cleaners used by the schools facilities staff and those left by cleaners brought in by others.

Other Conditions

Other conditions that can affect indoor air quality were observed during the assessment. Different types of air purifying equipment were observed in the AES. An air purifier with an ionizer was observed in classroom 101; this air purifier also had a filtration system, but does not use HEPA filters (Picture 41). An air ionizer is designed to release negatively charged ions to attract positively charged particles, such as dust, pollen, smoke (Hunter Fan Company, 2006; Appendix B). While air ionizers are not designed to emit ozone, it does emit low levels of ozone as a by-product. Caution should be used when operating such equipment. Ozone is a highly irritating substance to the respiratory system. The efficacy of ozone as an indoor air cleaner has been examined by the US EPA. The EPA has concluded "available scientific evidence shows that, at concentrations that do not exceed public health standards, ozone is generally ineffective in controlling indoor pollution" (US EPA, 2009). If use of an air purifier is desired, consideration should be given to using one that is equipped with a high efficiency particulate air (HEPA) filter, similar to the one observed classroom 105 (Picture 42; Appendix C). Air purifiers should be placed within the breathing zone rather than at floor level. In addition, filters for HEPA air purifiers should be cleaned or changed as per manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

Exposed and/or damaged fiberglass insulation was observed around pipes in the gym (Picture 43), as well as around duct work in the AHU room and the aforementioned FCUs. Exposed fiberglass insulation can provide a source of eye, skin and respiratory irritation. Damaged insulation should be repaired to prevent aerosolization.

A number of exhaust/return vents, air diffusers and personal fans were observed to have accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles. Re-activated supply vents and fans can also aerosolize dust accumulated on vents/fan blades.

In several classrooms, items were observed on the floor, windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

Accumulation of chalk dust, pencil shavings and dry erase particulate was observed in several classrooms. When windows are opened or FCUs are operating, these materials can become airborne. Once aerosolized, they can act as irritants to the eyes and respiratory system.

One classroom contained upholstered furniture and pillows. These items are covered with fabric that comes in contact with human skin, which can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. Furthermore, increased relative humidity levels above 60 percent can also perpetuate dust mite proliferation (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, 1994). It is also recommended that if upholstered furniture is present in schools, it should be professionally cleaned on an annual basis or every six months if dusty conditions exist (IICRC, 2000).

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 44). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g. spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix D (NIOSH, 1998).

BEH staff received a number of reports of rodent infestation in the building. Rodents can be a source of disease and infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine and feces contain a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms (e.g. rhinitis and skin rashes) in sensitive individuals. A three-step approach is necessary to eliminate rodent infestation:

1. removal of the rodents;
2. cleaning of waste products from the interior of the building; and
3. reduction/elimination of pathways/food sources that are attracting rodents such as toasters/toaster ovens in classrooms.

The cafeteria area is located on the ground floor of the AES, in the southwest corner. Rodents were reported to be in classrooms from the first to third floors of the northeast side of the building. The likely reason for mice to be in sections of the building other than the cafeteria is the ready availability of food sources that will attract rodents. BEH staff observed food products being used for art projects, which can serve as a pest attractant. The following examples of rodent attractors in non-cafeteria areas were observed:

- During the December 2008 visit, one classroom floor had sufficient enough paper mâché residue on its floor to cause the BEH staff member's feet to stick to the floor while examining the room. A major component of paper mâché is flour, which is derived from wheat, which is a significant attractant for rodents.
- Food was stored in classrooms.
- The faculty staff room contains food preparation equipment which does not appear to be cleaned on a regular basis.
- Multiple bait traps were found inside one HVAC mechanical room as part of an effort to address building occupant concerns about rodents (Picture 45). The bait traps will serve as a rodent attractant to the HVAC mechanical room closet.

In order to prevent/reduce rodent infestation in classrooms, a concerted effort by school staff must be undertaken to the proper handling of food in classrooms. According to the Integrated Pesticide Management Guide, the following steps can be taken to reduce attractions for pests.

- Don't keep open, unsealed foods in desks, file cabinets, or lockers. If you need to keep food, keep it in tightly sealed plastic containers. Thin plastic bags will not keep a hungry mouse or roach from sharing your lunch.
- Clean up any crumbs or drinks that might spill. A few crumbs under a desk can support a lot of roaches.
- It's best if everyone eats in a central area. If people do eat at their desks, be tidy. If possible, provide one central wastebasket with a tight fitting lid where all food and drink containers can be disposed of. Pour liquids down sinks before throwing away cups. Wrap up any crumbs in wrappers tightly before discarding.

- If you must eat at your desk, discard unfinished foods and scraps (including food wrappers) by wrapping them tightly and placing in the rubbish container.
- Some water coolers have a catch basin for spilled water. Make sure this is emptied at the end of every work day. (MDFA, Unknown)

In addition, use of food products as art/project components and reuse of food containers is discouraged, as these can serve as pest attractants. Reused food containers can contain enough food residues to attract pests and should not be used in classrooms, particularly in a building with a documented rodent problem.

Complaints were reported concerning the noise in the gymnasium that is created by the HVAC system. The AHU is hung from the ceiling of the gymnasium. The AHU and its ductwork are not externally insulated. BEH staff also determined that ductwork does not appear to be internally insulated. In this configuration, the HVAC system ductwork act amplifies noise from the AHU fan and motors. Insulation on the ductwork would dampen the vibrations and reduce noise.

Health Concerns

As mentioned, the Bureau of Environmental Health (BEH) received reports of health concerns at the AES. To address these concerns, environmental analyst and risk communication specialists from BEH's Community Assessment Program (CAP) individually interviewed those school employees who wished to share their health concerns during the time of the December 11, 2008 and January 21, 2009 inspections. Individually-identifying information shared by employees is confidential, under both state and federal regulations, and will therefore not be reported in this or any other public report. Aggregated data describing the results of the interviews are summarized below.

In all, 15 AES employees agreed to be interviewed. Each interview lasted no longer than 20 minutes. The data were reviewed to identify the types of symptoms reported, their frequency of occurrence, and whether any unusual patterns emerged that might suggest an association with environmental conditions at the AES. For analytic purposes, responses were also grouped by respiratory symptoms, allergic response, and central nervous system (CNS) effects. Respiratory symptoms included: sore or dry throat, stuffy or runny nose, sinus congestion, and other miscellaneous types of symptoms associated with the respiratory tract. Allergic response included irritation and itchiness as well as reported exacerbation of allergies. Finally, CNS effects included: headache, dizziness or lightheadedness, difficulty remembering things, or unusual tiredness or fatigue.

Interview Results

Health Effects

Eleven of the 15 individuals interviewed reported experiencing at least one CNS symptom. The predominant symptom in this category was headaches. Similarly, eleven of the 15 individuals reported experiencing at least one respiratory effect. The predominant symptoms in this category were sinus congestion/infection and colds. Four of these eleven individuals reported cough or bronchitis, shortness of breath, or asthma. Ten individuals reported having allergies or allergy-like health effects, such as eye irritation and itchiness with two of them reporting that their symptoms improved when they left the building.

General Indoor Air Quality

Several individuals interviewed reported specific indoor environmental concerns including:

- variation in temperature (some individuals reported the building being too hot while others reported it being too cold)
- variation in humidity (some individuals reported that the air is too dry while others reported that it is too moist)
- water damage
- poor ventilation
- mold
- pests
- dust
- general building deterioration

Medical Record Reviews

CAP staff offered each of the AES employees who were interviewed the opportunity to have their medical records reviewed by a MDPH BEH physician. The purpose of the medical record review was to identify any reported symptoms or conditions that could be associated with poor indoor air quality as well as to confirm symptoms or diagnoses that may have been reported in the surveys. Special attention was given during the medical record reviews to diagnoses and complaints of the respiratory system and those reflecting possible allergic symptoms; higher levels of exposure to allergens and respiratory irritants could result in syndromes of eye and respiratory irritation and possible allergic symptoms.

Of the 15 employees interviewed, five consented to have their medical records reviewed and returned signed medical record release consent forms. Medical records were requested from physicians reported to MDPH by AES employees and were reviewed by BEH's physician.

Despite repeated requests, MDPH staff were not able to obtain one set of medical records for one individual.

According to BEH's physician, several of the IAQ conditions observed may contribute to eye or respiratory irritation; these include low levels of humidity, the presence of particulates, VOCs and dust, and conditions conducive to attracting rodents. The five cases reviewed show one commonality, rhinosinusitis (a condition involving inflammation in one or more of the paranasal sinuses) symptoms. Typically, rhinosinusitis is the result of irritation, allergic reaction, or infection.

Discussion

The symptoms reported among participants of this health investigation are generally those most commonly experienced in buildings with less than optimal indoor air quality. The symptoms most frequently reported by individuals at the AES were respiratory/irritant effects including allergies, headaches, sinus congestion or sore, hoarse or dry throat as well as headaches. These symptoms are commonly associated with ventilation problems in buildings, although other factors (e.g., odors, microbiological contamination) may also contribute (Stolwijk et al. 1991; Burr et al. 1996; Nordstrom et al. 1995).

Ten of the 15 individuals surveyed reported having allergies. The onset of allergic reactions to mold/moisture can be either immediate or delayed. Allergic responses include hay fever-type symptoms such as runny nose and red/irritated eyes. Exposure to mold/moisture can exacerbate pre-existing symptoms.

More than 30 million people in the United States likely have sinus disease. Symptoms may be exacerbated by allergic, viral, bacterial, or environmental conditions. In the context of the IAQ findings, it is possible that the dry air, the presence of dust, and moisture/mold in some areas may be exacerbating the symptoms in these patients.

Conclusions/Recommendations

The conditions at the AES present a number of complex issues. It appears that the building was intended to be an energy efficient building when constructed in 1973, as evidenced by the use of heat exchangers for the fresh air supply. However, the construction of the building does not retain heat readily, as demonstrated by the temperature assessment of the walls and window frames. In addition, the configuration of FCU hot water pipes as well as the size, the condition/lack of insulation, and location of the FCUs all play a role in the lack of temperature control in the AES. A long-term solution would involve replacement of windows, repair of leaks in the building envelope, and installation of gypsum wallboard with insulation. If this option were to be pursued, separation of all interior walls from the exterior walls would have to occur to break the temperature bridge that is chilling the interior walls. This recommendation assumes that no insulation exists within the exterior walls.

In order to address the conditions listed in this assessment, the recommendations made to improve indoor air quality are divided into **short-term** and **long-term** corrective measures. The **short-term** recommendations can be implemented as soon as possible. **Long-term** solutions are more complex and will require planning and resources to adequately address overall indoor air quality concerns. In view of the findings at the time of the visit, the following recommendations are made:

Short Term Recommendations

1. Remove/replace original, water-damaged wood sills from the base of all windows if wood is water stained or materially degrading.
2. Operate both supply and exhaust ventilation continuously during periods of school occupancy to maximize air exchange.
3. Clean accumulated debris from FCU drip pans on a regular schedule.
4. Install filter racks on FCUs to hold filters in place.
5. Remove obstructions from FCU air intakes and diffusers.
6. Operate FCUs during periods of school occupancy to facilitate airflow in classrooms.
7. Close classroom doors to maximize air exchange.
8. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
9. Remove rodent bait traps from HVAC system mechanical rooms.
10. Use the principles of integrated pest management (IPM) to rid this building of pest. Activities that can be used to eliminate pest infestation may include the following activities.
    - a) Refrain from using recycled food containers. Seal recycled containers in a tight fitting lid to prevent rodent access.
    - b) Ensure that areas where paper mache is practiced are thoroughly cleaned after such activities.
    - c) Remove non-food items that rodents are consuming.
    - d) Store foods in tight fitting containers.

e) Avoid eating at workstations. In areas were food is consumed, periodic vacuuming to remove crumbs is recommended.

f) Regularly clean crumbs and other food residues from toasters, toaster ovens, microwave ovens coffee pots and other food preparation equipment.

g) Examine each room and the exterior walls of the building for means of rodent egress and seal appropriately. Holes as small as ¼" is enough space for rodents to enter an area. If doors do not seal at the bottom, install a weather strip as a barrier to rodents.

h) Reduce harborages (cardboard boxes) where rodent may reside.

A copy of the IPM Guide can be obtained at the following Internet address: http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf. For additional advice regarding pest control contact the Massachusetts Department of Agricultural Resources, Pesticide/School IPM Program at (617) 626-1700 http://www.mass.gov/agr/

11. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. 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).

12. Change filters for air-handling equipment (e.g., AHUs, FCUs and air purifiers) as per the manufacturer's instructions or more frequently if needed. 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.

13. Ensure leaks are repaired. Remove/replace water damaged ceiling tiles. Examine the areas above and around for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

14. Remove dirt/debris from roof/drains to ensure proper drainage and to prevent plant growth. Consider methods to prevent water from pooling at the base of the sloped stairwell roof.

15. Consider regrading the apron of the building to prevent water pooling/penetration through the building's foundation and slab.

16. Move plants away from FCUs in classrooms. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.

17. Keep windows closed during hot, humid weather to maintain indoor temperatures and to avoid condensation problems when air conditioning is activated.

18. Clean and maintain humidifiers and dehumidifiers as per the manufacturer's instructions.

19. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect wallboard for water damage and mold growth, repair/replace as necessary. Disinfect areas with an appropriate antimicrobial, as needed. Consider replacing with single piece molded countertops.

20. Refrain from using plug-in air fresheners or other air deodorizers.

21. Clean and maintain aquariums and terrariums to prevent mold growth and associated odors.

22. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled. *All* cleaning products used at the facility should be approved by the school department with MSDS' available at a central location.

23. 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.

24. Clean personal fans/heaters, air diffusers, return vents and exhaust vents periodically of accumulated dust.

25. Clean chalk and dry erase trays to prevent accumulation of materials.

26. Clean upholstered furniture and pillows on the schedule recommended in this report. If not possible/practical, consider removal from classrooms.

27. Replace latex-based tennis balls with latex-free tennis balls or alternative "glides".

28. Consider adopting the US EPA document, "Tools for Schools", to maintain a good indoor air quality environment in the building (US EPA, 2000). This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.

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

Long Term Recommendations

1. Consider plans for evaluating FCUs to ascertain whether this HVAC system component can be repaired to prevent condensation generation. If not repairable, consideration should be given to replacing FCUs.
2. Consider plans for repairing the roof and installing additional drainage.
3. Consider having a building engineer evaluate the building envelope in order to ascertain whether the exterior wall of classrooms can be improved to prevent thermal bridges and more controlled heating and cooling of the AES. Activities to consider include, but are not limited to the following:
    a. Installing an interior wall with insulation over the existing classroom exterior walls. Ensure proper integration with the new window systems planned for installation in 2009. It may also include separation of interior walls from the exterior walls to disrupt the likely temperature bridge that exists.
4. Consider having a ventilation engineer examine the existing heat exchange system for adequacy of design.
5. Consider having exterior walls re-pointed and waterproofed to prevent water intrusion. This measure should include a full building envelope evaluation.
6. Examine the feasibility of insulating the FCUs and duct work in the gymnasium to reduce noise.
7. Consider plans for having an energy audit conducted.

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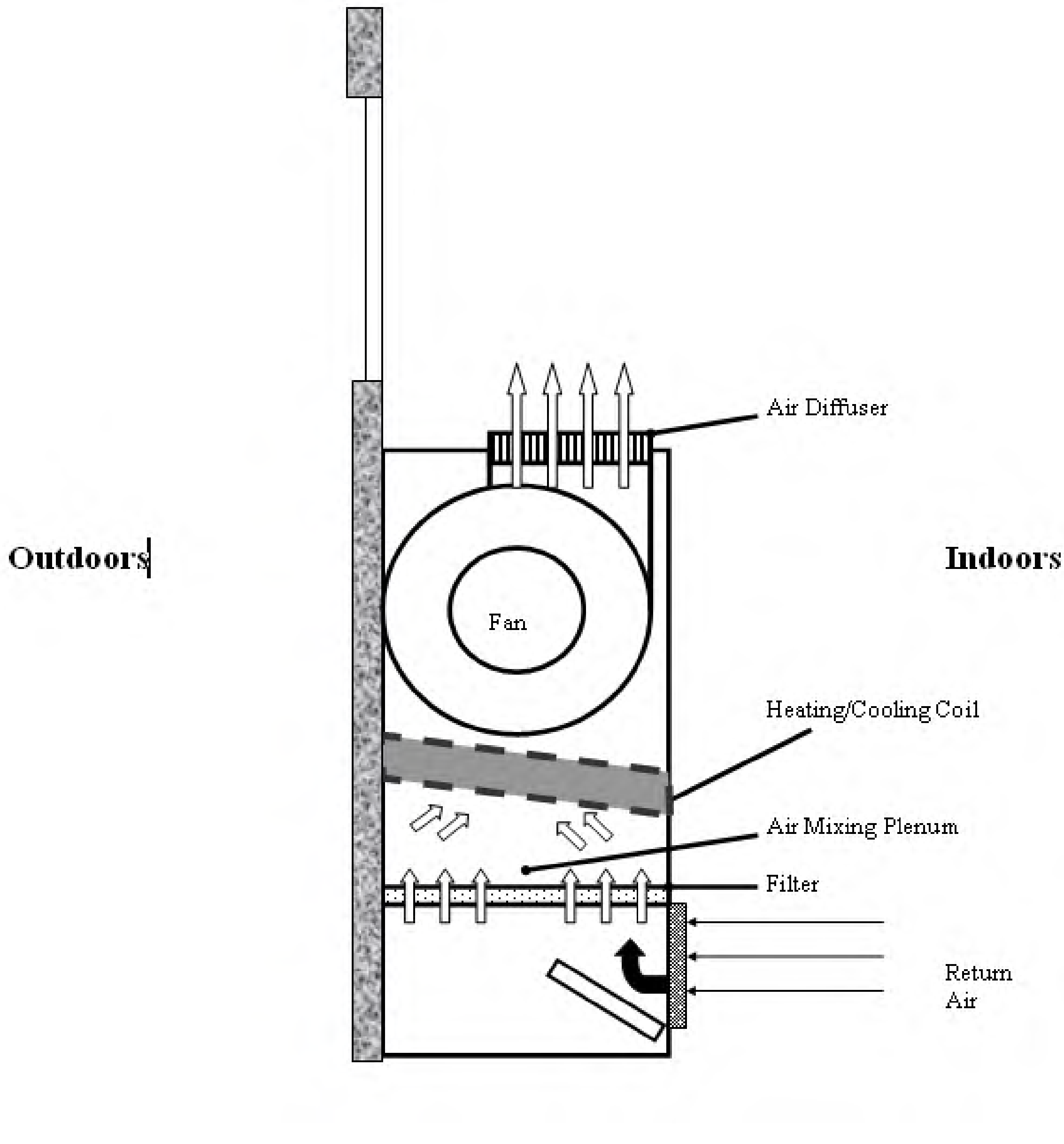
Figure 1



Fan Coil Unit (FCU)

Map 1

Aerial view of Agassiz Elementary School, note homes and trees on the west side of the building and open field to the east of the building

Picture 1

Heat exchanger

Picture 2

Classroom supply vent

Picture 3

Classroom exhaust vent

Picture 4

Classroom exhaust vent near door

Picture 5

Classroom FCU

Picture 6

FCU settings

Picture 7

Occluded filter, note that filter is sitting in FCU and off floor

Picture 8

Filter sitting on floor due to missing brackets

Picture 9

Items placed in front of FCU

Picture 10

Supply and return heating system pipes connected from FCU to ceiling instead of along walls

Picture 11

Example of typical univent supply and return heating system pipes configured to provide heat for windows and walls, note radiator register flanking the univent
(Granville Village School, Granville, MA)

Picture 12

FCU insulation losing adherence to surfaces, resulting in condensation

Picture 13

Damaged FCU insulation

Picture 14

Heat exchanger panel

Picture 15

Rusting below insulated pipes

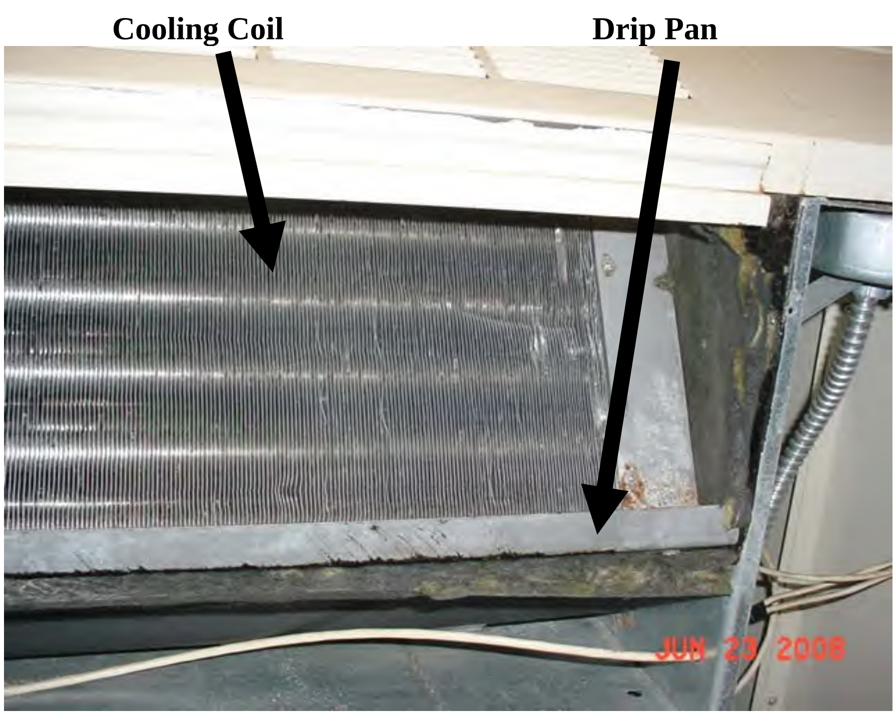
Picture 16

Condensation on surface of FCU

Picture 17

FCU in stairwell with floor stained from water leaking

Picture 18

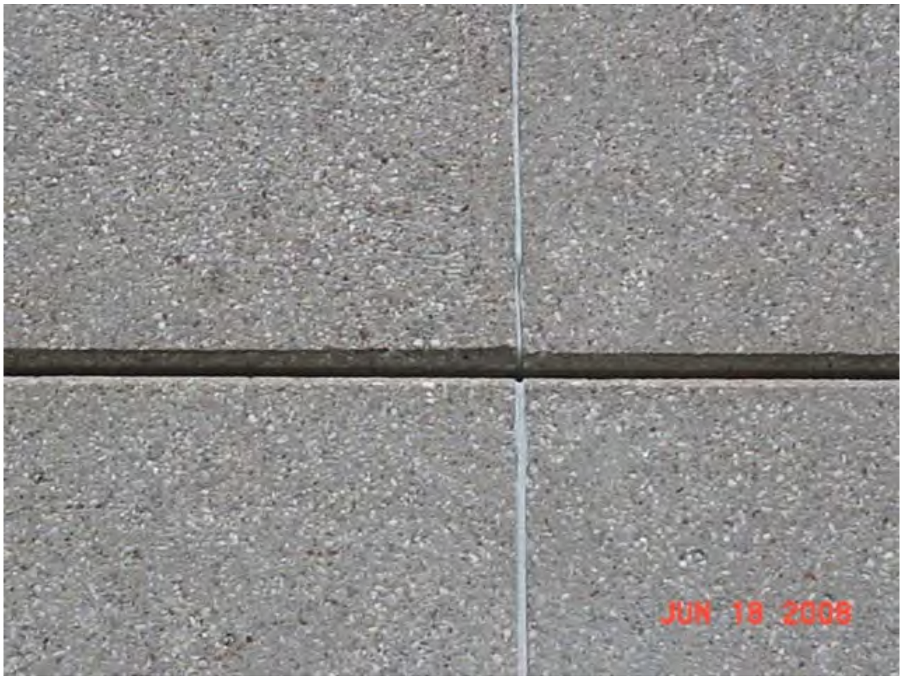


FCU cooling coil and debris in drip pan

Picture 19

Auxiliary drain pan, note debris in pan, lack of insulation on copper drain pipe elbow, rust on cabinet components and water staining on floor of cabinet

Picture 20



Spaces between stone panels

Picture 21

Water damaged stained window frame wood

Picture 22

Staining from rainwater, note damaged window frames

Picture 23

Damaged window frame

Picture 24

Breach in window frame where wooden sill was removed

Picture 25

Hole in window frame, broken glass, water penetration

Picture 26

Water damaged ceiling tile and water staining of wall

Picture 27

Water drip stains down wall

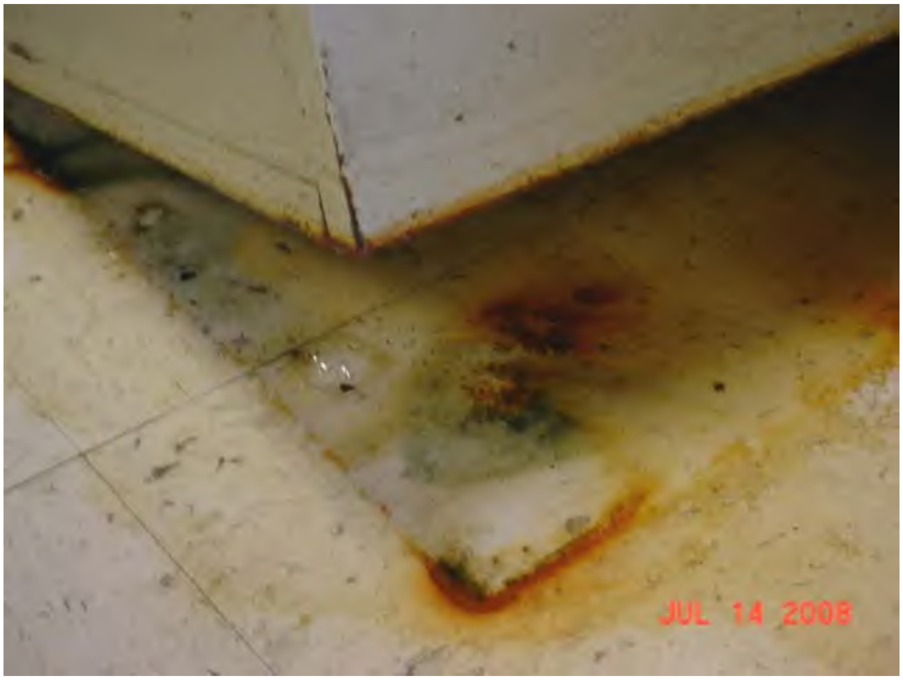
Picture 28

Efflorescence and peeling paint

Picture 29

Stained/lifting floor tiles

Picture 30



Standing water on floor beneath filing cabinet

Picture 31

Plug in floor, note staining indicating water leakage

Picture 32

Signs of water pooling against the building

Picture 33

Clogged roof drain

Picture 34

Accumulated water on roof below slope

Picture 35

Efflorescence around Plaster Patch, corresponds to pooling water noted in Picture 34

Picture 36

Accumulated materials on roof, note plant growth

Picture 37

Lifted repair sections on roof

Picture 38

Example of open seam between sink countertops and walls

Picture 39

Dehumidifier operating with the window open

Picture 40

Aquarium appearing green with growth

Picture 41

Air purifier with ionizer

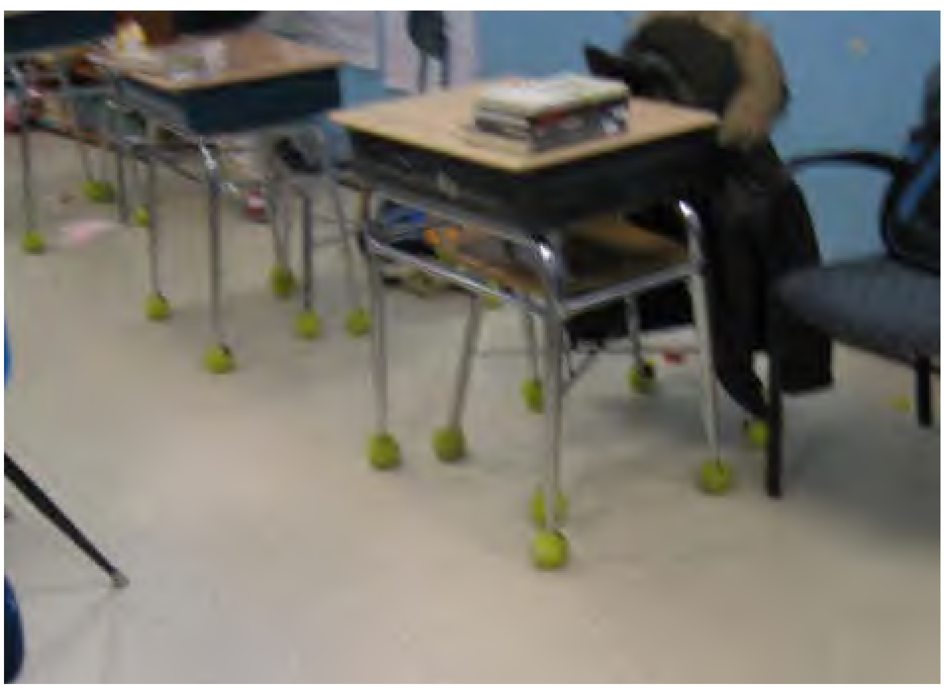
Picture 42

Air purifier using HEPA filter with no ionizer

Picture 43

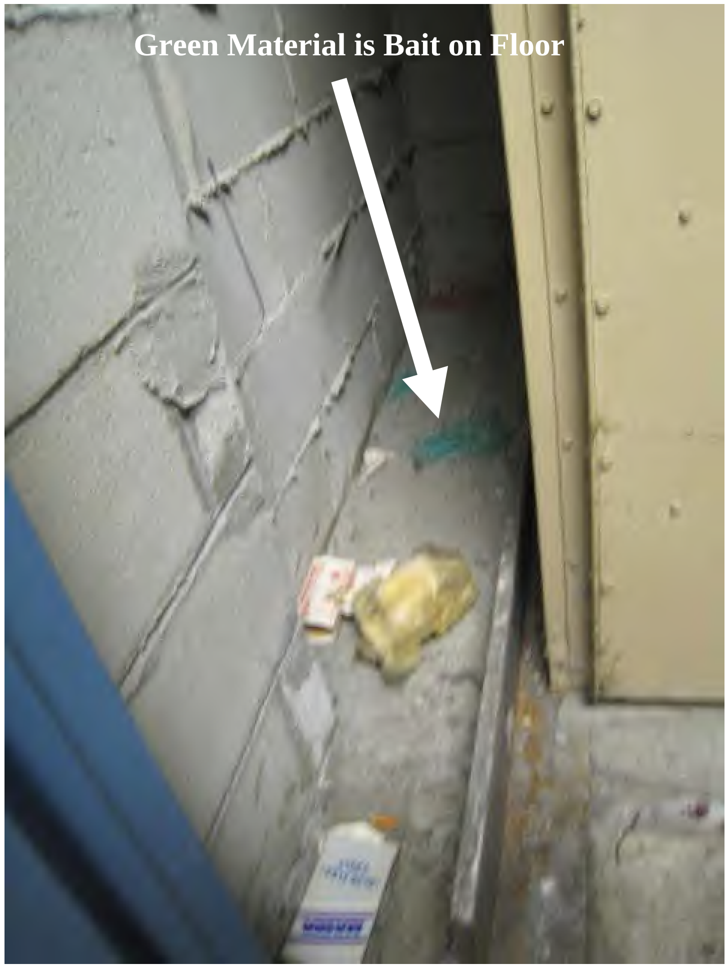
Exposed fiberglass insulation

Picture 44



Tennis Balls on Chair Legs

Picture 45



Bait traps in AHU room

Location: Agassiz Elementary School

Address: 20 Child Street, Jamaica Plain, Boston, MA

Table 1

Indoor Air Results

Date: 12/11/2008

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
background			100	398	ND	17				
Assistant principal	1	73	29	529	ND	8	Y	Y	Y	Supply off, exhaust off
Auditorium	42 0	74	28	375	ND	8	N	Y	Y	WD-CT
Basement copy room	0	73	30	473	ND	9	N	Y	Y	PC, DO
Cafeteria (small)	20	70	37	537	ND	9	N	Y	Y	FCU on, environmental tobacco smoke odor
Cafeteria (large)	100	72	31	651	ND	9	N	Y	Y	FCU on, 5 WD-CT
Child care center	0	72	29	443	ND	9	N	Y	Y	DO, CD
Child Office	1	71	30	450	ND	9	M	Y	Y	PC, microwave, fridge
City Year office	5	73	30	524	ND	10	N	Y	Y	FCU on, CD, food storage
Gym	2	70	31	442	ND	8	N	Y	Y	Exposed fiberglass insulation

Comfort Guidelines

Location: Agassiz Elementary School

Address: 20 Child Street, Jamaica Plain, Boston, MA

Indoor Air Results

Date: 12/11/2008

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Gym office	0	72	30	455	ND	8	N	Y	Y	Plug-in AD, 5 WD-CT, DO
Health Suite 1st right	0	73	32	567	ND	9	N	Y	Y	
Libro Allegre	0	71	31	469	ND	12	N	Y	y	Humidifier
Main office	4	72	30	542	ND	10	N	Y	Y	
Main Office copy room	0	73	31	508	ND	8	N	Y	Y	FCU off, PC, DO
Main Office teacher lunch	0	73	29	427	ND	9	N	Y	Y	FCU on, PC, DO, microwave
Nurse	1	71	31	493	ND	8	Y	Y	Y	DO
Office 1	0	73	29	499	ND	9	N	Y	Y	AD, damaged floor tile
Office 2	0	73	30	448	ND	10	N	Y	Y	Plastic odor, WD-CT

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect

AD = air deodorizer
AP = air purifier
AT = ajar ceiling tile
CD = chalk dust

CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
DO = door open

FCU = fan coil unit
MT = missing ceiling tile
PC = photocopier
PF = personal fan

UF = upholstered furniture
TB = tennis balls
WD = water-damaged
WP = wall plaster

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: Agassiz Elementary School **Indoor Air Results**

Address: 20 Child Street, Jamaica Plain, Boston, MA **Table 1 (continued)** **Date: 12/11/2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Outer gym	31	72	33	717	ND	12	N	N	Y	Exhaust off
Secretary	1	73	29	490	ND	8	Y	Y	Y	Supply off, exhaust off, FCU off, DO
Special services office	1	73	31	528	ND	8	N	Y	Y	Supply off, exhaust off, DO
Speech	1	72	31	519	ND	9	N	Y	Y	Exhaust weak and dusty
Speech/ Language	1	72	32	504	ND	8	N	Y	Y	DO, exhaust dusty
Storage 2C	0	73	29	486	ND	10	N	Y	Y	Risograph, DO
101	18	68	45	1126	ND	15	Y	Y	Y	Paper mâché debris coating floor, plants, dehumidifier on, PF-dusty, AP, plug-in AD
102	3	72	30	602	ND	10	Y	Y	Y	FCU off
103	0	71	31	564	ND	11	Y	Y	Y	FCU on, items on FCU, DO

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Location: Agassiz Elementary School **Indoor Air Results**

Address: 20 Child Street, Jamaica Plain, Boston, MA **Table 1 (continued)** **Date: 12/11/2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m³)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
104	11	71	33	626	ND	10	Y	Y	Y	FCU on
105	1	72	31	539	ND	10	N	Y	Y	WD-CT, AP
106	2	71	32	577	ND	10	Y	Y	Y	Exhaust off, FCU on, FCU blocked, cleaners
107	2	71	31	479	ND	8	Y	Y	Y	FCU on, DO
108	0	71	31	526	ND	10	N	Y	Y	DO, FCU off, WD-CT, aquarium
109	1	73	32	534	ND	9	Y	Y	Y	FCU on, WD-CT, water stained WP
110C	2	71	34	615	ND	10	N	Y	Y	Items
201	19	72	33	651	ND	12	Y	Y	Y	FCU off, breaches on floor near window
202	21	72	33	941	ND	10	Y	Y	Y	FCU off, exhaust dusty

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
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AD = air deodorizer
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Address: 20 Child Street, Jamaica Plain, Boston, MA **Date: 12/11/2008**

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m³)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
203	15	71	32	413	ND	10	Y	Y	Y	FCU on, WD-window, sink counter breach, plants
204	19	72	32	632	ND	12	Y	Y	Y	FCU off, WD-window, filter out of FCU, CD
205	0	71	31	481	ND	10	Y	Y	Y	FCU on
206	6	73	30	601	ND	10	Y	Y	Y	FCU off, FCU cabinet cover not secured, TB, DEM
207	0	73	29	435	ND	8	Y	Y	Y	FCU on, DEM
208	0	73	29	415	ND	8	Y	Y	Y	FCU on, cleaners
209	5	73	30	557	ND	9	Y	Y	Y	FCU on, FCU blocked
210	1	73	29	421	ND	9	Y	Y	Y	FCU on, CD, UF, plants, terrarium
211	7	73	33	725	ND	10	Y	Y	Y	FCU on, DO

ppm = parts per million
μg/m³ = micrograms per cubic meter
ND = non detect

AD = air deodorizer
AP = air purifier
AT = ajar ceiling tile
CD = chalk dust

CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
DO = door open

FCU = fan coil unit
MT = missing ceiling tile
PC = photocopier
PF = personal fan

UF = upholstered furniture
TB = tennis balls
WD = water-damaged
WP = wall plaster

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: Agassiz Elementary School **Indoor Air Results**

Address: 20 Child Street, Jamaica Plain, Boston, MA **Table 1 (continued)** **Date: 12/11/2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
212	20	71	33	567	ND	10	Y	Y	Y	FCU on
213	0	70	32	517	ND	10	Y	Y	Y	FCU on, paper in FCU
214	0	70	32	486	ND	11	Y	Y	Y	FCU on
215	20	72	34	837	ND	11	Y	Y	Y	FCU on
216	18	72	33	737	ND	10	Y	Y	Y	FCU on, plants on FCU
217	22	73	33	714	ND	10	Y	Y	Y	FCU on, FCU blocked
219	9	72	31	591	ND	11	Y	Y	Y	FCU off, FCU blocked
301	16	71	33	600	ND	12	Y	Y	Y	FCU off, FCU blocked
302	23	71	33	597	ND	14	Y	Y	Y	FCU off, blocked, exhaust dusty

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect

AD = air deodorizer
AP = air purifier
AT = ajar ceiling tile
CD = chalk dust

CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
DO = door open

FCU = fan coil unit
MT = missing ceiling tile
PC = photocopier
PF = personal fan

UF = upholstered furniture
TB = tennis balls
WD = water-damaged
WP = wall plaster

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: Agassiz Elementary School **Indoor Air Results**

Address: 20 Child Street, Jamaica Plain, Boston, MA **Date: 12/11/2008**

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
303	13	71	32	604	ND	12	Y	Y	Y	FCU on, food storage
304	13	71	32	593	ND	10	Y	Y	Y	FCU on (noisy)
305	0	70	31	477	ND	10	Y	Y	Y	
306	0	71	34	589	ND	12	Y	Y	Y	FCU on, DEM, CD, exhaust weak
307	20	74	33	746	ND	8	Y	Y	Y	Exhaust weak, FCU off, DO, 28 computers, cleaners
308	3	71	34	628	ND	11	Y	Y	Y	Exhaust weak, FCU off, DO, DEM, cleaner, plants
310-311	19	74	32	743	ND	13	Y	Y	Y	Exhaust weak, FCU off, 26 computers
312	1	72	31	575	ND	12	Y	Y	Y	FCU on, plants, water infiltration around windows
313	1	72	31	529	ND	9	Y	Y	Y	FCU on

ppm = parts per million
µg/m^3 = micrograms per cubic meter
ND = non detect

AD = air deodorizer
AP = air purifier
AT = ajar ceiling tile
CD = chalk dust

CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
DO = door open

FCU = fan coil unit
MT = missing ceiling tile
PC = photocopier
PF = personal fan

UF = upholstered furniture
TB = tennis balls
WD = water-damaged
WP = wall plaster

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	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
314	2	71	32	581	ND	10	Y	Y	Y	FCU on
315	0	72	33	811	ND	12	Y	Y	Y	FCU on, CD
316	0	71	31	605	ND	10	Y	Y	Y	FCU on, CD
317	22	72	33	691	ND	11	Y	Y	Y	FCU on, CD
318	1	72	36	918	ND	7	N	Y	N	FCU off, DO
319	23	70	35	837	ND	12	Y	Y	Y	Exhaust weak, FCU on, water through window frame, DO
320	0	72	28	410	ND	10	N	Y	Y	Exhaust weak, FCU on, items on FCU
359	0	73	32	685	ND	11	N	Y	Y	FCU off, AD, PF, DO, DEM

ppm = parts per million
μg/m^3 = micrograms per cubic meter
ND = non detect

AD = air deodorizer
AP = air purifier
AT = ajar ceiling tile
CD = chalk dust

CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
DO = door open

FCU = fan coil unit
MT = missing ceiling tile
PC = photocopier
PF = personal fan

UF = upholstered furniture
TB = tennis balls
WD = water-damaged
WP = wall plaster

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: Agassiz Elementary School
Address: 20 Child Street, Jamaica Plain, Boston, MA

Window/Wall Temp
Date: 1/21/2009

Table 2

Location	Temperature Hallway Wall (°F)	Temperature Interior Wall (°F)	Temperature Window Frame (°F)	Temperature Wall around Window Frame (°F)	Temperature of Exterior Door Frame (°F)	Windows in Sun or Shade
Auditorium	45	40	37		0	Shade
C-125	41	40	19	30		Shade
Cafeteria 1	54	52	26	37		Shade
Cafeteria 2	38	47	16-21	53		Shade
D-125	44	42	15-19	30		Shade
Gymnasium	43	46				
H210	52	55	92	48		Sun
Library	52	53	93	47		Sun
Nurse's Office	37	35	1	21		
Principal	50	50	27-40	50		Shade
Special Services	45	47				
Speech	47	48				
Storeroom 2nd Floor	48	49				
Vice Principal	44	45	17-21	35		Shade
102	58	59	8	47		Shade
103	50	50	9	40		Shade
104	55	57	0	46		Shade
105	48	49	11	20		Shade

Table 2 (continued)

Location	Temperature Hallway Wall (°F)	Temperature Interior Wall (°F)	Temperature Window Frame (°F)	Temperature Wall around Window Frame (°F)	Temperature of Exterior Door Frame (°F)	Windows in Sun or Shade
106	48	45	0	35	0	Shade
107	67	66	25	57	25	Shade
108	56	57	32	58	26	Shade
109	56	54	9	47	2	Shade
201	43	40	19	39		Shade
202	42	42	0	39		Shade
203	38	37	0	35		Shade
204	46	46	0	43		Shade
205	52	53	6	48		Shade
206	51	50	7	41		Shade
207	51	50	11	37		Shade
208	49	49	13	45		Shade
209	57	58	34	54		Sun
211	51	54	101	48		Sun
211A	55	54				
212	46	49	30 46	47		Shade Sun
213	45	46	17	47		Shade

Table 2 (continued)

Location	Temperature Hallway Wall (°F)	Temperature Interior Wall (°F)	Temperature Window Frame (°F)	Temperature Wall around Window Frame (°F)	Temperature of Exterior Door Frame (°F)	Windows in Sun or Shade
			65			Sun
214	50	49		49		Sun
215	47	47	103	45		Sun
216	48	48	19	40		Shade
217	49	47	16	47		Shade
219	46	45	9	35		Shade
220	41	41		29		
223	48	45				
301	50	51	100	48		Sun
302	41	41		34		
303	41	39	7	23		Shade
304	51	41	7	33		Shade
305A	51	56	17	39		Shade
306	57	54	9	46		Shade
307	47	43	11	38		Shade
308	69	67	20	63		Sun
310	50	50	29	43		Shade
312	47	44	25	40		Shade

Table 2 (continued)

Location	Temperature Hallway Wall (°F)	Temperature Interior Wall (°F)	Temperature Window Frame (°F)	Temperature Wall around Window Frame (°F)	Temperature of Exterior Door Frame (°F)	Windows in Sun or Shade
313	48	54	19	41		Shade
314	45	48	92	36		Sun
315	47	48	102	46		Sun
316	51	47	31	46		Shade
317	50	53	47	38		Shade
318	45	44				
319	50	51	17	35		
320	56	56				
323	56	57				

Location: Agassiz Elementary School
Address: 20 Child Street, Jamaica Plain, Boston, MA

Indoor Air Results
Date: 1/21/2009

Table 3

Location/ Room	Temp (°F)	Relative Humidity (%)	Dew Point* (°F)	Windows Openable	Ventilation		Remarks
					Supply	Exhaust	
background	83	61	71				
Auditorium	71	74	64	N	Y	Y	WD-CTs
Cafeteria large	75	61	64	N	Y Off	Y Off	FCU on
Cafeteria small	76	62	65	N	Y Off	Y Off	FCU on
Child care room	73	58	61	N	Y	Y	Chalk dust
Gym	80	64	69	N	Y	Y	Water stain on wall, Ozone-like odor, DO
Gym office	75	56	62	N	Y	Y	DO
Gym side office	74	57	61	N	Y	Y	DO
Health office	74	59	62	Y	Y Off	Y Off	Condensation on FCU
Jeanette office	73	59	61	N	Y	Y	

* +/- 3% accuracy of relative humidity measuring device

AT = ajar ceiling tile   CT = ceiling tile   DO = door open   FCU = fan coil unit   WD = water-damaged

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	Temp (°F)	Relative Humidity (%)	Dew Point* (°F)	Windows Openable	Ventilation		Remarks
					Supply	Exhaust	
Library	73	62	62	Y	Y	Y	5 WD-CTs, damaged window caulking
Library	73	59	61	N	Y	Y	5 WD-CTs, WD window frame
Nurse main	75	65	65	N	Y	Y	
Office lounge	75	63	64	N	Y Off	Y Off	CD
Principal's office	73	60	61	Y	Y Off	Y Off	
Special services office	75	62	64	N	Y	Y	DO
Teen Center A	77	50	61	N	Y	Y	
Teen Center B	76	54	62	N	Y	Y	1 AT
Time room	74	60	62	N	Y	Y	Condensation on supply vent, photocopier
101	72	57	59	Y	Y	Y	

* +/- 3% accuracy of relative humidity measuring device

AT = ajar ceiling tile CT = ceiling tile DO = door open FCU = fan coil unit WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%
Particle matter 2.5 < 35 ug/m^3

Table 3 (continued)

Location/ Room	Temp (°F)	Relative Humidity (%)	Dew Point* (°F)	Windows Openable	Ventilation		Remarks
					Supply	Exhaust	
102	73	68	64	y	Y Off	Y Off	FCUs off
103	72	57	59	Y	Y	Y Off	Condensation on FCU
104	68	71	60	Y	Y	Y	FCU off, condensation on FCU, 3 WD-CTs, WD wall
105	73	66	64	N	Y	Y	
106	74	67	65	Y	Y	Y	Standing water under file cabinets, wet carpet, DO
107	74	64	64	Y	Y	Y	FCU on, 2 ATs
108	74	70	66	N	Y	Y	Water stained floor
109	73	65	63	Y	Y	Y	FCU off, condensation on FCU
110	73	69	65	N	Y	Y	
115	73	58	61	N	Y	Y	FCU off

* +/- 3% accuracy of relative humidity measuring device

AT = ajar ceiling tile CT = ceiling tile DO = door open FCU = fan coil unit WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%
Particle matter 2.5 < 35 ug/m^3

Table 3 (continued)

Location/ Room	Temp (°F)	Relative Humidity (%)	Dew Point* (°F)	Windows Openable	Ventilation		Remarks
					Supply	Exhaust	
211	71	57	59	Y	Y	Y	
215	77	58	64	Y	Y	Y	
216	77	59	65	Y	Y	Y	
217	77	57	64	Y	Y	Y	FCU off, condensation on FCU
219	73	64	63	Y	Y	Y	FCU off, condensation on FCU, water leaks through window frame, DO
259	71	63	61	N	Y	Y	FCU off, condensation on FCU, DO
301/302	76	53	62	Y	Y	Y	WD window
304	77	55	63	Y	Y	Y	FCU off
305	76	56	63	Y	Y	Y	FCU off
307	75	52	60	Y	Y	Y	29 computers

* +/- 3% accuracy of relative humidity measuring device

AT = ajar ceiling tile CT = ceiling tile DO = door open FCU = fan coil unit WD = water-damaged

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 3 (continued)

Location/ Room	Temp (°F)	Relative Humidity (%)	Dew Point* (°F)	Windows Openable	Ventilation		Remarks
					Supply	Exhaust	
312/314	74	58	62	Y	Y	Y	FCU on, 2 ATs
315	76	57	63	Y	Y	Y	WD window
317	75	58	63	Y	Y	Y	
319	75	62	62	Y	Y	Y	FCU on, condensation on FCU, DO
359	73	54	59	N	Y	Y	
359 office	73	55	60	N	Y	Y	WD-CTs, DO

* +/- 3% accuracy of relative humidity measuring device

AT = ajar ceiling tile CT = ceiling tile DO = door open FCU = fan coil unit WD = water-damaged

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

Appendix A

Carbon Dioxide and its Use in Evaluating Adequacy of Ventilation in Buildings

The Bureau of Environmental Health's (BEH) Indoor Air Quality (IAQ) Program examines indoor air quality conditions that may have an effect on building occupants. The status of the ventilation system, potential moisture problems/microbial growth and identification of respiratory irritants are examined in detail, which are described in the attached report. In order to examine the function of the ventilation system, measurements for carbon dioxide, temperature and relative humidity are taken. Carbon dioxide measurements are commonly used to assess the adequacy of ventilation within an indoor environment.

Carbon dioxide is an odorless, colorless gas. It is found naturally in the environment and is produced in the respiration process of living beings. Another source of carbon dioxide is the burning of fossil fuels. Carbon dioxide concentration in the atmosphere is approximately 250-600 ppm (Beard, 1982; NIOSH, 1987).

Carbon dioxide measurements within an occupied building are a standard method used to gauge the adequacy of ventilation systems. Carbon dioxide is used in this process for a number of reasons. Any occupied building will have normally occurring environmental pollutants in its interior. Human beings produce waste heat, moisture and carbon dioxide as by-products of the respiration process. Equipment, plants, cleaning products or supplies normally found in any building can produce gases, vapors, fumes or dusts when in use. If a building has an adequately operating mechanical ventilation system, these normally occurring environmental pollutants will be diluted and removed from the interior of the building. The introduction of fresh air both increases the comfort of the occupants and serves to dilute normally occurring environmental pollutants.

Appendix A

An operating exhaust ventilation system physically removes air from a room and thereby removes environmental pollutants. The operation of supply in conjunction with the exhaust ventilation system creates airflow through a room, which increases the comfort of the occupants. If all or part of the ventilation system becomes non-functional, a build up of normally occurring environmental pollutants may occur, resulting in an increase in the discomfort of occupants.

The MDPH approach to resolving indoor air quality problems in schools and public buildings is generally two-fold: 1) improving ventilation to dilute and remove environmental pollutants and 2) reducing or eliminating exposure opportunities from materials that may be adversely affecting indoor air quality. In the case of an odor complaint of unknown origin, it is common for BEH staff to receive several descriptions from building occupants. A description of odor is subjective, based on the individual's life experiences and perception. Rather than test for a potential series of thousands of chemicals to identify the unknown material, carbon dioxide is used to judge the adequacy of airflow as it both dilutes and removes indoor air environmental pollutants.

As previously mentioned, carbon dioxide is used as a diagnostic tool to evaluate air exchange by building ventilation systems. The presence of increased levels of carbon dioxide in indoor air of buildings is attributed to occupancy. As individuals breathe, carbon dioxide is exhaled. The greater the number of occupants, the greater the amount of carbon dioxide produced. Carbon dioxide concentration build up in indoor environments is attributed to inefficient or non-functioning ventilation systems. 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).

Appendix A

Carbon dioxide can be a hazard within enclosed areas with **no air supply**. These types of enclosed areas are known as confined spaces. Manholes, mines and sewer systems are examples of confined spaces. An ordinary building is not considered a confined space. Carbon dioxide air exposure limits for employees and the general public have been established by a number of governmental health and industrial safety groups. Each of these standards of air concentrations is expressed in parts per million (ppm). *Table 1* is a listing of carbon dioxide air concentrations and related health effects and standards.

The MDPH uses a guideline of 800 ppm for publicly occupied buildings (Burge et al., 1990; Gold, 1992; Norback, 1990; OSHA, 1994; Redlich, 1997; Rosenstock, 1996; SMACNA, 1998). 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. Several sources indicate that indoor air problems *are significantly reduced* at 600 ppm or less of carbon dioxide (ACGIH, 1998; Bright et al., 1992; Hill, 1992; NIOSH, 1987). Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Air levels for carbon dioxide that indicate that indoor air quality may be a problem have been established by the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE). Above 1,000 ppm of carbon dioxide, ASHRAE recommends adjustment of the building's ventilation system (ASHRAE, 1989). In 2001, ASHRAE modified their standard to indicate that no more than 700 ppm above the outdoor air concentration; however, 800 ppm is the level where further investigation will occur.

Carbon dioxide itself has no acute (short-term) health effects associated with low level exposure (below 5,000 ppm). The main effect of carbon dioxide involves its ability to displace

Appendix A

oxygen for the air in a confined space. As oxygen is inhaled, carbon dioxide levels build up in the confined space, with a decrease in oxygen content in the available air. This displacement of oxygen makes carbon dioxide a simple asphyxiant. At carbon dioxide levels of 30,000 ppm, severe headaches, diffuse sweating, and labored breathing have been reported. No **chronic** health effects are reported at air levels below 5,000 ppm.

Air testing is one method used to determine whether carbon dioxide levels exceed the comfort levels recommended. If carbon dioxide levels are over 800-1,000 ppm, the MDPH recommends adjustment of the building's ventilation system. The MDPH recommends that corrective measures be taken at levels above 800 ppm of carbon dioxide in office buildings or schools. (Please note that carbon dioxide levels measured below 800 ppm may not decrease indoor air quality complaints). Sources of environmental pollutants indoors can often induce symptoms in exposed individuals regardless of the adequacy of the ventilation system. As an example, an idling bus outside a building may have minimal effect on carbon dioxide levels, but can be a source of carbon monoxide, particulates and odors via the ventilation system.

Therefore, the MDPH strategy of adequate ventilation coupled with pollutant source reduction/removal serves to improve indoor air quality in a building. Please note that each table included in the IAQ assessment lists BEH comfort levels for carbon dioxide levels at the bottom (i.e. carbon dioxide levels between 600 ppm to 800 ppm are acceptable and <600 ppm is preferable). While carbon dioxide levels are important, focusing on these air measurements in isolation to all other recommendations is a misinterpretation of the recommendations made in these assessments.

Appendix A

Table 1: Carbon Dioxide Air Level Standards

Carbon Dioxide Level	Health Effects	Standards or Use of Concentration	Reference
250-600 ppm	None	Concentrations in ambient air	Beard, R.R., 1982 NIOSH, 1987
600 ppm	None	Most indoor air complaints eliminated, used as reference for air exchange for protection of children	ACGIH, 1998; Bright et al., 1992; Hill, 1992; NIOSH 1987
800 ppm	None	Used as an indicator of ventilation inadequacy in schools and public buildings, used as reference for air exchange for protection of children	Mendler, 2003 Bell, A. A., 2000; NCOSP, 1998; SMACNA, 1998; EA, 1997; Redlich, 1997; Rosenstock, 1996; OSHA, 1994; Gold, 1992; Burge et al., 1990; Norback, 1990 ; IDPH, Unknown
1000 ppm	None	Used as an indicator of ventilation inadequacy concerning removal of odors from the interior of building.	ASHRAE, 1989
950-1300 ppm*	None	Used as an indicator of ventilation inadequacy concerning removal of odors from the interior of building.	ASHRAE, 1999
700 ppm (over background)	None	Used as an indicator of ventilation inadequacy concerning removal of odors from the interior of building.	ASHRAE, 2001
5000 ppm	No acute (short term) or chronic (long-term) health effects	Permissible Exposure Limit/Threshold Limit Value	ACGIH, 1999 OSHA, 1997
30,000 ppm	Severe headaches, diffuse sweating, and labored breathing	Short-term Exposure Limit	ACGIH, 1999 ACGIH, 1986

* outdoor carbon dioxide measurement +700 ppm

Appendix A

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HUNTER
SINCE 1886

PermaLife™
AIR PURIFIER

Model 30546 & 30547
(remote included)

Replacement Filter Information	
MODEL	PRE-FILTER
30546	30901
30547	30901

www.hunterfan.com

41959-01 03/30/2006

Table of Contents

SAFETY INSTRUCTIONS

IMPORTANT!
READ ALL INSTRUCTIONS BEFORE USING THIS AIR PURIFIER.

1. This air purifier is designed for use on a flat level floor and may not work properly on an uneven floor. **ALWAYS** place the air purifier on a firm level floor. **ALWAYS** place the air purifier at least six (6) inches away from walls and heat sources such as stoves, radiators, or heaters.
2. Place the air purifier in an area that is out of the reach of children.
3. Before using the air purifier, extend the cord and inspect for any signs of damage. **DO NOT** use the product if the cord has been damaged.
4. This product has a polarized plug (one blade is wider than the other) as a safety feature. This plug will fit into a polarized outlet only one way. If the plug does not fit fully into the outlet, reverse the plug. If the plug still does not fit, contact a qualified electrician. **DO NOT** attempt to defeat or override this safety feature.
5. **ALWAYS UNPLUG** the air purifier while it is being cleaned.
6. **DO NOT** move or tilt the air purifier while it is in operation. Turn off and unplug before moving.
7. **DO NOT** immerse the air purifier in water at any time because permanent damage will occur. To properly clean your air purifier, follow the instructions in the Maintenance section of this manual (pg. 20).

READ AND SAVE ALL INSTRUCTIONS.

Introduction

Thank you for purchasing the PermaLife™ Air Purifier from Hunter Fan Company. You have purchased our latest development in portable air purification which has been designed to improve the quality of the air that you breathe. The following innovative features are included in your Hunter Air Purifier.

- **High Particulate Efficiency:** The cleanable filter will remove 99.5% of 0.5 micron particles from the air that passes through the filter.
- **Odor Removal:** The activated carbon pre-filter helps remove odors such as cooking, smoke, and pet smells from the air. It also traps lint, hair, and other large particles to help extend the life and performance of the cleanable filter.
- **Remote Control:** This air purifier may also be controlled by the included remote. Using the remote, you can turn off the air purifier or change the speed to sleep (1), active (2), or turbo clean (3).
- **Ionizer:** The ionizer improves the quality of air in the room by releasing negative ions into the air that attract positively charged dust, smoke, and pollen particles.
- **Quiet:** The air purifier has been designed to operate quietly and efficiently. You can choose among three speeds to best meet your needs at different times.
- **Filter Counters:** Filter maintenance is critical to the performance of the air purifier. To help you determine when to change or clean the pre-filter and cleanable filter, the unit has built in life counters that keep track of the life remaining of each filter.

Description of Air Filtration System

How the PermaLife™ Air Purifier System Works

As the air is pulled into the purifier, the activated carbon pre-filter absorbs odors and catches large particles. Then, the air travels through the PermaLife™ Cleanable Filtration System where the smaller particles are collected. Then, the ionizer releases negative ions into the air that attract positively charged dust, smoke, and pollen particles. Finally, the clean purified air is released back into the room.

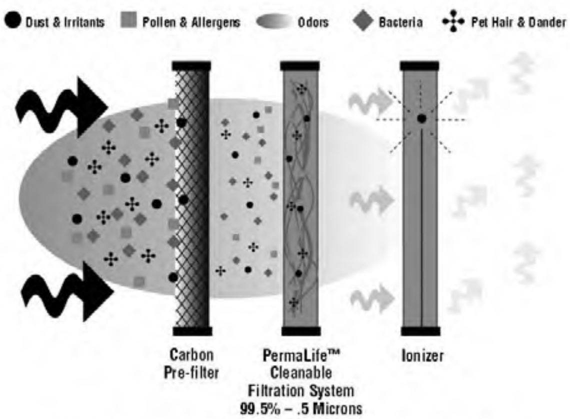

Fig. 1 - Illustration of the Air Filtration System

Air Purifier Components

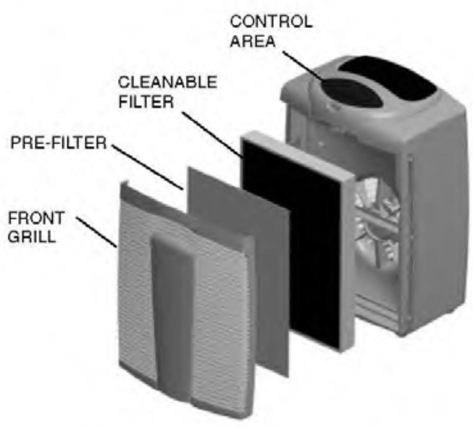

Fig. 2 - Air Purifier Components

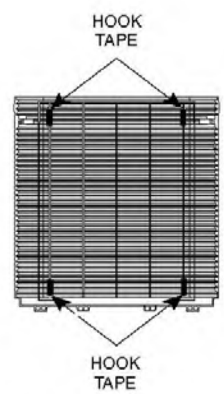

Fig. 3 - Inside Surface of Front Grill

Description of Air Filtration System

Display and Control Keys

The display and control keys allow for easy operation of the air purifier.

IONIZER: Turns the ionizer on and off.

ON/OFF: Turns the unit on and off.

AUTO: Toggles between manual and auto modes. (*Manual mode and Auto mode on page 10.*)

UP/DOWN KEYS: Adjusts the blower speed and changes values in clock setting and programming modes.

FILTER RESET: Resets the pre-filter and filter counters. (*FIlter run-time counters on page 13.)*

DISPLAY: Selects the clock, pre-filter, or filter display. (*Display modes on page 9.)*

DAY/TIME: Used to set the day and time. (*Setting day and time on page 14.*)

PROGRAM: Allows you to enter program mode and define user programs. (*User programming on page 16.*)

RESET: Returns unit to factory settings. (*Resetting the air purifier on page 19.*)

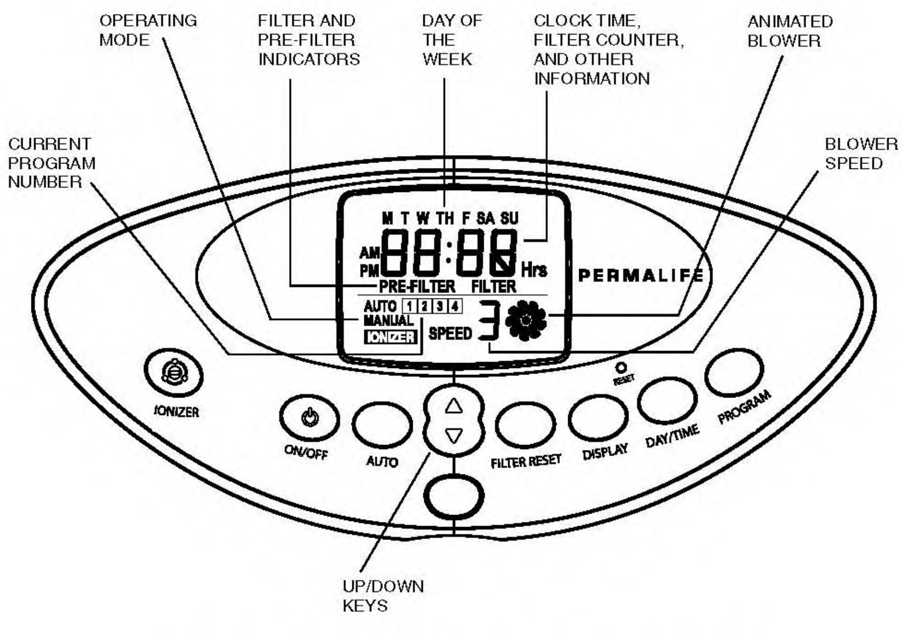

Fig. 4 - Air Purifier Control Area and Alpha-numeric Display

Appendix C

Technical Information

Specifications	HealthPro Compact	HealthPro	HealthPro Plus
Maximum air delivery *	240 cfm	260 cfm	240 cfm
Air delivery for all six fan speeds (in cfm) *	45 75 115 150 180 240	45 75 115 150 180 260	40 70 110 140 170 240
Dimensions (HxWxD)	24" x 15" x 16"	28" x 15" x 16"	28" x 15" x 16"
Weight (incl. filters)	25 lbs.	29 lbs.	35 lbs.
Power requirements	120 Volt / 60 Hz		
Maximum energy consumption	215 w		
Fan motor	700 cfm, 2750 rpm, centrifugal, backward curved, UL/CSA registered		
Control panel	4-key touch-pad with 32 character LCD display		
Air intake	dual arches at base of unit		
Air outlet	320° EvenFlow™ diffuser		
Color of main housing / locking arms	light grey / white		
Housing material	non-offgasing, impact-resistant, UV-stabilized ABS		
Performance			
Performance certification	every system is factory certified and issued with individual Certificate of Performance		
Certified filtration efficiency	greater than 99.97% for particles ≥ 0.3 microns (μm)		
Certified air delivery	+/- 10% (+ 10 cfm) of specified air delivery		
Leak tested	yes		
Filter Configuration			
Pre-filter	***PreMax™*** large capacity pre-filter. Purpose: control of coarse and fine dust particles. Media: wet laid nonwoven glass microfiber, mini-pleated. Surface area: 25 sq.ft. Efficiency: >99% efficient at 5 μm.		
Gas & odor filter	no gas & odor filter not upgradable	no gas & odor filter upgradable at any time ***with V5-Cell™***	***V5-Cell™*** wide-spectrum gas and odor filter. Purpose: control of wide range of gaseous chemicals. Media: activated carbon & alumina impregnated with potassium permanganate. Weight: 5 lbs.
HEPA filter	***HyperHEPA®*** cleanroom-grade high-efficiency particulate arresting filter. Media: wet laid glass microfiber, mini-pleated with solvent-free separators. Purpose: control of very fine particles such as allergens, bacteria and viruses. Surface area: 40 sq. ft. Classification (EN1822): Class H13 at 0-112 cfm, MPPS efficiency: 99.95% @ 0.22μm; Class H12 at 112-280 cfm, MPPS efficiency: 99.5% @ 0.16μm		
Average Filter Life Based on 10 hours usage per day on speed setting 3.	PreMax Filter: 6 – 18 months HyperHEPA Filter: 2 – 4 years	PreMax Filter: 6 – 18 months HyperHEPA Filter: 2 – 4 years	PreMax Filter: 6 – 18 months V5-Cell: 1 – 2 years HyperHEPA Filter: 2 – 4 years
Control Panel Features			
Display languages	English (default), French, German, Spanish		
Intelligent filter life monitor	yes		
Filter life status LED	yes		
Programmable timer (hourly/daily), 2 Speeds	yes		
Timer status LED	yes		
Countdown timer	yes		
Adjustable filter load index	yes		
Accessories			
Standard	remote control (battery included), set of casters		
Optional (available from authorized IQAir dealers)	wall mount bracket, positive/negative pressure ducting, coarse dust pre-filter		
Warranty			
Warranty period	5 years on parts and labor (excluding filters)		

All technical specifications are subject to change without prior notice. * tolerance +/- 10% (+ 10 cfm) 0407/105 01 00 06

Appendix D

National Institute for Occupational Safety and Health

LATEX ALLERGY

June 1997

What Is Latex Allergy?

Latex allergy can result from repeated exposures to proteins in natural rubber latex through skin contact or inhalation. Reactions usually begin within minutes of exposure to latex, but they can occur hours later and can produce various symptoms. These include skin rash and inflammation, respiratory irritation, asthma, and in rare cases shock. In some instances, sensitized employees have experienced reactions so severe that they impeded the worker's ability to continue working in their current job.

The amount of exposure needed to sensitize individuals to natural rubber latex is not known, but reductions in exposure to latex proteins have been reported to be associated with decreased sensitization and symptoms. People at increased risk for developing latex allergy include workers with ongoing latex exposure, persons with a tendency to have multiple allergic conditions, and persons with spina bifida. Latex allergy is also associated with allergies to certain foods such as avocados, potatoes, bananas, tomatoes, chestnuts, kiwi fruit, and papaya.

How Large a Problem is Latex Allergy?

Reports of work-related allergic reactions to latex have increased in recent years, especially among employees in the growing health-care industry, where latex gloves are widely used to prevent exposure to infectious agents. At least 7.7 million people are employed in the health-care industry in the U.S. Once sensitized, workers may go on to experience the effects of latex allergy. Studies indicate that 8-12% of health-care workers regularly exposed to latex are sensitized, compared with 1-6% of the general population, although total numbers of exposed workers are not known. In the health-care industry, workers at risk of latex allergy from ongoing latex exposure include physicians, nurses, aides, dentists, dental hygienists, operating room employees, laboratory technicians, and housekeeping personnel.

Workers who use gloves less frequently, such as law enforcement personnel, ambulance attendants, fire fighters, food service employees, painters, gardeners, housekeeping personnel outside the health-care industry, and funeral home employees, also may develop latex allergy. Workers in factories where natural rubber latex products are manufactured or used also may be affected.

Prevention

The National Institute for Occupational Safety and Health (NIOSH) recommends wherever feasible the selection of products and implementation of work practices that reduces the risk of allergic reactions. These recommendations include:

Use non-latex gloves for activities that are not likely to involve contact with infectious materials (food preparation, routine housekeeping, maintenance, etc.).

1. Appropriate barrier protection is necessary when handling infectious materials. If you choose latex gloves, use powder-free gloves with reduced protein content.
2. When wearing latex gloves, do not use oil-based hand creams or lotions unless they have been shown to reduce latex-related problems.
3. Frequently clean work areas contaminated with latex dust (upholstery, carpets, ventilation ducts, and plenums).
4. Frequently change the ventilation filters and vacuum bags used in latex-contaminated areas.
5. Learn to recognize the symptoms of latex allergy: skin rashes; hives; flushing; itching; nasal, eye, or sinus symptoms; asthma; and shock.

6. If you develop symptoms of latex allergy, avoid direct contact with latex gloves and products until you can see a physician experienced in treating latex allergy.
7. If you have latex allergy, consult your physician regarding the following precautions:
8. Avoid contact with latex gloves and products.
9. Avoid areas where you might inhale the powder from latex gloves worn by others.
10. Tell your employers, physicians, nurses, and dentists that you have latex allergy.
11. Wear a medical alert bracelet.
12. Take advantage of latex allergy education and training provided by your employer.

Additional Information

NIOSH has issued an Alert, *Preventing Allergic Reactions to Natural Rubber Latex in the Workplace* (DHHS [NIOSH] Publication No. 97-135), that summarizes the existing data on latex allergy. Copies are available free-of-charge from the NIOSH Publications Office while supplies last:

fax 513-533-8573
telephone **1-800-35-NIOSH** (1-800-356-4674)

For a complete listing of documents available on the **CDC Fax Information Service** call **1-888-CDC-FAXX (1-888-232-3299)** and request document #000006. This information is also available on the Internet at CDC's web site.

Document #705006

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