INDOOR AIR QUALITY REASSESSMENT

Underwood Elementary School
101 Vernon Street
Newton, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of the Newton Health Department (NHD), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Underwood Elementary School (UES), 101 Vernon Street, Newton, MA.

The school was visited by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, on April 17, 2003 to conduct an indoor air quality assessment. Cory Holmes, an Environmental Analyst in the ER/IAQ Program, and Bob Deluca, of the Newton Health Department accompanied Mr. Feeney during the assessment. The school was previously visited by Mr. Feeney, in November of 1997. A report was issued (MDPH, 1997) which described conditions of the building at that time and gave recommendations on how to correct those problems.

The school is a two-story brick building constructed in 1924. The building underwent renovations in 1979. The second floor contains general classrooms and the library office. The first floor contains general classrooms, the gym/assembly hall, library and office space. The basement contains an art room, a computer room, a music room, the boiler room, the kitchen, an after school program area and a multi purpose room.

The NHD provided BEHA staff with copies of reports, letters and memorandum related to the IAQ problems at the UES. From these reports, the UES appears to have a history of indoor air quality concerns. Attempts have been made by city health and school officials to address those concerns. As reported by city/school officials, the building experienced substantial water damage from a leaking roof (personal communication with Bob Deluca). In response to indoor air quality complaints, an indoor air quality study was conducted to assess the UES by a

consultant, FLI Environmental, Inc. (FLI), in March of 2002. This consultant recommended the following remedial actions:

1. Replacement of water damaged ceiling tiles;
2. Increased maintenance of unit ventilators;
3. Unblocking of classroom exhaust vents;
4. Replacement of mold-colonized porous building materials;
5. Cleaning and disinfection of non-porous materials;
6. Examination of the schools exhaust ventilation system (FLI, 2002a).

Further air testing was conducted by FLI in May of 2002 and a second report was issued in June of 2002. The June FLI report recommended the following remedial actions:

1. A thorough review of the buildings mechanical ventilation systems;
2. Balancing the ventilation system;
3. Increased maintenance on unit ventilators and
4. Inspection of exhaust fans (FLI, 2002b).

The Newton School Department (NSD) working in conjunction with the NHD, has completed a number of capital and repair projects to improve conditions at the school. These efforts include extensive repair and maintenance on the school's heating and ventilation systems, replacing carpet with tile, roof repairs and interior renovations in a number of areas.

Actions on Recommendations Previously Made by MDPH

As previously discussed, BEHA staff visited the building in November 1997 and issued a report that made recommendations to improve indoor air quality (MDPH, 1997). A summary of actions taken on previous recommendations is included as Appendix A of this reassessment.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school houses kindergarten through fifth grade students and has population of approximately 425 and a staff of approximately 35-40. Tests were taken during normal operations at the school and results appear in Table 1

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated slightly above 800 parts per million (ppm) parts of air in 6 out of 33 areas, indicating adequate fresh air ventilation in most areas of the school. Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (see Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were operating in classrooms throughout the school with the exception of classroom 5, which was deactivated. This univent had its fresh air intake louver frozen in the open position, which allows (cold) outside air to freely penetrate into the classroom. Obstructions to airflow, such as papers and books stored on univents and/or items in front of univent returns were seen in some classrooms (see Picture 1). In order for univents to

provide fresh air as designed, intakes must remain free of obstructions and allowed to operate while rooms are occupied.

Exhaust ventilation is provided by a ducted system, with an exhaust grille mounted in the ceiling above the sink/countertop area of each classroom. It was reported by Mr. Deluca that these vents were originally designed as passive (non-motorized) exhaust vents that relied on the pressurization of classrooms to force air into the vents. A lack of pressurization (e.g. deactivation of univents, opening of classroom doors and windows) would prevent the removal of exhaust air from classrooms. Without proper exhaust ventilation, indoor air pollutants can build up and lead to indoor air quality/comfort complaints. The passive vents were replaced with modern mechanical rooftop exhaust vents (see Picture 2) several weeks prior to this BEHA reassessment. All exhaust vents were operating during the reassessment.

To maximize air exchange, the BEHA 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. The last balancing of these systems was reportedly performed in 1999. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in

the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

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

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

Temperature measurements ranged from 70^{o} F to 76^{o} F, which were within the BEHA recommended comfort guidelines. The BEHA 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. Some temperature complaints were expressed by staff, primarily heat issues in the library.

The relative humidity in the building was very close to or within the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from

36 to 58 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Classrooms in the basement located at the front of the UES had signs of water penetration through foundation walls. This was evidenced by the presence of peeling paint and efflorescence along exterior brick walls. 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 around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As the solution moves to the surface of the brick or mortar, the water evaporates, leaving behind white, powdery mineral deposits. A coat of paint can serve as a water impermeable barrier, which can trap moisture. Brick, mortar and wall plaster are not good mold growth media, however water trapped behind wallpaper or paint coats can become mold growth media.

Shrubbery and other plants exist in close proximity to the foundation walls (see Picture 3). The growth of roots against the exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level (see Picture 3). Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Of note is the configuration of the univent fresh air intakes (UFAIs). In most buildings assessed by BEHA staff, the exterior grills of the UFAIs are installed with the louvers parallel to

the ground (see Picture 4). These louvers are also usually beveled in a manner for rainwater to pour away from the univent opening, similar to a peaked roof on a house. The UFAI louvers at the UES are perpendicular to the ground (see Picture 5). This configuration can allow for driving rain to penetrate into the fresh air intake and accumulate in the floor of the univent instead of rolling off the louver and away from the univent. Moist weather tends to travel in a northeasterly track up the Atlantic Coast towards New England (Trewartha, 1943). Wet weather systems generally produce south/southwesterly winds, which can impact on westerly and southerly facing UFAIs. UFAIs are also prone to accumulating outdoor debris, dirt and other materials that can serve as mold growth media. With repeated water penetration, these accumulated materials can become moistened, resulting in potential mold growth, particularly within several days after rainstorms.

Several classrooms contained a number of plants. Plant soil and drip pans can serve as sources of mold growth. Plants should also be located away from univents and exhaust ventilation to prevent aerosolization of dirt, pollen or mold. Two aquariums were observed in the building. Aquariums should be properly cleaned and maintained to prevent bacterial/mold growth and nuisance odors.

In a number of classrooms, spaces between the sink countertop and backsplash were noted. Repeated leakage or improper drainage/overflow can lead to water penetration of countertop wood, the cabinet interior and behind cabinets. Like other porous materials, if these materials become wet repeatedly, they can provide mediums for mold growth.

Other Concerns

Several of the interiors of univents were randomly evaluated. Spaces and holes within the air handling cabinet of univents were observed (see Pictures 6 and 7). Dust around the edges of each hole indicates that unfiltered air enters the air handling cabinet. The existence of these holes allows for air to by-pass filters, resulting in aerosolization of materials (e.g. dust) into the classroom. In addition, spaces exist around heating pipes that penetrate through the floor. Spaces of this nature can result in the univent drawing air and debris from the wall cavities or crawl spaces and distributing these materials to the interior of the building.

Of note was the heavy accumulation of mouse droppings inside the wall cavity, which was found open to the univent cabinet (see Picture 8). Classrooms contained a number of conditions that may attract rodents. Stored food containers were noted in some classrooms. In addition, one classroom and hallway (see Picture 9) had student art projects that were made with food. Each of these circumstances can create conditions that attract pests. Under current Massachusetts law (effective November 1, 2001) the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). Pesticide use indoors can introduce chemicals into the indoor environment that can be sources of eye, nose and throat irritation. The reduction/elimination of pathways/food sources that are attracting these insects should be the first step taken to prevent or eliminate this infestation.

Rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine is known to contain a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms in exposed individuals can cause running nose or skin rashes in sensitive individuals (e.g., running nose or skin rashes). 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.

To eliminate exposure to allergens, rodents must be removed from the building. Please note that removal, even after cleaning, may not provide immediate relief since allergens can exist in the interior for several months after rodents are eliminated (Burge, 1995). A combination of cleaning,, along with an increase in ventilation and filtration should serve to reduce rodent associated allergens once the infestation is eliminated.

Univents were equipped with disposable filters. The filter medium used in these metal racks provides minimal filtration of respirable particulates that can be distributed by univents. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow (called pressure drop), which can reduce the efficiency of the univents due to increased resistance. Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

In an effort to reduce noise from sliding chairs, tennis balls are sliced open and placed on chair legs. 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 to off-gas TVOCs. 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 C (NIOSH, 1998).

The main office and teachers' lounges have photocopiers. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992). School personnel should ensure that local exhaust ventilation is activated while equipment is in use to help reduce excess heat and odors in these areas.

A number of classrooms contained upholstered furniture. Upholstered furniture is covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (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 upholstered furniture (if present in schools), be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000).

Accumulated chalk dust was noted in several classrooms. Chalk dust is a fine particulate, which can be easily aerosolized and is an eye and respiratory irritant. Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry

erase board cleaners may contain VOCs (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Cleaning products were found in a number of classrooms and insecticides have reportedly been brought in by individuals. Cleaning products and insecticides contain chemicals that can be irritating to the eyes, nose and throat and should be kept out of reach of students. Unlabeled/poorly labeled spray bottles were also noted. 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.

Also of note was the amount of materials stored inside classrooms. In several areas, items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. In one classroom, the floor was dust and gritty as the result of using a sandbox indoors (see Picture 10). These items (e.g., papers, folders, and boxes) make it difficult for custodial staff to clean in and around these areas. Dust can be irritating to the eyes, nose and respiratory tract. For this reason, items should be relocated and/or cleaned periodically to avoid excessive dust build up. In addition, a number of exhaust vents in classrooms were noted with accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles.

Conclusions/Recommendations

The Newton School Department and Newton Health Department have clearly taken a number of positive steps to remediate the ongoing, perceived indoor air quality concerns at the UES. The majority of these actions have served to improve conditions in

the building. The installation of mechanical exhaust ventilation, ducting of the pottery kiln to the outdoors and other related remedial actions have helped decrease sources of materials that can adversely impact indoor air quality. In order to address the conditions listed in this reassessment, 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 practicable. Long-term solution measures 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 this assessment, the following recommendations are made:

Short Term Recommendations

1. Ensure univents and exhaust vents are free of obstruction.
2. Seal all holes in the walls of the univent air handling cabinets to limit filter bypass.
3. Seal wall and pipe floor holes within univent casing.
4. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.
5. Repair the fresh air intake louver for classroom 5 univent.
6. 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. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

7. Move plants away from univents in classrooms. Ensure all plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants.
8. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
9. It is highly recommended that the principles of integrated pest management (IPM) be used to rid the building of pest. A copy of the IPM recommendations can be obtained from the Massachusetts Department of Food and Agriculture (MDFA) website at the following website: http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf. Activities that can be used to eliminate pest infestation may include the following activities.
    a) Do not use food as components in student artwork.
    b) Rinse out recycled food containers. Seal recycled containers in a tight fitting lid to prevent rodent access.
    c) Remove non-food items that rodents are consuming.
    d) Stored foods in tight fitting containers.
    e) Avoid eating at workstations. In areas were food is consumed, periodic vacuuming to remove crumbs are recommended.
    f) Regularly clean crumbs and other food residues from ovens, toasters, toaster ovens, microwave ovens coffee pots and other food preparation equipment;

g) Holes as small as ¼" are enough space for rodents to enter an area. Examine each room and the exterior walls of the building for means of rodent egress and seal. If doors do not seal at the bottom, install a weather strip as a barrier to rodents. Reduce harborages (cardboard boxes) where rodents may reside (MDFA, 1996).

10. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.
11. Discontinue the use of tennis balls on chairs to prevent latex dust generation.
12. Store cleaning products properly and out of reach of students.
13. Have a chemical inventory done in all storage areas and classrooms. Properly store flammable materials in a manner consistent with the local fire code. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Label chemical containers with the chemical name of its contents. Follow proper procedures for storing and securing hazardous materials.
14. Obtain Material Safety Data Sheets (MSDS) for chemicals from manufacturers or suppliers. Maintain these MSDS' and train individuals in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL, 1983).
15. Clean chalkboards and trays regularly to avoid the build-up of excessive chalk dust.
16. In order to maintain a good indoor air quality environment on the building, consideration should be give to adopting the US EPA document, "Tools for Schools", which can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

17. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

Long Term Recommendations

1. Due to the apparent configuration of the curtain wall/drainage plane system, measures should be taken to minimize water contact with the exterior walls. Removing trees outside of the kindergarten classrooms and foliage close to exterior walls is recommended.
2. If water penetration/efflorescence observed in various areas of the building returns, consideration should be given to having a building engineer examine each damaged area with the intent to recommend possible drainage plane remediation strategies.

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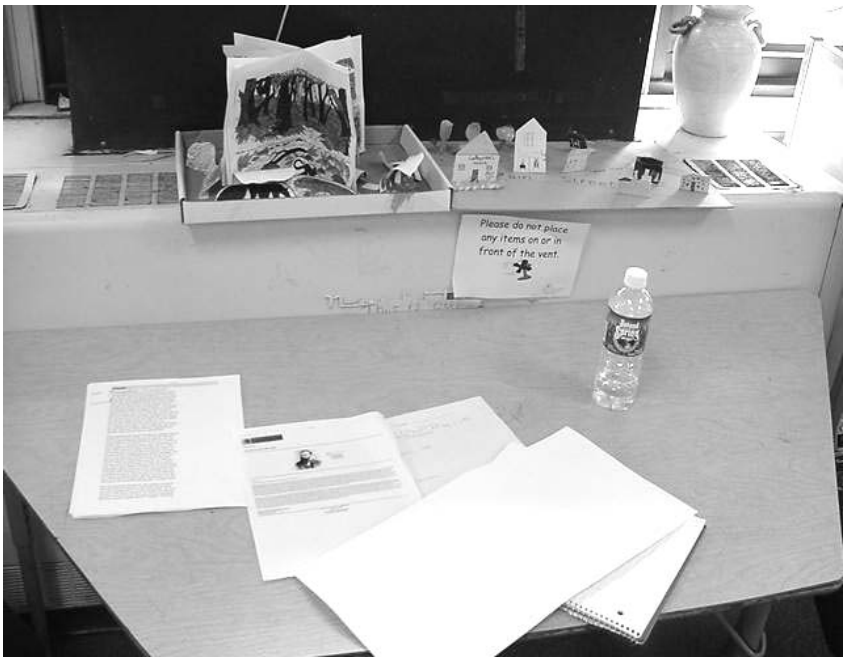
Picture 1



Blocked Univent

Picture 2

Newly Installed Exhaust Vent Motors, Note Original Passive Exhaust Vent Covers

Picture 3

Shrubbery and Other Plants Exist in Close Proximity to the Foundation Walls, Note Crack in Foundation

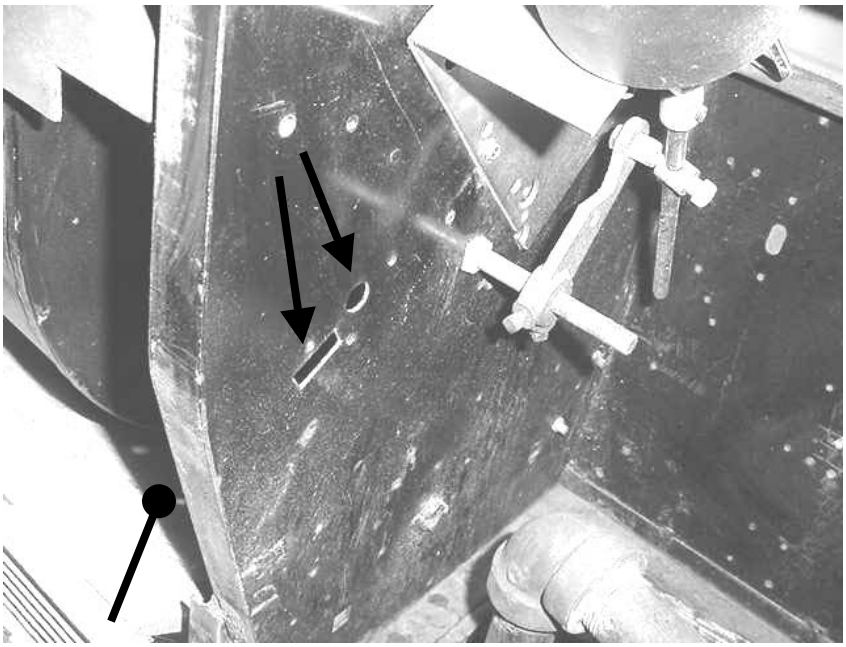
Picture 4

Typical Exterior Grills of the UFAIs Installed with the Louvers Parallel to the Ground

Picture 5

UFAIs Louvers on the UES Installed Perpendicular to the Ground

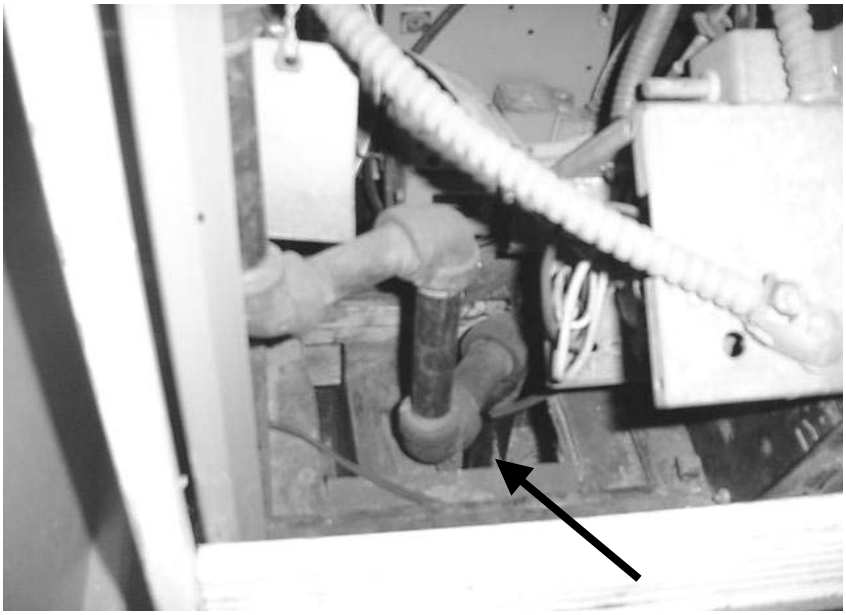
Picture 6



Filter

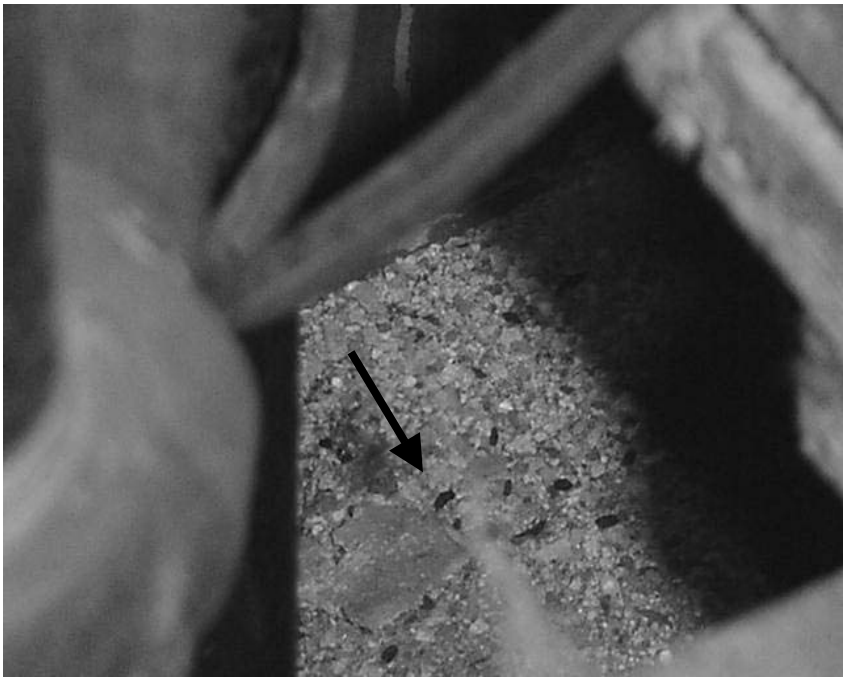
Holes Post-Filter in Wall of Air Handling Chamber of Univent

Picture 7



Hole in Floor of Univent

Picture 8



Mouse Droppings in Wall/Floor Cavity below Univent

Picture 9

Student Art Projects That Were Made With Food

Picture 10

Sandbox in Classroom

TABLE 1

Indoor Air Test Results –Underwood Elementary School - Newton MA April 17, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outdoors (Background)	430	52	13					Scattered clouds, NW wind (15-20 mph)
Room 8	933	70	22	18	Y	Y	Y	WB
Room 9	762	70	20	7	Y	Y	Y	WB Tennis balls, door open
Room 10	668	70	18	7	Y	Y	Y	WB Tennis balls
Room 11	790	71	16	20	Y	Y	Y	WB Tennis balls
Room 12	551	72	15	4	Y	Y	Y	Supply blocked Plants
Room 13	719	72	15	0	Y	Y	Y	
Room 14	764	72	15	0	Y	Y	Y	
Room 6	761	72	17	0	Y	Y	Y	Clutter Door open
Room 5	856	76	17	0	Y	Y	Y	Supply off, door open Food as art
Room 4	722	74	15	0	Y	Y	Y	Cleaners

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles
WB = white board

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%

TABLE 2

Indoor Air Test Results –Underwood Elementary School - Newton MA April 17, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Room 3	814	74	16	16	Y	Y	Y	
Teachers Lounge	550	72	14	0	Y	Y	Y	Plants
Art	800	73	18	17	Y	Y	Y	Exhaust off Door open
After School	611	71	15	0	Y	Y	Y	Exhaust and supply off
Tutorial 4	782	72	17	3	Y	N	N	WB
Tutorial 3	909	76	18	2	Y	N	N	
Tutorial 2	633	77	17	0	Y	N	N	WB Door open
Tutorial 1	662	79	21	0	Y	N	N	Computer
Media Room	650	73	17	2	Y	N	N	WB Door open
Nurse's Office	617	73	15	2	Y	N	N	Ceiling fan Door open
2nd Floor Hallway Outside Rm. 9								WD plaster 2 CT

*** ppm = parts per million parts of air**
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TABLE 3

Indoor Air Test Results –Underwood Elementary School - Newton MA April 17, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Room 16	680	70	20	15	Y	Y	Y	DEB particulate Spray cleaning product under sink Items hang from ceiling tile
Staff Lounge						N	N	2 CT, photocopier, tennis balls/ chair, no local exhaust, no mechanical vent, food debris in stove/electric stove
Staff Lounge Rest Room	650	71	17	0	N	N	Y	Near sink/countertop, exhaust weak/dusty, no passive vent on door
Room 15	619	70	15	2	Y	Y	Y	Debris particulate, spray cleaning product under sink, items hang form ceiling tiles
Room 7	824	70	18	16	Y	Y	Y	Planter on water-stained paper towels, UV off, UV not open, cleaning product and unlabeled, spray bottles under sink, desks against UV
Library	688	72	19	2	Y	Y	Y	23 occupants gone 10 min. MT (2), CT in corner
Room 1	730	73	16	16	Y	Y	Y	Items blocking UV, Solvent/ spray cleaning product under sink, not secured, plants in standing water,

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles
WB = white board

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%

TABLE 4

Indoor Air Test Results –Underwood Elementary School - Newton MA April 17, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
								water-damaged wall plaster
Teacher's Room						Y	Y	Rec relocating --- beneath local exhaust
Music Room	706	76	18	22	Y	Y	Y	Door open UV suspended from ceiling
Basement Hallway								Boiler room/custodian's door wedged open
Underwood After School Room	511	73	17	0	Y	Y	N	Door open Unvented stove
Boiler Room	634	85	16	0	Y	Y		Holes in ceiling plaster
Basement Boys Rest Room					Y	N	Y	Exhaust no operating
Gym								Material on and around AHV
Room 15	776	72	17	22	Y	Y	Y	
Reading Lounge	588	71	17	2	Y	Y	N	Items around UV
Ross's Office	546	70	16	0	Y	N	N	Window difficult to open 1 CT in hallway

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles
WB = white board

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%

TABLE 5

Indoor Air Test Results –Underwood Elementary School - Newton MA April 17, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Main Office	676	72	18	4	Y	Y	Y	Laminating machine, window AC, ceiling fan, no filter in AC, dust/debris in cooling fans
Principal's Office	700	72	16	3	Y	Y	N	
Room 13	928	73	18	21	Y	Y	Y	Tennis balls
Room 14	924	72	18	19	Y	Y	Y	
Perimeter Notes:								Cracks in foundation, fiberglass in library UV air intake, plants around foundation/tarmac, shrubbery

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles
WB = white board

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Appendix A

The following is a status report of action(s) taken on previous BEHA recommendations (**in bold**) based on reports from town/building staff, documents, photographs and BEHA staff observations.

1. **Connect the kiln local exhaust to a duct that vents outdoors. Make sure the kiln exhaust is a sufficient distance from univent from univent fresh air intakes to prevent entrainment of kiln exhaust into classrooms.**

   Action taken: Kiln exhaust duct was installed.

2. **Improve univent function.**

   Action taken: See main report.

3. **Examine and repair exhaust vents.**

   Action taken: See main report.

4. **Remove obstructions of univent and exhaust vents.**

   Action taken: Some classrooms continue to have univents blocked.

5. **Balance the ventilation system.**

   Action taken: See main report.

6. **Replace stained ceiling tiles and repair water leaks.**

   Action taken: The roof of the UES was replaced prior to the reassessment. Classrooms had water damaged ceiling tiles replaced. Some water damaged plaster remains in the second floor hallway.

7. **Discard rotted pumpkin in classroom 6.**

   Action taken: Pumpkin removed from classroom.

8. **Clean rabbit cage in room 5.**

   Action taken: Rabbit removed.

Appendix A

9. **Consider using water-based markers in art room.**

   Action taken: Non water-based markers were noted in the UES. In addition, white boards are also in use in classrooms.