The Commonwealth of Massachusetts
Executive Office of Health and Human Services
Department of Public Health
250 Washington Street, Boston, MA 02108-4619

December 29, 2004

Patrick A. Schettini, Jr., Superintendent of Schools
Reading Public Schools
Administration Offices
82 Oakland Road, P.O. Box 180
Reading, MA 01867

Dear Mr. Schettini

Enclosed is a copy of the report by Cory Holmes and Sharon Lee, Environmental Analysts of our Emergency Response/Indoor Air Quality Program, on their visit to the Barrows at Wood End Elementary School to conduct an indoor air assessment. The report shows that there were problems identified. Please refer to the recommendations section for advice on how to correct these problems.

If you have any questions regarding the report or if we can be of further assistance in this matter, please feel free to call us at (617) 624-5757.

Sincerely,

Suzanne K. Condon, Associate Commissioner
Center for Environmental Health

Enclosure

cc: Mike Feeney, Director, Emergency Response/Indoor Air Quality
John Thiffault, Director of Facilities, Reading Public Schools
Donald Johnson, Assistant Director of Facilities, Reading Public Schools
Karen Callan, Principal, Barrows at Wood End Elementary School
Jane Fiore, Director, Reading Health Department
Senator Richard R. Tisei
Representative Bradley H. Jones

INDOOR AIR QUALITY ASSESSMENT

Barrows at Wood End Elementary School
85 Sunset Rock Lane
Reading, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
December 2004

Background/Introduction

After consultation with the Reading School Department (RSD) as a result of an anonymous complaint, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH) Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the newly constructed Wood End Elementary School (WEES), 85 Sunset Rock Lane, Reading, Massachusetts. The request was prompted by a school evacuation reportedly related to solvent odors from roof work conducted while the school was occupied.

On November 5, 2004, a visit to conduct an indoor air quality assessment at the WEES was made by Cory Holmes and Sharon Lee, Environmental Analysts in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Accompanying BEHA staff was Don Johnson, Assistant Director of Facilities for the RSD.

The WEES is two-story post and beam brick building. Construction of the building was completed during the summer of 2004. The upper level of the school contains general classrooms. The main level consists of the gymnasium, general classrooms, media center, administrative offices, kitchen and cafeteria. The WEES is currently occupied by students from the Barrows Elementary School, since the Barrows Elementary School is undergoing renovations. In light of present occupancy, the school is referred to as the Barrows at WEES.

On Tuesday October 26, 2004 a number of students and staff became sick as a result of odor infiltration from roofing materials (i.e., solvents and adhesive). According to school officials, roofing contractors were patching several areas on the roof during school hours. Due to the close proximity of the roofing work to rooftop air handling equipment (Picture 1), odors from materials were entrained (drawn) into the ventilation system. The Reading Fire

Department was contacted, and classrooms in the immediate area serviced by these AHUs were evacuated. Several occupants were sent to an area hospital for evaluation. As reported to the MDPH, several hours after the school was evacuated, the RSD hired Universal Environmental Consultants (UEC), an environmental consultant firm, to conduct air testing. UEC recommended that the stairwell and main office be ventilated to the outdoors using a high capacity fan (UEC, 2004).

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The school currently houses approximately 460 kindergarten through fifth grade students, as well as a staff of approximately 60. Tests were taken during normal operations at the school, and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed, indicating adequate ventilation. As previously mentioned, mechanical ventilation is provided by AHUs, four of which are located on the roof, the other two are located in a mechanical room on the ground floor. Fresh air is distributed via ceiling-mounted air diffusers and ducted back to AHUs via ceiling or wall-mounted return vents (Pictures 2 to 4). It is important to note that the location of some exhaust vents can limit exhaust efficiency. In several classrooms, exhaust vents are located above hallway doors (Picture 4). When classroom doors are open, exhaust vents will tend to draw air from both the hallway and the classroom reducing the effectiveness of the exhaust vent to remove common environmental pollutants.

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. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). Mr. Johnson stated that the system was balanced over the summer of 2004 prior to occupation.

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 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, consult Appendix A.

Temperature measurements ranged from 69° F to 75° F, which were within or very close the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. Temperature control complaints were expressed to BEHA staff in a few areas. Mr. Johnson reported that the RSD is continuing to work with the school's HVAC contractor to resolve temperature/comfort control issues. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 23 to 33 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several classrooms had a number of plants. Moistened plant soil and drip pans can be a source of mold growth. Plants are also a source of pollen. An atrium is located in the main hallway. This atrium, which is designed to serve as an indoor garden, has floor drains and a spigot/hose. During the assessment, the spigot/hose was observed to be leaking, and water was pooling against the wall in this area (Picture 5). BEHA staff conducted moisture measurements of the gypsum wallboard (GW) and found it to be saturated. Repeated water damage to porous building materials (e.g., GW, ceiling tiles, and carpet) can result in microbial 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 porous materials are not dried within this time frame, mold growth may occur. BEHA staff recommended to Mr. Johnson that this GW be dried or replaced. Mr. Johnson stated that the GW would be replaced and ceramic tiles would be installed in this area to prevent further wetting.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

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

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, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (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 established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

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

The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 3 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 1 to 10 $\mu g/m^3$. Although PM2.5 measurements were above background in some areas, they were below the NAAQS of 65 $\mu g/m^3$. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of 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.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs), such as the roofing materials (i.e., solvents and adhesives) that infiltrated into the WEES during the roof patching. VOCs are 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 determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC measurements throughout the building were also ND.

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. A number of 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.

Several areas contain photocopiers and lamination machines. 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). Lamination machines can produce irritating odors during use. These areas are equipped with local exhaust ventilation; occupants should ensure that vents are operating to help reduce excess heat and odors.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 6). 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 cause TVOCs to off-gas. 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 B (NIOSH, 1998).

Several other conditions that can affect indoor air quality were noted during the assessment. In some classrooms, items were observed on 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. A number of exhaust/return vents in classrooms and restrooms had accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles. As discussed, dust can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation. Dust can be irritating to eyes, nose and respiratory tract.

Conclusions/Recommendations

At the time of the BEHA assessment, odors from roofing materials had dissipated and measures had been taken to ventilate the building. Based upon the non-detectable results of testing for VOCs, these measures appear to have been effective. In view of the findings at the time of the visit, the following recommendations are made to improve general indoor air quality:

1. Continue to work with the roofing contractor to schedule roof repairs during unoccupied periods. Ensure that outside contractors check in with school maintenance personnel before conducting repairs/activities that create odors, dusts fumes, etc.
2. Use local exhaust ventilation and isolation techniques to control for renovation pollutants (i.e., deactivation and sealing of AHUs).
3. Continue working with HVAC contractor to troubleshoot problems and develop a preventive maintenance plan prior to turnover of ownership of mechanical ventilation system and components.
4. Change filters for air-handling equipment as per manufacturer's instructions or more frequently if needed. Ensure filters fit flush in their racks with no spaces to prevent bypass of unfiltered air.

5. Consider having the ventilation system balanced by an HVAC engineer every five years (SMACNA, 1994).
6. Ensure classroom doors are closed during periods of school occupancy to maximize exhaust ventilation.
7. Encourage faculty and staff to report concerns regarding temperature control/preventive maintenance issues to the facilities department via the main office or alternate reporting procedure.
8. 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 high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
9. Continue with plans to install ceramic tiles in the atrium to prevent wetting of GW.
10. Ensure all plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
11. Consider adopting the US EPA (2000b) document, *Tools for Schools*, in order to provide a self assessment and maintain a good indoor air quality environment at your building. The document is available from the Internet: http://www.epa.gov/iaq/schools/index.html.
12. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These documents are located on the MDPH's website: http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

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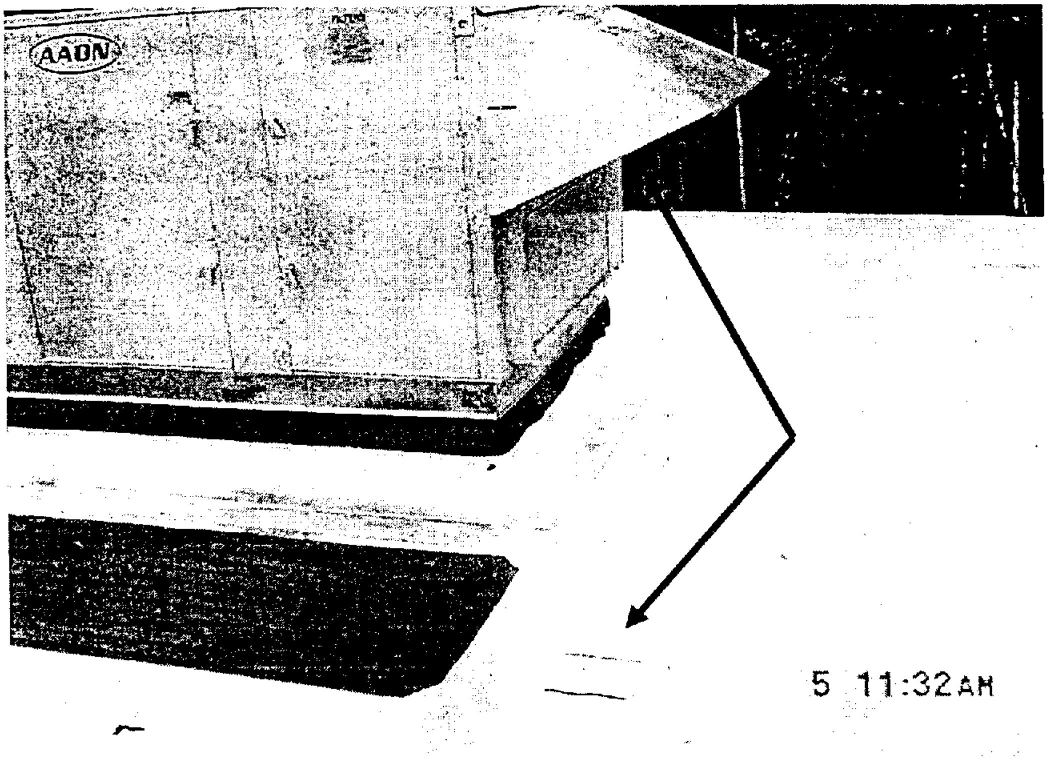
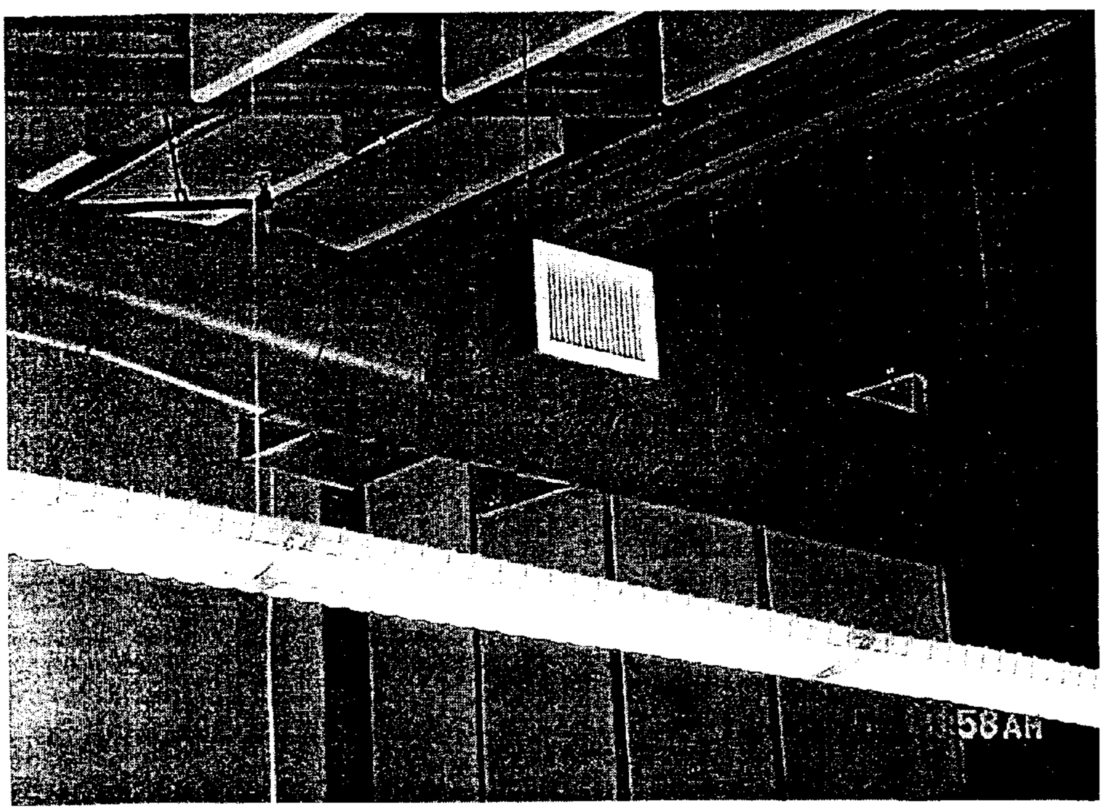
Picture 1



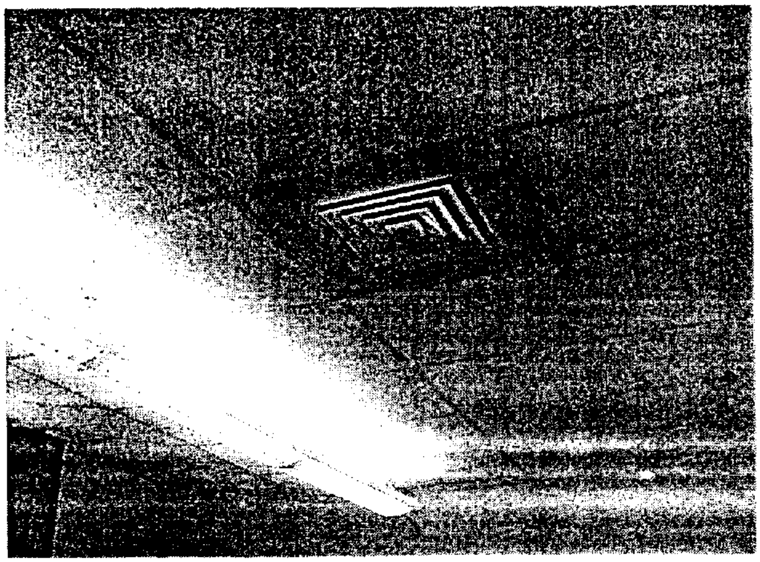
Roof Patch in Close Proximity to Rooftop Air Handling Unit Air Intake

Picture 2



Ducted Supply Diffuser

Picture 3



Ducted Supply Diffuser

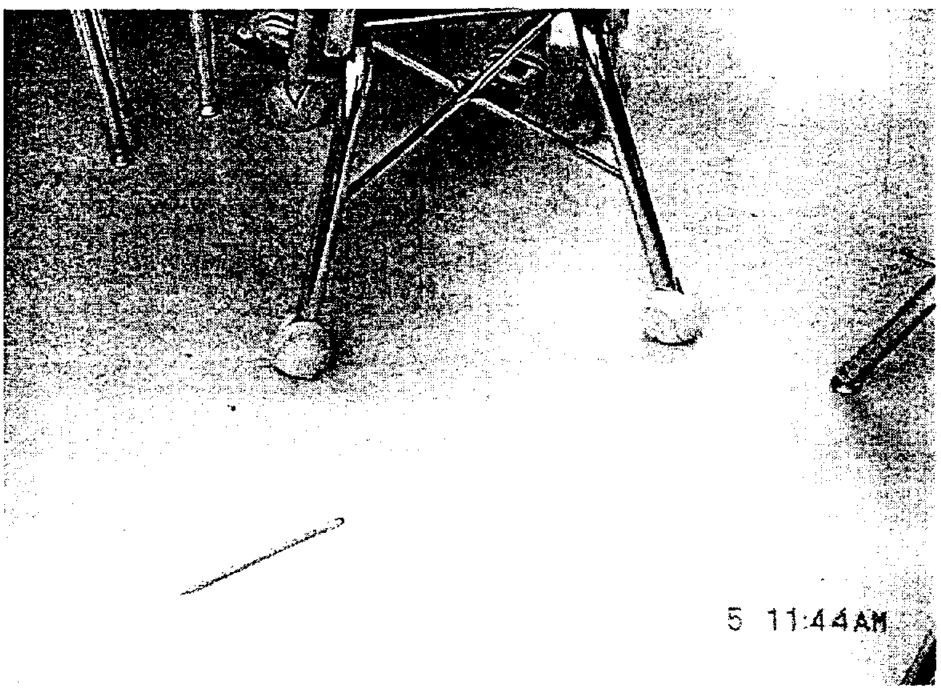
Picture 4

Return Vent, Note Proximity to Open Classroom/Hallway Door

Picture 5

Water Pooling Against Gypsum Wallboard in Atrium Area

Picture 6



Tennis Balls on Chair Legs

Barrows @ Wood End Elementary School
85 Sunset Rock Lane, Reading, MA 01867

Table 1

Indoor Air Results
November 5, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background	51	39	330	ND	ND	3		-	-	-	Partly cloudy, west wind 25-30 mph
103	71	26	473	ND	ND	4	0	Y	Y	Y	Hallway door open; DEM
105	72	26	569	ND	ND	7	19	Y	Y	Y	DEM
107	72	26	605	ND	ND	5	20	Y	Y	Y	Hallway door open; DEM, TB
109	73	24	619	ND	ND	3	20	Y	Y	Y	Hallway door open; DEM, plants
110	72	25	442	ND	ND	7	0	Y	Y	Y	DEM
111	73	26	678	ND	ND	10	21	Y	Y	Y	Hallway door open; DEM
201	73	24	635	ND	ND	3	21	Y	Y	Y	DEM, aqua/terra

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
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%

Barrows @ Wood End Elementary School

85 Sunset Rock Lane, Reading, MA 01867

Indoor Air Results

November 5, 2004

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
202	73	25	657	ND	ND	4	19	Y	Y	Y	Hallway door open; DEM, PF
203	73	27	626	ND	ND	4	26	Y	Y	Y	DEM, aqua/terra; PF - dusty
204	73	26	683	ND	ND	5	22	Y	Y	Y	Hallway door open; DEM; terra., FC re-use
205	73	26	553	ND	ND	5	1	Y	Y	Y	Hallway door open; DEM, aqua/terra; 23 occupants left ~5 minutes prior to assessment
206	73	28	789	ND	ND	4	23	Y	Y	Y	Hallway door open; DEM, PF
207	73	28	679	ND	ND	8	23	Y	Y	Y	DEM, PF; 2 windows closed upon IAQ staff entry
208	72	24	493	ND	ND	2	0	Y	Y	Y	
209	72	29	661	ND	ND	7	25	Y	Y	Y	Hallway door open; DEM

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210	72	26	629	ND	ND	4	25	Y	Y	Y	DEM
210	72	26	629	ND	ND	4	25	Y	Y	Y	Hallway door open; DEM
211	72	29	671	ND	ND	5	21	Y	Y	Y	DEM, TB
212	72	31	721	ND	ND	6	22	Y	Y	Y	Hallway door open; DEM, PF, plants
212	71	31	721	ND	ND	6	22	Y	Y	Y	Hallway door open; DEM, PF, plants
213	72	29	625	ND	ND	4	25	Y	Y	Y	Hallway door open; DEM Note: no odors detected
214	72	27	509	ND	ND	5	4	Y	Y	Y near door	Hallway open door; DEM
215	72	24	515	ND	ND	2	3	N	Y	Y	DEM and DEM odors

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									Supply	Exhaust	
216	72	25	511	ND	ND	1	3	Y	Y	Y	Hallway door open; DEM, PF
Atrium garden											Dripping faucet; GW around faucet: saturated with moisture
Cafeteria	69	26	748	ND	ND	8	~200	Y	Y	Y	Hallway door open
Conference room	74	28	638	ND	ND	2	0	Y	Y	Y	Hallway and inter-room doors open
Girls' restroom	73	26	628	ND	ND	3	0	N	N	Y	Exhaust occluded with dirt/dust
Guidance	72	27	508	ND	ND	4	5	N	Y	Y	DEM
Gymnasium	69	24	486	ND	ND	7	0	N	Y	Y	Hallway door open
Main Office	75	75	648	ND	ND	9	5	Y	Y	Y	PC

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terra. = terrarium
UF = upholstered furniture
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%

Barrows @ Wood End Elementary School
85 Sunset Rock Lane, Reading, MA 01867

Table 1

Indoor Air Results
November 5, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Media center	72	23	462	ND	ND	3	2	Y	Y	Y	DEM; 15 computers
Nurse's office	75	30	678	ND	ND	7	3	N	Y	Y Dusty	
Principal's office	74	28	657	ND	ND	1	0	Y	Y	Y	Hallway and inter-room doors open
Stairway (east), near room 202	70	30	531	ND	ND	4	25	N	N	N	No chemical/VOC odors
Stairwell (south) near gym					ND						Ventilated by local exhaust fan; no noticeable odors
Teachers' Lounge	74	33	778	ND	ND	4	7	Y	Y	Y	2 laminators
Tutor room	73	29	655	ND	ND	1	0	N	Y	Y	

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical

MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener

PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
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Comfort Guidelines

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Appendix A

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

The Bureau of Environmental Health Assessment (BEHA), Emergency Response/Indoor Air Quality (ER/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 (NIOSH, 1987; Beard, 1982).

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 school supplies normally found in any school 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. This particular building has unit ventilators, which provide heat and fresh air during operation. The introduction of fresh air both increases the comfort of the occupants and serves to dilute normally occurring environmental pollutants.

An operating exhaust ventilation system physically removes air from a room and thereby removes environmental pollutants. The operation of univents 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 BEHA 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).

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 Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings (SMACNA, 1998; Redlich, 1997; Rosenstock, 1996; OSHA, 1994; Gold, 1992; Burge et al., 1990; Norback, 1990). 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.

Appendix A

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).

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 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 Department 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.

Appendix A

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 BEHA 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 ambiant 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	Bell, A. A., 2000; SMACNA, 1998; Redlich, 1997; Rosenstock, 1996; OSHA, 1994; Gold, 1992; Burge et al., 1990; Norback, 1990
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
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

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Redlich, C.; Sparer, J.; and Cullen, M. 1997. Sick-building Syndrome. Lancet. 349:1016.

Rosenstock, L. 1996. NIOSH Testimony to the U.S. Department of Labor on Air Quality,. Appl. Occup. Environ. Hyg. 11(12):1368.

SMACNA. 1998. Indoor Air Quality: A Systems Approach. 3rd ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc, Chantilly, VA.
National Association, Inc.

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 reduce the risk of allergic reactions. These recommendations include:

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

2. Appropriate barrier protection is necessary when handling infectious materials. If you choose latex gloves, use powder-free gloves with reduced protein content.

Appendix B

3. When wearing latex gloves, do not use oil-based hand creams or lotions unless they have been shown to reduce latex-related problems.

4. Frequently clean work areas contaminated with latex dust (upholstery, carpets, ventilation ducts, and plenums).

5. Frequently change the ventilation filters and vacuum bags used in latex-contaminated areas.

6. Learn to recognize the symptoms of latex allergy: skin rashes; hives; flushing; itching; nasal, eye, or sinus symptoms; asthma; and shock.

7. 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.

8. If you have latex allergy, consult your physician regarding the following precautions:

Avoid contact with latex gloves and products.

Avoid areas where you might inhale the powder from latex gloves worn by others.

Tell your employers, physicians, nurses, and dentists that you have latex allergy.

Wear a medical alert bracelet.

9. Take advantage of latex allergy education and training provided by your employer.

Appendix B

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)
fax 513-533-8573

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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