INDOOR AIR QUALITY ASSESSMENT

Veteran's Memorial Elementary School
25 Hurd Ave
Saugus, MA 01906

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
August 2006

Background/Introduction

At the request of parents, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) was requested to provide assistance and consultation regarding indoor air quality at each of Saugus's public schools, the majority of which took place over the spring of 2006. These assessments were jointly coordinated through Sharon McCabe, Director of the Saugus Health Department, and Ralph Materissi, Director of the Saugus Building Maintenance Program. The remainder of the Saugus public schools will be scheduled over the fall of 2006. On May 12, 2006 a visit to conduct an assessment of the Veterans Memorial Elementary School (VMES) was made by Cory Holmes, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program.

The VMES is a two-story red brick building constructed in 2001. The building contains general classrooms, music room, library, art room, office space, kitchen, cafeteria, gymnasium and auditorium. Windows are openable throughout the building.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken 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 Hnu, Model 102 Snap-on Photo Ionization Detector (PID). CEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The VMES houses approximately 700 students in grades pre-K through 5 and has a staff of approximately 100. Tests were taken under normal operating conditions. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) in twelve of thirty-nine areas surveyed, indicating poor air exchange in those areas on the day of the assessment. Fresh air in classrooms is supplied by a computerized unit ventilator (univent) system (Picture 1). A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building (Picture 2) and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated/cooled and provided to classrooms through an air diffuser located in the top of the unit.

The majority of univents were operating during the assessment. Two univents were reportedly on a repair list and several were found to be deactivated by occupants; no means of mechanical ventilation were being provided in these areas during the assessment. Obstructions to airflow, such as papers and books stored on univents and items placed in front of univent returns, were seen in a number of classrooms (Picture 3). In order for univents to provide fresh air as designed, these units must be activated and allowed to operate while rooms are occupied. Univent return vents and diffusers must also remain free of obstructions.

Exhaust ventilation is provided by wall-mounted vents powered by rooftop motors (Picture 4). The majority of exhaust vents were operating, however several were not during the assessment (Table 1). Exhaust vents were also found obstructed by various items in a number of areas (Picture 5), restricting airflow. As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions.

Mechanical ventilation for common areas (e.g., offices, library, gym) is provided by rooftop air-handling units (AHUs). Fresh air is ducted to classrooms via ceiling-mounted fresh air diffusers. Exhaust air is drawn through ceiling-mounted vents and ducted back to the AHUs. These systems were functioning during the assessment.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced subsequent to installation 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 reportedly occurred prior to occupation in 2000.

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 have 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 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, see Appendix A.

Temperature readings ranged from 70^{o} F to 75^{o} F, which were within the MDPH comfort guidelines on the day of the assessment. 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. It is also difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (univents deactivated/obstructed, exhaust vents blocked).

The relative humidity measurements ranged from 46 to 62 percent, which were also within the MDPH recommended comfort range the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Breaches were observed between the counter and sink backsplashes in some classrooms (Picture 6). If not watertight, water can penetrate through these seams. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage, which can subsequently lead to mold growth.

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from ventilation sources (e.g., univent air diffusers/Picture 7) to prevent the entrainment and/or aerosolization of dirt, pollen or mold.

Other IAQ Evaluations

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, CEH 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 and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). 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, 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. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). Carbon monoxide levels measured in the school were ND (Table 1).

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, 2000a). These standards were 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 particle 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, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 13 $\mu g/m^3$ (Table 1). PM2.5 levels within the school ranged from 8 to 29 $\mu g/m^3$, which were below the NAAQS of 65 $\mu g/m^3$ (Table 1). Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate 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, operating an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials 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 determine whether VOCs were present in the building, air monitoring for TVOCs was conducted during the assessment. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC concentrations were also ND (Table 1).

In an effort to identify materials that can potentially increase indoor TVOC concentrations, CEH staff examined classrooms for products containing these respiratory irritants. Several classrooms contained dry erase boards and dry erase board markers, and many dry erase board trays contained dry erase particles. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Cleaning products were found on countertops and in unlocked cabinets beneath sinks in some classrooms (Picture 8). Many of these products appeared to be brought from home possibly without the knowledge of school personnel who maintain material data safety sheets (MSDS) for chemicals used in the school. Therefore it is unlikely that MSDSs for these materials are available on site. Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 9) in a few classrooms. Most classrooms had alternative glides installed (Picture 10). 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).

Other conditions that can affect indoor air quality were observed during the assessment. Several ceiling and wall-mounted exhaust vents were occluded with dust (Picture 11). Dust can be a source for eye and respiratory irritation. If exhaust vents are not functioning, backdrafting can occur and aerosolize dust particles. Dust particles can also be aerosolized when fans are activated. Once aerosolized, these materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently become re-aerosolized, causing further irritation.

Also of note was the amount of materials stored inside classrooms. In some classrooms items were observed on windowsills, tabletops, counters, univents, bookcases and desks. The stored materials in classrooms provide surfaces for dust to accumulate. Accumulation of these items (e.g., papers, folders, boxes) makes cleaning difficult for custodial staff.

Conclusions/Recommendations

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

1. Continue with plans to make repairs to univents.
2. Inspect exhaust motors and belts for proper function, repair and replace as necessary.
3. Once repaired, operate all ventilation systems throughout the building (e.g., gym, auditorium, classrooms) *continuously* during periods of school occupancy independent of thermostat control to maximize air exchange.
4. Remove all obstructions from univents and exhaust vents to facilitate airflow.
5. Close classroom doors to improve air exchange.
6. Use openable windows in conjunction with mechanical ventilation to introduce fresh air. Care should be taken to ensure windows are properly closed at night and weekends during winter months to avoid the freezing of pipes and potential flooding. The opening of windows should also be limited during air conditioning season to prevent condensation (i.e., outdoor relative humidity over 70%).

7. Consider adopting a balancing schedule for mechanical ventilation systems every 5 years, as recommended by ventilation industrial standards (SMACNA, 1994).
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. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).
9. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Remove plants from the air stream of univents.
10. 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.
11. 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.
12. Clean exhaust/return vents of accumulated dust periodically to prevent the aerosolization of dirt, dust and particulates.
13. Replace tennis balls on chair legs with alternative glides shown in Picture 10 to prevent latex dust generation.

14. Consider adopting the US EPA document, *Tools for Schools* (US EPA, 2000b), as a means to maintaining a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
15. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://mass.gov/dph/indoor_air

References

ASHRAE. 1989. ASHRAE Standard: Ventilation for Acceptable Indoor Air Quality. Sections 5.11, 5.12. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA.

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

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

NIOSH. 1997. NIOSH Alert Preventing Allergic Reactions to Natural Rubber latex in the Workplace. National Institute for Occupational Safety and Health, Atlanta, GA.

NIOSH. 1998. Latex Allergy A Prevention. National Institute for Occupational Safety and Health, Atlanta, GA.

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

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

SBAA. 2001. Latex In the Home And Community Updated Spring 2001. Spina Bifida Association of America, Washington, DC.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning

US EPA. 2000a. National Ambient Air Quality Standards (NAAQS). . US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

US EPA. 2000b. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/tools4s2.html

Picture 1

Classroom Univent

Picture 2

Univent Fresh Air Intake

Picture 3

Obstructed Univent Return Vent (along front of unit)

Picture 4

Rooftop Exhaust Motor

Picture 5

Classrooms Items Obstructing Exhaust Vent

Picture 6

Space between Sink Countertop and Backsplash

Picture 7

Plants near Univent Air Diffuser

Picture 8

Spray Cleaner on Classroom Countertop

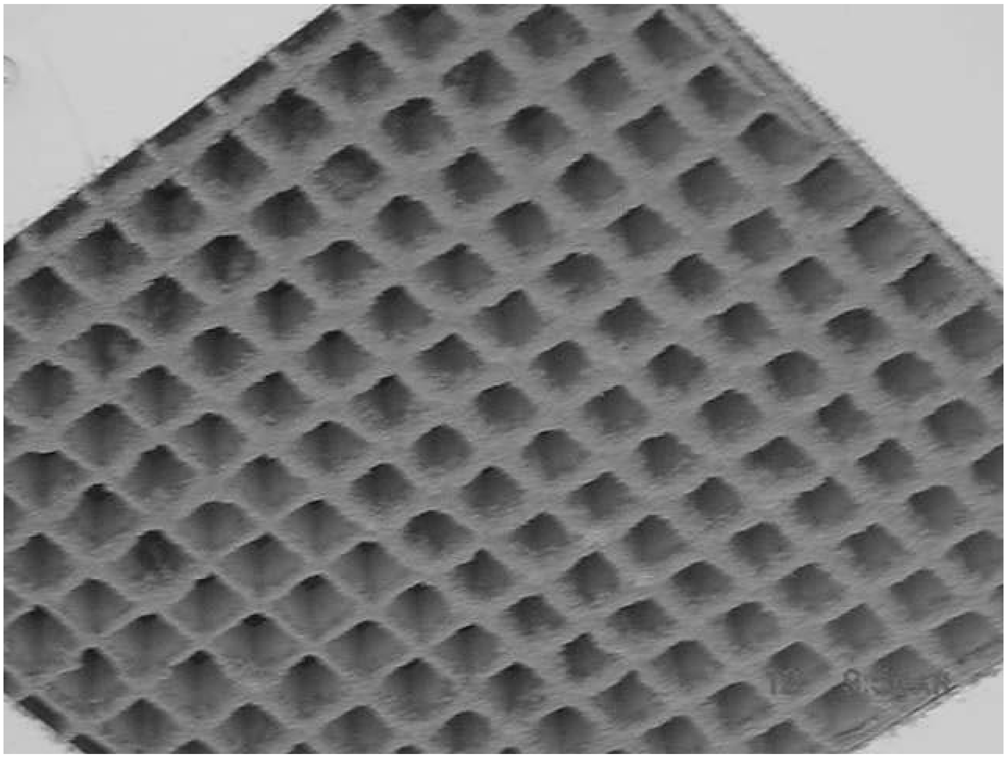
Picture 9

Tennis Balls on Chair Legs

Picture 10

Replacement for Tennis Balls on Chair Legs

Picture 11



Ceiling-Mounted Exhaust Vent Occluded with Dust

Veterans Memorial School

25 Hurd Avenue, Saugus, MA 01906

Indoor Air Results

Date: 05/12/2006

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
background		51	98	385	ND	ND	13				windy/foggy/cloudy, drizzle am.
1st floor reading room	1	72	47	560	ND	ND	21	N	Y ceiling plant(s)	Y ceiling	Hallway DO, breach sink/counter, DEM, cleaners.
art	19	71	51	711	ND	ND	8	Y # open: 0 # total: 0	Y univent plant(s)	Y wall	DEM.
art office	0	71	48	698	ND	ND	15	N	Y ceiling	Y ceiling dust/debris	Hallway DO, DEM.
cafeteria	150	71	47	560	ND	ND	10	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO,
kitchen	5	70	53	859	ND	ND	15	N			Hallway DO, Inter-room DO, NC floor-mold, mold on floor tiles, BOH ordered to be clean with bleach and water.
media center	2	71	47	592	ND	ND	9	N	Y ceiling	Y wall	Hallway DO, DEM.

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
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
VL = vent location
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%

Veterans Memorial School

25 Hurd Avenue, Saugus, MA 01906

Indoor Air Results

Date: 05/12/2006

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
music	24	71	50	720	ND	ND	9	Y # open: 0 # total: 2	Y univent items	Y wall	#WD-CT: 1, DEM.
occupational therapy	7	72	50	790	ND	ND	14	N	Y ceiling	Y ceiling	#WD-CT: 2.
office 0	8	71	50	696	ND	ND	11	N	Y ceiling	Y ceiling	Hallway DO, DEM.
small group room	1	71	50	747	ND	ND	14	N	Y ceiling	Y ceiling dust/debris	Hallway DO, DEM.
tech Lab	1	71	47	560	ND	ND	10	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 1, DEM.
101	17	73	49	729	ND	ND	15	Y # open: 0 # total: 2	Y (off)	Y	Hallway DO, breach sink/counter.
102	19	72	49	675	ND	ND	14	Y # open: 0 # total: 2	Y univent	Y wall	Hallway DO, DEM.

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
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
VL = vent location
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		

Veterans Memorial School **Indoor Air Results**

25 Hurd Avenue, Saugus, MA 01906 **Date: 05/12/2006**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
103	19	71	49	626	ND	ND	16	Y # open: 0 # total: 2	Y univent	Y wall	Hallway DO,
104	8	72	50	713	ND	ND	14	Y # open: 0 # total: 2	Y univent	Y wall (off)	breach sink/counter, DEM.
105	13	72	48	652	ND	ND	12	Y # open: 0 # total: 2	Y univent	Y wall furniture	breach sink/counter.
107	23	70	51	787	ND	ND	17	Y # open: 0 # total: 2	Y univent	Y wall	breach sink/counter, items.
108	21	73	53	1079	ND	ND	14	Y # open: 0 # total: 2	Y univent	Y wall	items.
109	0	74	51	1173	ND	ND	24	Y # open: 0 # total: 2	Y univent (off)	Y wall furniture	DEM.
110	18	71	48	812	ND	ND	14	Y # open: 0 # total: 2	Y univent	Y wall dust/debris	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
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
VL = vent location
WP = wall plaster

Comfort Guidelines

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

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
111	1	72	50	895	ND	ND	10	Y # open: 0 # total: 2	Y univent	Y wall	17 occupants gone 7 mins.
112	23	72	48	856	ND	ND	11	Y # open: 0 # total: 2	Y univent	Y wall	breach sink/counter, DEM.
113	0	71	47	616	ND	ND	15	N	Y univent plant(s)	Y wall items	breach sink/counter, DEM, occupants at lunch.
114	0	71	47	593	ND	ND	15	Y # open: 0 # total: 2	Y univent	Y wall	cleaners, occupants at lunch.
201	14	71	49	763	ND	ND	14	Y # open: 0 # total: 2	Y univent	Y wall items	Hallway DO, DEM, cleaners.
202	30	70	49	569	ND	ND	29	Y # open: 0 # total: 2	Y univent	Y wall	Hallway DO, AP, DEM, aqua/terra, occupants at lunch, UV-deactivated.
204	29	71	50	635	ND	ND	15	Y # open: 0 # total: 2	Y univent	Y wall	Hallway DO, DEM.

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
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
VL = vent location
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%

Veterans Memorial School **Indoor Air Results**

25 Hurd Avenue, Saugus, MA 01906 **Table 1** **Date: 05/12/2006**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
205	28	73	51	781	ND	ND	11	Y # open: 0 # total: 2	Y univent (off)	Y wall	Hallway DO,
207	7	71	62	675	ND	ND	12	Y # open: 0 # total: 1	Y ceiling	N	Hallway DO, Inter-room DO, plants.
208	7	72	57	831	ND	ND	16	Y # open: 0 # total: 1	Y univent plant(s)	Y wall	Hallway DO, DEM.
209	2	72	55	590	ND	ND	10	N	Y ceiling	Y ceiling	DEM.
210	23	75	51	1063	ND	ND	11	Y # open: 0 # total: 2	Y univent (off)	Y wall	DEM, UV deactivated by occupant.
211	17	72	46	642	ND	ND	8	Y # open: 0 # total: 2	Y univent	Y wall	Hallway DO, DEM, TB.
212	23	71	49	838	ND	ND	11	Y # open: 0 # total: 2	Y univent	Y wall	DEM.

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
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
VL = vent location
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%

Veterans Memorial School

25 Hurd Avenue, Saugus, MA 01906

Table 1

Indoor Air Results

Date: 05/12/2006

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
213	27	75	51	991	ND	ND	15	Y # open: 0 # total: 2	Y univent items	Y wall furniture	Hallway DO, DEM.
214	28	70	47	662	ND	ND	10	Y # open: 2 # total: 2	Y univent	Y wall (off)	breach sink/counter, DEM, TB.
215	22	70	50	892	ND	ND	9	Y # open: 0 # total: 2	Y univent (off)	Y wall (off)	breach sink/counter, DEM, TB.
216	24	70	51	786	ND	ND	9	Y # open: 0 # total: 2	Y univent	Y wall	breach sink/counter, DEM.
217	21	70	51	901	ND	ND	10	Y # open: 0 # total: 2	Y univent	Y wall	Hallway DO, DEM, plants.

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
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
VL = vent location
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%