INDOOR AIR QUALITY ASSESSMENT

East Junior High School
464 Centre Street
Brockton, Massachusetts 02302

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

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality concerns at the East Junior High School (EJHS) located at 464 Centre Street, Brockton, Massachusetts. The request was prompted by occupant complaints of water damage, mold growth, and other air quality and sanitary conditions in the building.

On April 1, 2008, Cory Holmes and James Tobin, Environmental Analysts in BEH's Indoor Air Quality (IAQ) Program conducted an indoor air quality assessment of the EJHS. BEH staff were accompanied by Doreen Quaglia, Sanitary Inspector, Brockton Health Department (BHD) and Principal Barbara Lovell during the assessment. BEH staff noted visible mold growth in the auditorium, which had been discussed in a previous report that included recommendations for remediation (MDPH, 2008). For more information concerning this report, consult Appendix A. This report describes general IAQ conditions observed in the building at the time of the assessment.

The building was previously evaluated by the Massachusetts Department of Labor and Workforce Development (MDLWD), Division of Occupational Safety (DOS) in June, 2005. To address issues found at EJHS, DOS listed the following corrective actions:

- address the roof/pointing leak in the auditorium;
- conduct mold remediation using the *US EPA Mold Remediation in Schools and Public Buildings* guidance document;
- replace water-damaged and stained ceiling tiles;
- repair damaged fire doors by replacing missing glass;
- consider running ventilation at all times when building is occupied;

- prevent mold proliferation by operating ventilation during humid months and through summer;
- provide training and personal protective equipment to employees conducting remediation activities; and
- develop an Indoor Air Quality Management Plan that incorporates and coordinates with the schools Energy Management System (MDLWD, 2005).

The school is a two-story brick building that was constructed in the early 1960s. The building contains general classrooms, science classrooms, computer rooms, a gymnasium, kitchen, cafeteria, auditorium, library, music room, office space and a wood shop. The auditorium is partially below grade and the remainder of the building is constructed on a concrete slab. The window system was replaced 7-8 years ago. The roof is flat and made of rubber membrane. It should be noted that a roof replacement was included in the Capital Improvements budget; however, this work is still pending.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted 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. BEH staff also performed a visual inspection of building materials for water damage and/or microbial growth. Moisture content of porous building materials was measured with a Delmhorst, BD-2000 Model, Moisture Detector equipped with a Delmhorst Standard Probe.

Results

The school houses approximately 600 students in grades 7 and 8 with approximately 70 staff members. 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 above 800 parts per million (ppm) in 29 of 39 areas at the time of the assessment, indicating poor air exchange in the majority of areas surveyed. Elevated carbon dioxide levels were mainly due to deactivated mechanical ventilation equipment. It is also important to note that several classrooms had open windows and/or were empty/sparsely populated, which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with full occupancy and with windows closed.

Fresh air in classrooms is supplied by unit ventilator (univent) systems (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 and provided to classrooms through an air diffuser located in the top of the unit. Univents are original to the building; therefore, efficient function of such equipment can be difficult to maintain since compatible replacement parts are often unavailable. Univents were found operating weakly or deactivated in a number of areas. Therefore, limited means at best exists to provide mechanical ventilation in these rooms at the time of the assessment. Univents were also found obstructed by books, furniture and stored materials (Picture 3). In order for univents to provide fresh air as designed, intakes/returns must remain free of obstructions. Importantly, these units must remain "on" and be allowed to operate while rooms are occupied.

Exhaust ventilation in classrooms is provided by wall or ceiling vents ducted to rooftop motors (Pictures 4 and 5). Exhaust ventilation was found deactivated in a number of areas during the assessment (Table 1). In addition, a heavy accumulation of dirt, dust and debris was observed in several exhaust vents (Pictures 6 and 7), which limits airflow. As with univents, in order to function properly, exhaust vents must be activated and allowed to operate while rooms are occupied. Without adequate supply and exhaust ventilation, excess heat and environmental pollutants can build up and lead to indoor air/comfort complaints.

Mechanical ventilation in interior rooms and common areas (e.g., gym, auditorium) is provided by rooftop or ceiling-mounted air-handling units (AHUs). Fresh air is distributed via ceiling-mounted air diffusers and ducted back to AHUs via ceiling or wall-mounted return vents.

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

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

Temperature measurements ranged from 68^{o} F to 77^{o} F, which were within or slightly below the lower end of the MDPH recommended comfort range during 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. A lack of temperature control was expressed in a number of areas. It is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents/exhaust vents deactivated/obstructed).

The relative humidity in the building ranged from 43 to 65 percent, which was 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

Several potential sources of water damage and/or mold growth were observed. Numerous areas had water-damaged/missing ceiling tiles and/or stains on walls, which can indicate leaks from either the roof or plumbing system (Picture 8/Table 1). Active roof leaks were reported and evidenced in the form of water damaged building materials in various rooms and hallways throughout the building. In order to prevent water from pooling above the ceiling, holes were cut in ceiling tiles allowing water to drain (Picture 9). The ceiling tile system at EJHS consists of inter-locking tiles that necessitate removal of portions of the ceiling, which makes removal/replacement difficult. In the gym hallway, mold was visible on a ceiling tile (Picture 10). However, there was no evidence of further mold growth above the ceiling tiles. Dark staining was observed on the gym hallway wall; however, the substance appeared to be from roofing material and not mold growth (Picture 11). Water-damaged ceiling tiles can indicate sources of water penetration and provide a source of mold. Ceiling tiles should be replaced after a water leak is discovered and repaired.

As discussed in detail in a previous MDPH report, visible mold growth was observed in the auditorium. Consult that report for more information about remediation (MDPH, 2008).

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

Several exterior doors throughout the building had damaged weather stripping, and light could be seen penetrating through the spaces underneath the door from the outdoors (Picture 12). Spaces beneath exterior doors can serve as a source of water entry into the building, causing water damage and potentially leading to mold growth. In addition, these spaces can serve as pathways for insects, rodents and other pests into the building. Rodent droppings were observed in one classroom (105).

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

Pooling water was observed in a number of areas on the roof (Picture 13) due to lack of drainage. The freezing and thawing of water during winter months can lead to roof leaks and subsequent water penetration into the interior of the building. Pooling water can also become stagnant, which can lead to mold and bacterial growth, and serve as a breeding ground for mosquitoes.

BEH staff examined the exterior of the building to identify breaches in the building envelope that could provide a source of water penetration. Several potential sources were identified:

- Exterior brickwork was visibly moist and had moss growth on the surface (Pictures 14 and 15). Moss growth is a sign of heavy/continuous water exposure and holds moisture against the building;
- Shrubbery/trees growing in close proximity to the building (Picture 15), which holds moisture against exterior brick and prevents drying;
- Missing/damaged mortar and exterior brick (Pictures 16 and 17);
- Open utility holes (Picture 18);
- Corroded/damaged metal bulkhead in the rear of the building (Picture 19);
- Missing/damaged joint compound (Picture 20); and
- Missing/damaged caulking around univent fresh air intakes (Picture 16).

The aforementioned conditions represent potential water penetration sources. Over time, these conditions can undermine the integrity of the building envelope and provide a means of water entry into the building via capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001). In addition, these breaches may provide a means for pests/rodents into the building.

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, BEH staff obtained measurements for carbon monoxide and PM2.5.

Carbon Monoxide

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

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

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

Particulate Matter (PM2.5)

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

PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 19 $\mu g/m^3$ (Table 1). PM2.5 levels measured in the school were between 6 to 19 $\mu g/m^3$ (Table 1), which were below the NAAQS PM2.5 level of 35 $\mu g/m^3$. 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.

TVOCs

Indoor air concentrations can be greatly impacted by the use of products containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to identify materials that can potentially increase indoor VOC concentrations, BEH staff examined classrooms for products containing these respiratory irritants.

Several classrooms contained dry erase boards and dry erase board markers. 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 also found on countertops and in unlocked cabinets beneath sinks in some classrooms. Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

Other conditions that can affect indoor air quality were observed during the assessment. In several classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks (Pictures 21 and 22). The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

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

A number of exhaust/return vents, univent air diffusers and personal fans were observed to have accumulated dust/debris (Pictures 6 and 7). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles. Re-activated univents and fans can also aerosolize dust accumulated on vents/fan blades.

Several areas had window-mounted air conditioners (ACs) (Picture 23). ACs are normally equipped with filters, which should be cleaned or changed as per manufacturer's instructions to avoid the build-up and re-aerosolization of dirt, dust and particulate matter.

Finally, in several areas of the building, BEH staff observed extensive wall damage (Picture 24). These breaches (if opened into wall cavities) can provide pathways for drafts, dust, odors and particulates to migrate into occupied areas.

Conclusions/Recommendations

The conditions related to indoor air quality problems at the EJHS raise a number of issues. The general building conditions, maintenance, work hygiene practices and the condition of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further degrade indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is recommended. The first consists of **short-term** measures to improve air quality and the second consists of **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Continue to implement corrective actions listed in the DOS report (MDLWD, 2005).
2. Operate all ventilation systems throughout the building (e.g., gym, cafeteria, classrooms) continuously during periods of school occupancy and independent of thermostat control. To increase airflow in classrooms, set univent controls to “high”.
3. Inspect exhaust motors and belts for proper function. Repair and replace as necessary.
4. Remove all blockages from univents and exhaust vents to ensure adequate airflow.

5. Use openable windows in conjunction with classroom univents and exhaust vents to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
6. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
7. 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).
8. Until roof can be replaced, continue to patch roof leaks as needed. Remove/replace any water damaged ceiling tiles.
9. Clean staining on walls in gym hallway (shown in Picture 11).
10. Install weather stripping around exterior doors to prevent drafts, water penetration and pest entry.
11. Examine all expansion joint seals on the exterior wall system. Reseal all expansion joints with damaged, missing or eroded sealant.
12. Make repairs/replace damaged metal bulkhead at the rear of the building and seal spaces around exterior utility holes.

13. Move plants away from univents in classrooms. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
14. 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.
15. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
16. Clean personal fans, univent air diffusers, return vents and exhaust vents periodically of accumulated dust.
17. Clean chalk and dry erase trays to prevent accumulation of materials.
18. Change filters for air-handling equipment (e.g., univents, AHUs and ACs) as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.
19. Seal any open holes/breaches in interior walls to prevent the migration of drafts, odors, particulates from wall cavities into occupied areas.
20. Consider adopting the US EPA (2000) document, "Tools for Schools", as an instrument for maintaining a good indoor air quality environment in the building. This document is available at: http://www.epa.gov/iaq/schools/index.html.

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

The following **long-term measures** should be considered:

1. Continue with plans for roof replacement to prevent further leaks into the building interior. Plans for roof work should include improved drainage to prevent pooling.
2. Consider total removal/replacement of interlocking ceiling tile system.
3. Contact an HVAC engineering firm for an assessment of the ventilation system (e.g., controls, air intake louvers, thermostats). Based on the age, physical deterioration and availability of parts for ventilation components, such an evaluation is necessary to determine the operability and feasibility of repairing/replacing the equipment.

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Picture 1

Classroom Univent

Picture 2

Univent Fresh Air Intake

Picture 3

Univent Blocked by Desk and Papers

Picture 4

Wall-mounted Exhaust Vent

Picture 5

Rooftop Exhaust Motors

Picture 6

Accumulation of Dirt, Dust and Debris in Cafeteria Exhaust Vent, Note Vent is almost Completely Occluded Preventing Airflow

Picture 7

Accumulation of Dust and Debris in Exhaust Vent in classroom

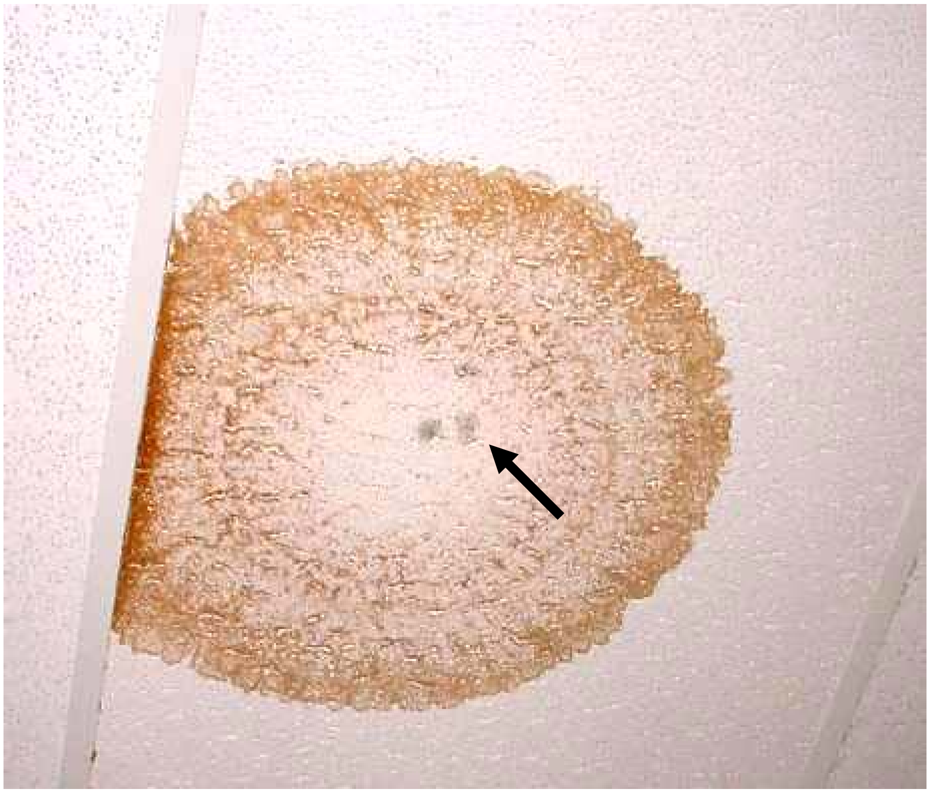
Picture 8

Water-damaged Ceiling Tiles

Picture 9

Holes Cut in Ceiling Tile to Allow Water to Drain

Picture 10



Visible Mold (Dark Staining in Center)
on Water Damaged Ceiling Tile in Gymnasium Hallway

Picture 11

Dark Staining on Wall in Gym Hallway

Picture 12

Damaged Weather Stripping on Exterior Door, Note Light Penetration

Picture 13

Water Pooling on Roof over Main Entrance

Picture 14

Moss Growth (Dark Staining) on Exterior Brickwork

Picture 15

Moss (Dark Staining along Base) and Tree Growth on/near Exterior Brickwork

Picture 16

Damaged Mortar and Exterior Wall Cracks

Picture 17

Damaged Mortar and Exterior Brick

Picture 18

Open Utility Hole on Building Exterior

Picture 19

Corroded/Damaged Metal Bulkhead at Rear of Building

Picture 20

Missing/Damaged Joint Compound

Picture 21

Accumulated Items on Flat Surfaces in Classroom

Picture 22

Accumulated Items on Flat Surfaces in Classroom

Picture 23

Window-mounted AC

Picture 24

Damaged Interior Wall in Classroom

Location: East Junior High School | **Indoor Air Results**

Address: 464 Centre Street, Brockton, MA 02302 | **Date: 4-1-2008**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
background		60	83	402	ND	19				overcast
100	1	71	58	568	ND	8	Y	N	N	CD; DEM; 2 WD CT
101	27	72	65	1018	ND	10	Y	Y	Y	Univent weak; plants; windows open; PF
102	9	70	60	491	ND	8	Y	Y	Y	Exhaust off; DEM; CD
103	24	74	62	1961	ND	19	Y	Y	Y	Exhaust off, debris in vents
104	16	71	60	624	ND	10	Y	Y	Y	Supply off; exhaust off; CD; DEM
105	20	73	59	1043	ND	13	Y	Y	Y	Exhaust off; 7 WD CT along windows; rodent droppings
106	15	73	60	1217	ND	14	Y	Y	Y	Exhaust off, blocked; clutter; cleaners; DEM
107	12	72	57	1089	ND	12	Y	Y	Y	Exhaust off; 10 WD CT along window; DO
108	24	74	58	1122	ND	9	Y	Y	Y	Vents blocked by student chairs; clutter; cleaners

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
AC = air conditioner
BD = backdraft
CD = chalk dust
CT = ceiling tile
DEM = dry erase materials
DO = door open
PF = personal fan
PS = pencil shavings
WD = water-damaged

Comfort Guidelines

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

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

Location: East Junior High School **Indoor Air Results**

Address: 464 Centre Street, Brockton, MA 02302 **Table 1 (continued)** **Date: 4-1-2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
109	28	74	59	1289	ND	14	Y	Y	Y	WD wall plaster; 6 WD CT along window
110	15	74	55	865	ND	8	Y	Y	Y	Supply blocked by items; exhaust off, blocked; DEM; cleaners; CD; PF; microwave; stove; washer; dryer; refrigerator
111	25	74	58	1328	ND	11	Y	Y	Y	Plants; PF; 3 WD CT
112	14	73	57	887	ND	11	Y	Y	Y	DEM; cleaners
113	26	74	57	1069	ND	15	Y	Y	Y	Windows open; 4 WD CT
114	16	71	56	593	ND	14	Y	Y	Y	Exhaust off; windows open
116	11	73	50	980	ND	17	Y	Y	Y	Exhaust off; DO; 1 WD CT in corner
201	16	75	50	982	ND	12	Y	Y	Y	Exhaust off; windows open
202	16	73	54	606	ND	13	Y	Y	Y	Windows open; 6 WD CT

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Address: 464 Centre Street, Brockton, MA 02302 **Table 1 (continued)** **Date: 4-1-2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
203	19	75	51	966	ND	10	Y	Y	Y	Exhaust off; cleaners; clutters; DEM
204	15	76	49	800	ND	13	Y	Y	Y	Exhaust off
205	21	76	51	837	ND	9	Y	Y	Y	Univent blocked by items; exhaust off; cleaners; AC; DEM
206	15	77	49	836	ND	11	Y	Y	Y	Exhaust off; PF
207	9	76	47	846	ND	10	Y	Y	Y	Exhaust off; windows open; cleaners; clutter; CD; DEM
208	9	75	48	709	ND	16	Y	Y	Y	Univent-items on top; windows open; PF; DO
209	16	77	46	943	ND	13	Y	Y	Y	Univent blocked by boxes; exhaust off; windows open; clutter; DEM; CD
210	0	76	44	590	ND	13	Y	Y	Y	Univent off; exhaust off; DO
211	20	75	52	935	ND	12	Y	Y	Y	Exhaust off; wall damage; DEM; CD; PF; DO
212	0	76	48	548	ND	9	Y	Y	Y	Exhaust off, BD; cleaners; PF

ppm = parts per million
μg/m^3 = micrograms per cubic meter
ND = non detect
AC = air conditioner
BD = backdraft
CD = chalk dust
CT = ceiling tile
DEM = dry erase materials
DO = door open
PF = personal fan
PS = pencil shavings
WD = water-damaged

Comfort Guidelines

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

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

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
214	22	75	52	920	ND	16	Y	Y	Y	Univent off, items on top; exhaust off; debris accumulated items; windows open
Art	22	73	46	1462	ND	10	Y	Y	Y	Exhaust off
Auditorium	0	68	55	420	ND	6	N	Y	Y	Visible mold growth on vinyl wall paper; moisture levels high; musty smell; WD wall plaster; damaged CT; space under exterior door
Auditorium classroom	25	71	49	874	ND	11	Y	N	N	Active leak near entrance reported; missing WD CTs
Café	200	75	60	1693	ND	15	Y	Y	Y	Exhaust vent blocked by trash and papers in vent
Café Hallway										WD ceiling plaster; holes
Gym	24	73	45	862	ND	7	N	Y	Y	
Gym Hallway										Numerous WD CT, one with visible mold-low moisture measurements; dark stain on wall; space under exterior door

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Comfort Guidelines

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

Location: East Junior High School **Indoor Air Results**

Address: 464 Centre Street, Brockton, MA 02302 **Table 1 (continued)** **Date: 4-1-2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Library	0	77	43	918	ND	14	Y	Y	Y	Univent-heat but no air ; aquarium; DEM; window open
Music	19	70	54	1224	ND	14	Y	Y	Y	Supply vents off; drafts from exhaust vents; plants; DEM; numerous WD CT
PLATO	3	72	45	882	ND	8	Y	Y	Y	AC-dirty vents; DEM
Shop II Computers	18	73	44	983	ND	9	Y	Y	Y	ACs; 26 computers
Woodshop	10	70	44	658	ND	9	Y	Y	Y	Local exhaust good

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