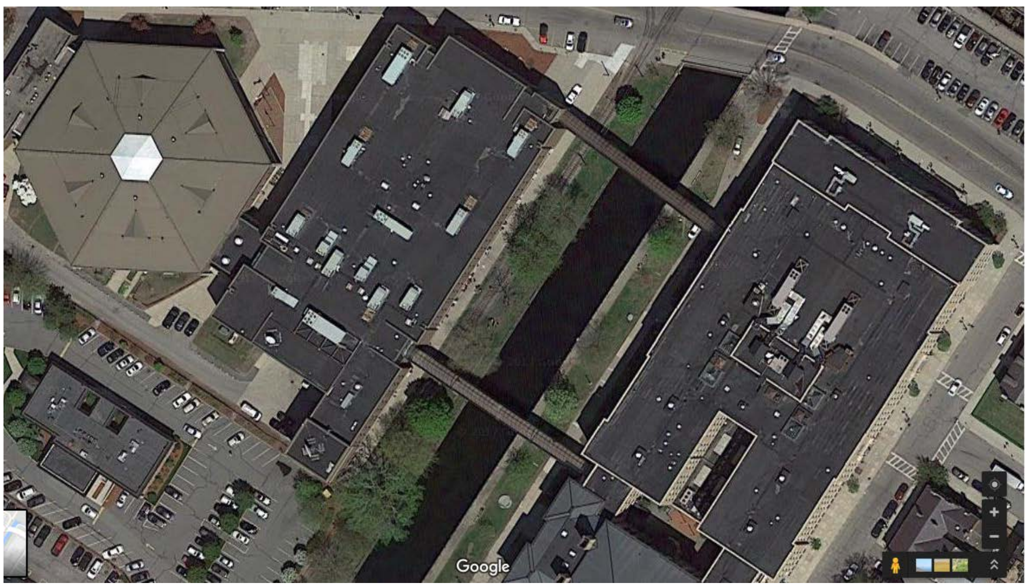
BOH HANDOUT 1/8/20
APPENDIX B & C ADDED

INDOOR AIR QUALITY REASSESSMENT

Lowell High School
"1980 Building"
50 Father Morissette Boulevard
Lowell, MA



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
December 2019

Background

Building:	Lowell High School (LHS) "1980s" building
Address:	50 Father Morissette Boulevard, Lowell, MA
Assessment Coordinated Through:	Lowell Public Schools
Reason for Request:	Reassessment based on actions taken since the previous visit in 2017.
Date of Assessment:	October 25, 2019
Massachusetts Department of Public Health/Bureau of Environmental Health (MDPH/BEH) Staff Conducting Assessment:	Jason Dustin, Environmental Analyst' Cory Holmes, Environmental Analyst, Ruth Alfasso, Environmental Engineer, and Mike Feeney Director, Indoor Air Quality Program (IAQ)
Building Description:	The building at 50 Father Morissette Boulevard is a brick and concrete complex constructed in 1980. It has an attached fieldhouse containing gymnasiums, locker rooms, and a pool, which is now closed. This building is connected to the building at 14 French Street by several enclosed walkways.
Windows:	Openable

This school was visited previously in 2017. Two visits were made: one during the summer when the school was unoccupied and again in the fall during normal occupancy. Recommendations were made in a report following each visit. The MDPH/IAQ Program returned to the school this year for a follow-up visit, in part to assess the response to recommendations made in our previous report as well as to provide further recommendations to improve IAQ. Appendix A shows recommendations from both 2017 reports. In addition, the LHS complex will be undergoing significant renovations over the next several years. Recommendations included in this report will also address planning for renovation-related issues.

Methods

Please refer to the IAQ Manual for methods, sampling procedures, and interpretation of results (MDPH, 2015).

IAQ Testing Results

Table 1 includes indoor air testing results, which are summarized below.

- ***Carbon dioxide levels*** were above the MDPH guideline of 800 parts per million (ppm) in about half of all areas assessed, indicating a lack of air exchange in those areas of the building. Appendix B is an additional resource about carbon dioxide.
- ***Temperature*** was within the recommended range of 70°F to 78°F in all areas the day of assessment.
- ***Relative humidity*** was within or close to the lower end of the recommended range of 40 to 60% in the areas tested.
- ***Carbon monoxide*** levels were non-detectable (ND) in the areas tested.
- ***Fine particulate matter (PM2.5)*** concentrations measured were below the National Ambient Air Quality (NAAQS) limit of 35 $\mu g/m^3$ in all areas tested.

Ventilation

A heating, ventilating, and air conditioning (HVAC) system has several functions. First it provides heating and, if equipped, cooling. Second, it is a source of fresh air. Finally, an HVAC system will dilute and remove normally occurring indoor environmental pollutants by not only introducing fresh air, but by filtering the airstream and ejecting stale air to the outdoors via exhaust ventilation. Even if an HVAC system is operating as designed, point sources of respiratory irritation may exist and cause symptoms in sensitive individuals.

Fresh air is provided by multiple air-handling units (AHUs) located on the roof. The AHUs are mostly "packaged" units that provide both heat and air conditioning (AC). Fresh air intakes draw in fresh air through an intake vent where it is filtered, then heated or cooled. The conditioned fresh air is mixed with some air returned from classrooms, then supplied to rooms through supply diffusers/grates throughout the building (Picture 1). Return vents (Picture 2) bring stale air back to the AHUs where a portion of this air is exhausted through louvers. The HVAC systems should be regularly maintained and operate continuously during occupied hours.

Based on air sampling, many classrooms with normal occupancy appeared to have a lack of air exchange provided by the HVAC system in its current operating mode. Given the age and operation of the existing HVAC system, it may be necessary to use openable windows to supplement fresh air supply for classrooms. It may be possible to adjust AHUs to allow more fresh air into the system, e.g. by opening supply louvers or adjusting the proportion of air exhausted rather than recirculated. Exhaust ventilation should also be checked periodically to ensure a draw of air from classrooms. In addition, no air circulation was detected in the Nurse's suite from either the supply or return/exhaust vents. This area is entirely dependent on mechanical ventilation for it has no windows.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air while removing stale air from a room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). It is unknown the last time these systems were balanced.

Microbial/Moisture Concerns

Water-damaged ceiling tiles and plaster walls were observed in many classrooms, offices, and hallways (Picture 1, 3 and 4; Table 1), indicating leaks from the building envelope or plumbing system. The roof of the 1980s building has not undergone any significant repair/replacement since the previous IAQ visit in 2017, so roof leaks account for the majority of stained ceiling tiles. In addition, occupants report active leaks in some areas.

Ceiling tiles should be replaced after the leak is found and repaired. In general, ceiling tiles have an open space above them (the ceiling plenum) and tend to dry out quickly, reducing the chance for mold colonization. Ceiling plaster does not contain organic material; therefore, it will not support microbial growth even when frequently moistened. In some cases, dust or paint on the surface of plaster can become mold colonized. If this occurs, plaster can often be cleaned to remove the mold.

In many areas, ceiling tiles were also missing (Picture 5; Table 1). These need to be replaced to maintain a continuous ceiling plenum and prevent dust and debris from above the ceiling tiles entering occupied areas.

Carpeting is a material that can become water-damaged and colonized with mold. The BEH/IAQ Program does not recommend the use of carpeting in schools, particularly in ground floor or basement levels, due to the likelihood of it becoming moistened due to spills, tracked in moisture, and condensation. During the previous visits to LHS, musty odors were noted in many classrooms with carpeting, and carpeting in the building was mostly found to be beyond its service life and in poor condition. Much of the older carpeting has been removed from the building since the 2017 visit (Table 1).

Some old carpeting remains in the building including some that is visibly stained, wrinkled, or threadbare (Table 1), indicating it was past its service life. The service life of carpeting in schools is approximately 10-11 years (IICRC, 2002). Aging carpet can produce fibers that can be irritating to the respiratory system. In addition, tears or lifting carpet can create tripping hazards. Carpeting should be cleaned annually or semi-annually in soiled high traffic areas as per the recommendations of the Institute of Inspection, Cleaning, and Restoration Certification (IICRC, 2012).

Measures should be taken to ensure water-damaged materials are cleaned, replaced, and/or repaired in a manner consistent with the U.S. Environmental Protection Agency's guidelines (US EPA, 2008). The US EPA and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials (e.g., ceiling tiles, gypsum wallboard) be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2008; ACGIH, 1989). If not dried within this time frame they should be removed/discarded.

Some areas in the buildings are equipped with AC from the AHUs. Doors between these areas and non-air-conditioned areas should be kept closed to prevent condensation of humid air on chilled surfaces. Windows should also not be opened in a room while AC is operating. This can lead to condensation on surfaces chilled by air conditioning which can moisten building materials.

Windows are openable in most exterior classrooms. Open windows can be an additional source of fresh air. However, windows need to be tightly closed at the end of each day to prevent water infiltration and pest intrusion. A window was found closed around ivy, which prevents a tight seal (Picture 6). In addition, ivy and other plants should be removed from in and adjacent to the exterior of the building as plants can hold water against the exterior and lead to building envelope deterioration. They can also be a source of pollen and odors through open windows.

Refrigerators and microwaves were found in some classrooms and offices (Table 1), which should be kept clean and free of spills and spoiled food (Picture 7). Refrigerators and water dispensers should not be placed in carpeted areas where spills or leaks could moisten carpeting.

There are sinks in some classrooms (and other areas; Table 1), some of which appear not to be used. There may also be unused floor drains. The trap seals in unused drains can dry out and allow sewer gas and odors into occupied areas. Seldom used drains should be wetted periodically to maintain the trap seal. Some science rooms had safety showers, which should be monitored and maintained to prevent leaks. No porous materials should be stored under or near the safety showers.

Other Conditions

Exposure to low levels of volatile organic compounds (VOCs) may produce eye, nose, throat, and/or respiratory irritation in some sensitive individuals. BEH/IAQ staff examined spaces for products containing VOCs, noting cleaning products, air fresheners, hand sanitizers and dry erase materials in a number of areas throughout the space (Table 1). All of these products have the potential to be irritants to the eyes, nose, throat, and respiratory system of sensitive individuals. Other sources of total volatile organic compounds (TVOCs) include copy machines and laminators. Excess heat, odors, 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). Laminators produce TVOCs and plastic odors. This equipment should be used in well-ventilated areas away from occupants.

Some occupants reported problems with mice in occupied areas. Mouse urine is a known sensitizer/allergen having irritant effects upon some occupants.

In many areas, items, including books, papers, and decorative items were observed on floors, windowsills, tabletops, counters, bookcases, and desks, which can make it more difficult for custodial staff to clean (Table 1). Many classrooms had personal fans and some of these had dusty blades. Many supply and exhaust vents were also observed to be dusty (Picture 2; Table 1). Dust on ventilation and fan equipment can be aerosolized when the units are activated.

Conclusions/Recommendations

The following recommendations are made to assist in improving IAQ:

1. Consult A for previous recommendations that need additional work.

2. Operate supply and exhaust ventilation continuously during occupied hours. Adjust ventilation equipment (e.g. louvers, flow rates) where possible to increase fresh air, particularly to frequently used classrooms.
3. Do not block supply or exhaust vents with furniture or items. Check exhaust/return vents periodically for proper function. Where exhaust vents are switch-operated, ensure they are turned on when the room is occupied.
4. Ensure mechanical ventilation to the Nurse's suite is functional/operating; make repairs as needed.
5. Use openable windows to supplement fresh air during temperate weather. Ensure all windows are tightly closed at the end of the day. Inform occupants that windows should not be opened while the HVAC system is in cooling mode to avoid condensation.
6. Ensure areas which generate pollutants, such as cooking class areas, have operable exhaust functioning.
7. Ensure that a system of regular "Operations and Maintenance" remains in place to keep HVAC systems in proper working order.
8. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
9. Replace remaining water-damaged ceiling tiles and monitor for new leaks (e.g., room 617). Prioritize replacement of ceiling tiles with potential mold staining and in frequently-occupied areas.
10. Remove remaining water-damaged, musty, or worn carpeting. Replace with non-porous materials if possible.
11. Repair water-damaged plaster.
12. Repair/replace any other water-damaged/mold-colonized porous building materials (e.g., gypsum wallboard) in classrooms, hallways and stairwell areas.
13. Ensure water-damaged materials are cleaned, replaced, and/or repaired in a manner consistent with the U.S. Environmental Protection Agency's guidelines (US EPA, 2008).
14. Replace any missing or ajar ceiling tiles to avoid pathways to unconditioned areas.
15. Regularly inspect window and portable air conditioning units to ensure proper drainage of condensate and regular cleaning of filters.

16. Ensure that doors are closed between areas with air conditioning and areas without air conditioning, to avoid condensation of humid air on chilled surfaces.
17. Refrain from storing porous items (e.g., boxes, books, paper, clothing) directly on flooring, in below grade spaces, under sink cabinets and near safety showers to avoid microbial colonization.
18. Ensure unused or seldom used drains are wetted periodically to maintain the trap seal.
19. Avoid placing refrigerators and water dispensers on carpet.
20. Clean refrigerators frequently to prevent spills and odors.
21. Trim back trees/vegetation within 5′ of the building. Remove vegetation (e.g., ivy) that is growing on the building to avoid damage to exterior from associated moisture.
22. Reduce the use of products containing fragrances and VOCs.
23. Locate photocopiers and laminators in well ventilated areas away from occupants.
24. Ensure Material Safety Sheets are available for all laboratory, maintenance and janitorial chemicals used in the building.
25. Contract with a pest control company to regularly inspect and control mice in occupied areas. Keep food in secure containers and seal any pathways that may allow rodent entry to the building. Thoroughly clean areas where mice have been observed to remove mouse dander and urine which are common allergens.
26. Regularly clean supply/return vents and fans to avoid aerosolizing accumulated particulate matter.
27. Consider reducing the amount of items stored in classrooms to make cleaning easier. Periodically move items to clean flat surfaces.
28. Clean any remaining carpeting and area rugs annually or more often in high-traffic locations in accordance with IICRC recommendations (IICRC, 2012) and discard those that are worn out or too soiled to be cleaned.
29. Encourage faculty to report classroom/building related issues via a tracking program.
30. 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).

31. As construction on this building is planned and commences, use the guidance "Methods Used to Reduce/Prevent Exposure to Construction/Renovation Generated Pollutants in Occupied Buildings" which is included as Appendix C.
32. Continue to adopt the US EPA (2000) document, "Tools for Schools", as an instrument for maintaining a good IAQ environment in the building available at: http://www.epa.gov/iaq/schools/index.html.
33. Refer to resource manual and other related IAQ 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/iaq.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

IICRC. 2002. Institute of Inspection, Cleaning and Restoration Certification. A Life-Cycle Cost Analysis for Floor Coverings in School Facilities.

IICRC. 2012. Institute of Inspection, Cleaning and Restoration Certification. Carpet Cleaning: FAQ.

MDPH. 2015. Massachusetts Department of Public Health. "Indoor Air Quality Manual: Chapters I-III". Available at: http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/exposure-topics/iaq/iaq-manual/.

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 2000. 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/index.html.

US EPA. 2008. "Mold Remediation in Schools and Commercial Buildings". Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. September 2008. Available at: http://www.epa.gov/mold/mold-remediation-schools-and-commercial-buildings-guide.

Picture 1

Supply vent (arrow) and water-damaged ceiling tiles

Picture 2

Return/exhaust vent, note dust on vent

Picture 3

Water-damaged ceiling tiles

Picture 4

Water-damaged ceiling tiles

Picture 5

Missing ceiling tiles

Picture 6

Ivy coming in window

Picture 7

Microwave with food spill

Location: Lowell High School 1980 building **Indoor Air Results**

Address: 50 Father Morisette Blvd, Lowell **Table 1** **Date: 10/25/2019**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background (outside)	422	ND	59	52	12	-	-	-	-	
Third Floor										
Mr. O'Keefe	1000	ND	74	44	14	1	N	Y	Y	DEM, NC
Hosmer office	906	ND	76	41	11	1	N	Y	Y	NC
Quinton office	943	ND	74	41	11	1	N	Y	Y	NC, fridge
Consultant's office	852	ND	74	40	12	0	N	Y	Y	NC
Plant room	760	ND	76	38	12	1	N	N	Y	PC, WD CT, floor drain, sink (currently used as an office)
Hallway next to plant room	-	-	-	-	-	-	-	-	-	WD CTs, MTs
610A	957	ND	74	39	12	1	N	Y	Y	HS, WD, DEM, computers

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
AF = air freshener
AI = accumulated items
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
GW = gypsum wallboard
HS = hand sanitizer
MT = missing CT
NC = not carpeted
PC = photocopier
PF = personal fan
WD = water-damaged

Comfort Guidelines

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

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
610B	746	ND	73	39	11	1	N	Y	Y	Carpet, DEM
612	1810	ND	74	48	14	25	N	Y	Y	HS, WD
613	1328	ND	74	44	14	30 gone 20 minute	N	Y	Y	Active WD CTs
614	1107	ND	73	44	12	26	N	Y	Y	DEM, HS
615	1027	ND	73	44	12	1	N	Y	Y	WD CTs, DEM
616	941	ND	72	42	12	25	N	Y	Y	MT, WD CT
617	1126	ND	73	43	7	15	Y	Y	Y	NC, WD CT and MT, reports of leaks “raining inside”, DEM
619	1227	ND	73	47	10	26	N	Y	Y	
620	1232	ND	75	42	10	0	N	Y	Y	NC, DEM, PF

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
AF = air freshener
AI = accumulated items
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
GW = gypsum wallboard
HS = hand sanitizer
MT = missing CT
NC = not carpeted
PC = photocopier
PF = personal fan
WD = water-damaged

Comfort Guidelines

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

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
622C	770	ND	75	39	9	11	N	Y	Y	4 MT, WD CT, dusty vents and adjacent CT, DEM, NC
623	1223	ND	75	41	9	30	N	Y	Y	NC, DEM, 4 WD CT
624	1028	ND	75	39	8	0	N	Y	Y	DEM, loud vent, dusty vents and dusty CT
624 science lab	1088	ND	75	40	8	0	N	Y	Y	Science sinks, one drips, AI, fridge and microwave
625	978	ND	74	39	8	1	N	Y	Y	DEM, CP
625 science lab	1008	ND	75	39	9	16	N	Y	Y	Science class in progress, DEM, dusty vents, auxiliary exhaust in lab – on
625 Science prep room									Y	Chemical storage in cabinets and shelves
626	849	ND	74	38	8	25	N	Y	Y	4 WD CT
626 lab	808	ND	74	37	7	3	N	Y	Y	Sink, dusty vents, CP, WD CT

ppm = parts per million
µg/m³ = micrograms per cubic meter
ND = non detect
AF = air freshener
AI = accumulated items
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
GW = gypsum wallboard
HS = hand sanitizer
MT = missing CT
NC = not carpeted
PC = photocopier
PF = personal fan
WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 800 ppm = preferable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location: Lowell High School 1980 building **Indoor Air Results**

Address: 50 Father Morisette Blvd, Lowell **Table 1 (continued)** **Date: 10/25/2019**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
628 computers	899	ND	73	37	7	0	N	Y	Y	Many WD CT, NC, computers
629 computers	772	ND	73	37	7	30	N	Y	Y	NC, DEM, computers
630	714	ND	75	37	9	0	N	Y	Y	NC, DEM, PF – dusty
640	967	ND	73	42	11	1	N	Y	Y	PF on
642	853	ND	74	40	10	0	N	Y	Y	AF odor (plug-in), NC, DEM
643	1015	ND	74	43	9	25	N	Y	Y	NC, DEM, dusty vents
644	907	ND	73	40	8	1	N	Y	Y	NC, DEM, HS
645	1187	ND	74	46	8	25	N	Y	Y	NC, dusty vents, DEM
646 A	832	ND	73	40	7	11	N	Y	Y	NC, WD CT, dusty vents

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
AF = air freshener
AI = accumulated items
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
GW = gypsum wallboard
HS = hand sanitizer
MT = missing CT
NC = not carpeted
PC = photocopier
PF = personal fan
WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 800 ppm = preferable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location: Lowell High School 1980 building **Indoor Air Results**

Address: 50 Father Morisette Blvd, Lowell **Table 1 (continued)** **Date: 10/25/2019**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m^3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
652	607	ND	71	40	8	1	Y 1 open	Y	Y	NC, DEM, dusty vents, WD CT
653	838	ND	71	42	6	16	Y	Y	Y	DEM, NC
654	754	ND	71	43	10	2	N	Y	Y	DEM, HS
655	868	ND	72	42	7	25	Y	Y	Y	DEM, chalk, NC
656	947	ND	72	44	11	28	N	Y	Y	DEM
657	790	ND	72	41	8	18	Y 3 open	Y	Y	NC, DEM, chalk
658	830	ND	72	43	9	1	N	Y	Y	DEM, WD CT
Second Floor										
Little Theater	499	ND	72	37	7	0	N	Y	Y	Carpet

ppm = parts per million
μg/m^3 = micrograms per cubic meter
ND = non detect
AF = air freshener
AI = accumulated items
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
GW = gypsum wallboard
HS = hand sanitizer
MT = missing CT
NC = not carpeted
PC = photocopier
PF = personal fan
WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 800 ppm = preferable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Library	553	ND	71	41	11	4	N	Y	Y	Old carpet, WD CTs and ceiling, reported allergy triggers
512	775	ND	72	44	8	7	N	Y	Y	HS, WD CT, WD GW
514	884	ND	73	43	8	11	N	Y	Y	
515	-	-	-	-	-	-	-	-	-	Locked
516	788	ND	72	42	10	9	N	Y	Y	
517	724	ND	72	42	9	1	Y	Y	Y	HS
518	693	ND	72	42	8	0	Y	Y	Y	MTs, HS, WD CT
522	653	ND	73	39	7	14	N	Y	Y	Computers, NC, DEM
523	764	ND	73	40	7	16	N	Y	Y	NC, DEM, dusty vents

ppm = parts per million	AF = air freshener	CT = ceiling tile	HS = hand sanitizer	PC = photocopier
µg/m³ = micrograms per cubic meter	AI = accumulated items	DEM = dry erase materials	MT = missing CT	PF = personal fan
ND = non detect	CP = cleaning products	GW = gypsum wallboard	NC = not carpeted	WD = water-damaged

Comfort Guidelines

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

Location: Lowell High School 1980 building **Indoor Air Results**

Address: 50 Father Morisette Blvd, Lowell **Table 1 (continued)** **Date: 10/25/2019**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
526	814	ND	72	41	8	23	N	Y	Y	DEM, NC
527	1021	ND	74	42	9	12	N	Y	Y	NC, DEM
533	626	ND	73	38	9	0	N	Y	Y	DEM, 1 WD CT
535	727	ND	74	40	8	30	N	Y	Y	PF – on, NC, 5 WD CT, food odors
537	790	ND	72	40	10	4	N	Y	Y	NC, 1 WD CT
542	688	ND	74	36	8	18	N	Y	Y	NC, DEM, computers
543	828	ND	74	37	13	30	N	Y	Y	DEM, NC
545	1075	ND	74	41	8	25	N	Y	Y	NC
546	842	ND	74	40	8	1	N	Y	Y	DEM, WD CT and MT (3)

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
AF = air freshener
AI = accumulated items
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
GW = gypsum wallboard
HS = hand sanitizer
MT = missing CT
NC = not carpeted
PC = photocopier
PF = personal fan
WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 800 ppm = preferable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location: Lowell High School 1980 building **Indoor Air Results**

Address: 50 Father Morisette Blvd, Lowell **Table 1 (continued)** **Date: 10/25/2019**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
547	1022	ND	73	43	9	14	N	Y	Y	NC, chalk, DEM
552	505	ND	72	39	12	7	Y	Y	Y	WD CTs
553	607	ND	74	38	12	1	Y	Y	Y	DEM
554	735	ND	73	42	10	16	Y	Y	Y	DEM
555	661	ND	73	40	11	1	Y	Y	Y	DEM
556	958	ND	73	44	13	21	Y	Y	Y	MT
557	757	ND	73	41	12	0	Y	Y	Y	DEM
558	867	ND	73	44	11	27	Y	Y	Y	HS
First Floor										

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
AF = air freshener
AI = accumulated items
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
GW = gypsum wallboard
HS = hand sanitizer
MT = missing CT
NC = not carpeted
PC = photocopier
PF = personal fan
WD = water-damaged

Comfort Guidelines

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

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Small Cafeteria	569	ND	72	41	8	~40	N	Y	Y	
Cafeteria	644	ND	72	40	7	~200	Y	Y	Y	Dust/debris on vents/CTs
Athletic Director Office	810	ND	73	43	8	1	N	Y	N	PC
Nurse's Suite	589	ND	74	46	9	3	Y	Y	Y	No airflow detected from vents
Wrestling Room	794	ND	72	43	6	28	N	Y	Y	MTs
Weight Room	733	ND	72	42	8	30	N	Y	Y	Dust/debris on vents, MTs
Girls Locker Room	545	ND	72	40	7	0	N	Y	Y	Dust/debris on vents, MTs, broken floor tiles
Girls Varsity Locker Room	528	ND	71	40	7	0	N	Y	Y	Dust/debris on vents, WD CTs
Cardio Room	589	ND	70	42	7	~25	N	Y	Y	MTs

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
AF = air freshener
AI = accumulated items
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
GW = gypsum wallboard
HS = hand sanitizer
MT = missing CT
NC = not carpeted
PC = photocopier
PF = personal fan
WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 800 ppm = preferable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (μg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Boys Locker Room	525	ND	72	42	9	0	N	Y	Y	Dust/debris on vents
Boys Varsity Locker Room	527	ND	71	40	6	4	N	Y	Y	Dust/debris on vents, MTs
412	612	ND	73	38	7	3	Y	Y	Y	Carpet
437	667	ND	74	38	5	0	N	Y	Y	Carpet
452C	796	ND	73	40	7	2	N	N	Y	Dust/debris on vents, door open
Field House										
Gym	672	ND	71	43	5	200+	N	Y	Y	Rubberized flooring

ppm = parts per million
μg/m³ = micrograms per cubic meter
ND = non detect
AF = air freshener
AI = accumulated items
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
GW = gypsum wallboard
HS = hand sanitizer
MT = missing CT
NC = not carpeted
PC = photocopier
PF = personal fan
WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 800 ppm = preferable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

APPENDIX A

Previous Recommendations

Conclusions/Recommendations from the visit made in July of 2017

The following recommendations are made to assist in improving IAQ:

1. Replace any water-damaged or mold-colonized porous building materials (e.g., ceiling tiles, gypsum wallboard, carpeting) in classrooms, hallways, and stairwell areas. Ensure water-damaged materials are cleaned, replaced, and/or repaired in a manner consistent with the U.S. Environmental Protection Agency's guidelines (US EPA, 2008).
2. Consult with a roofing contractor to assess the roofing system. Repairs should be made to stop leaks and chronic water damage to building materials. The roofing system should then be monitored regularly for water pooling, leaks, and other deteriorating conditions.
3. Consult with an HVAC contractor to thoroughly examine all HVAC system components to ensure proper function. Make any necessary repairs to ensure the system is working as designed.
4. Ensure that a system of regular "Operations and Maintenance" remains in place to keep HVAC systems in proper working order.
5. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
6. Operate all supply and exhaust ventilation equipment continuously during occupied periods. Do not block supply or exhaust vents with furniture or items.
7. Use openable windows to supplement fresh air during temperate weather. Ensure all windows are tightly closed at the end of the day. Inform occupants that windows should not be opened while the HVAC system is in cooling mode to avoid condensation.
8. Ensure chemical treatment of the pool is controlled to minimize pool odors. Ensure the exhaust system in the pool area is operating at all times and properly adjusted to effectively remove odors and moisture. In addition, ensure that doors between the pool and other occupied areas are weather-tight to prevent migration of odors and moisture.
9. Ensure any plumbing leaks are repaired to avoid chronic water damage in the building.
10. Ensure that condensation from AHU equipment is draining properly. Check collector pans, piping and any associated pumps for clogs and leaks and clean periodically to

prevent stagnant water build-up and remove debris that may provide a medium for microbial growth.

11. Ensure that doors are closed between areas with air conditioning and areas without air conditioning to avoid condensation of humid air on chilled surfaces.
12. Replace water-damaged and mold-colonized ceiling tiles after leaks have been addressed. Clean/remediate any moldy wall material consistent with the U.S. Environmental Protection Agency's guidelines (US EPA, 2008).
13. Replace any missing or ajar ceiling tiles to avoid pathways to unconditioned areas.
14. Consider utilizing MERV 8 filters in AHUs. Check with manufacturer's recommendations before changing filter efficiency. Continue to change filters 2-4 times a year.
15. Regularly clean supply/return vents and fans to avoid aerosolizing accumulated particulate matter.
16. Clean carpeting and area rugs annually or more often in high-traffic locations in accordance with IICRC recommendations (IICRC, 2012) and discard those that are worn out or too soiled to be cleaned.
17. Replace/repair fluorescent light covers; ensure fluorescent lights are fully secured to prevent breakage and clean debris out of covers.
18. Encourage faculty to report classroom/building related issues via a tracking program.
19. Continue to adopt the US EPA (2000) document, "Tools for Schools", as an instrument for maintaining a good IAQ environment in the building available at: http://www.epa.gov/iaq/schools/index.html.
20. Refer to resource manual and other related IAQ 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/iaq.

Conclusions/Recommendations from the visit made in December of 2017

The following recommendations are for improving indoor air and environmental quality:

1. Consult with an HVAC contractor to thoroughly examine all HVAC system components to ensure proper function. Make any necessary repairs to ensure the system is working as

designed. Assess whether adjustments can be made to allow more fresh air into the system.

2. Operate all supply and exhaust ventilation equipment continuously during occupied periods. Do not block supply or exhaust vents with furniture or items. Check exhaust/return vents periodically for proper function.
3. Consider changing the style of fresh air vents or relocating them to prevent drafts (e.g., Hosmer office; Table 2).
4. Ensure that a system of regular "Operations and Maintenance" remains in place to keep HVAC systems in proper working order.
5. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
6. Use openable windows to supplement fresh air during temperate weather. Ensure all windows are tightly closed at the end of the day. Inform occupants that windows should not be opened while the HVAC system is in cooling mode to avoid condensation.
7. Replace any water-damaged or mold-colonized porous building materials (e.g., ceiling tiles, gypsum wallboard, carpeting) in the library, classrooms, hallways, and stairwell areas. Ensure water-damaged materials are cleaned, replaced, and/or repaired in a manner consistent with the U.S. Environmental Protection Agency's guidelines (US EPA, 2008).
8. Consult with a roofing contractor to assess the roofing system. Repairs should be made to stop leaks and chronic water damage to building materials. The roofing system should then be monitored regularly for water pooling, leaks, and other deteriorating conditions.
9. Consider removal of wall-to-wall carpeting in classrooms and other areas where spills, leaks or wear are a concern. Replace with non-porous flooring.
10. Avoid locating refrigerators and water dispensers in carpeted areas. Place on non-porous flooring or use a waterproof mat to protect the carpet.
11. Seal gaps in sink backsplashes with an appropriate waterproof sealant. Do not store porous items underneath or adjacent to sinks and safety showers/eyewashes.
12. Ensure doors seal tightly between air conditioned and non-air-conditioned areas and that these doors are closed when air conditioning is in use.
13. Ensure chemical treatment of the pool is controlled to minimize pool odors. Ensure the exhaust system in the pool area is operating at all times and properly adjusted to

effectively remove odors and moisture. In addition, ensure that doors between the pool and other occupied areas are weather-tight to prevent migration of odors and moisture.

14. Ensure any plumbing leaks are repaired to avoid chronic water damage in the building.
15. Ensure that condensation from AHU equipment is draining properly. Check collector pans, piping and any associated pumps for clogs and leaks and clean periodically to prevent stagnant water build-up and remove debris that may provide a medium for microbial growth.
16. Replace water-damaged and mold-colonized ceiling tiles after leaks have been addressed. Clean/remediate any moldy wall materials consistent with the U.S. Environmental Protection Agency's guidelines (US EPA, 2008).
17. Replace any missing or ajar ceiling tiles to avoid pathways to unconditioned areas.
18. Reduce the use of products containing VOCs.
19. Locate photocopiers and laminators in well ventilated areas away from occupants.
20. Store laboratory chemicals in an organized manner consistent with the guidance in Appendix A ("Guidance Concerning Proper Use and Storage of Chemicals in Schools to Protect Public Health").
21. Ensure Material Safety Sheets are available for all laboratory, maintenance and janitorial chemicals used in the building.
22. Consider utilizing MERV 8 filters in AHUs. Check with manufacturer's recommendations before changing filter efficiency. Continue to change filters 2-4 times a year.
23. Regularly clean supply/return vents and fans to avoid aerosolizing accumulated particulate matter. If soiled ceiling tiles around vents cannot be cleaned, replace.
24. Consider reducing the amount of items stored in classrooms to make cleaning easier. Periodically move items to clean flat surfaces.
25. Clean carpeting and area rugs annually or more often in high-traffic locations in accordance with IICRC recommendations (IICRC, 2012) and discard those that are worn out or too soiled to be cleaned.
26. Affix the electrical outlet in medical office to wall. Identify the purpose of the wires in the medical office and cap/remove as needed.
27. Encourage faculty to report classroom/building related issues via a tracking program.

28. The school should be tested for radon by a certified radon measurement specialist during the heating season when school is in session. Radon measurement specialists and other information can be found at: www.nrsb.org, and http://aarst-nrpp.com/wp.
29. Continue to adopt the US EPA (2000) document, “Tools for Schools”, as an instrument for maintaining a good IAQ environment in the building available at: http://www.epa.gov/iaq/schools/index.html.
30. Refer to resource manual and other related IAQ 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/iaq.

Appendix B

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

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

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

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

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

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

As previously mentioned, carbon dioxide is used as a diagnostic tool to evaluate air exchange by building ventilation systems. The presence of increased levels of carbon dioxide in indoor air of buildings is attributed to occupancy. As individuals breathe, carbon dioxide is exhaled. The greater the number of occupants, the greater the amount of carbon dioxide produced. Carbon dioxide concentration build up in indoor environments is attributed to inefficient or non-functioning ventilation systems. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

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

The MDPH uses a guideline of 800 ppm for publicly occupied buildings (Burge et al., 1990; Gold, 1992; Norback, 1990; OSHA, 1994; Redlich, 1997; Rosenstock, 1996; SMACNA, 1998). A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Several sources indicate that indoor air problems *are significantly reduced* at 600 ppm or less of carbon dioxide (ACGIH, 1998; Bright et al., 1992; Hill, 1992; NIOSH, 1987). Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

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

Carbon dioxide itself has no acute (short-term) health effects associated with low level exposure (below 5,000 ppm). The main effect of carbon dioxide involves its ability to displace oxygen for the air in a confined space. As oxygen is inhaled, carbon dioxide levels build up in the confined space, with a decrease in oxygen content in the available air. This displacement of oxygen makes carbon dioxide a simple asphyxiant. At carbon dioxide levels of 30,000 ppm, severe headaches, diffuse sweating, and labored breathing have been reported. No **chronic** health effects are reported at air levels below 5,000 ppm.

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

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

Table 1: Carbon Dioxide Air Level Standards

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

* outdoor carbon dioxide measurement +700 ppm

References

ACGIH. 1986. Documentation of the Threshold Limit Values. American Conference of Governmental Industrial Hygienists. Cincinnati, OH.

ACGIH. 1998. Industrial Ventilation A Manual of Recommended Practice. 23rd Edition. American Conference of Governmental Industrial Hygienists. Cincinnati, OH.

ACGIH. 1999. Guide to Occupational Exposures-1999. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989.

ASHRAE. 1999. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1999.

ASHRAE. 2001. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-2001.

Beard, R.R. 1982. Chapter Fifty-two, Inorganic Compounds of Oxygen, Nitrogen, and Carbon. *Patty's Industrial Hygiene and Toxicology, Vol. IIc*. *3rd ed.* Clayton, G. D. & Clayton, F. E., eds. John Wiley & Sons, New York, NY.

Bright, P.; Mader, M.; Carpenter, D.; and Hermon-Cruz, I.Z. 1992. Guideline for Indoor Air Surveys. Brooks Air Force Base, TX. Armstrong Laboratory, Occupational and Environmental Health Directorate. NTIS AL-TR-1992-0016.

Burge, H. and Hoyer, M. 1990. Focus On … Indoor Air Quality. Appl. Occup. Environ. Hyg. 5(2):88.

EA. 1997. Indoor Air Quality. Environment Australia, Department of the Environment, Sport and Territories, Canberra, Australia.
www.environment.gov.au/soe/1996/publications/technical/pubs/12indora.pdf

Gold, D. 1992. Indoor Air Pollution. Clinics in Chest Medicine. 13(2):224-225.

Hill, B.; Craft, B.; and Burkart, J. 1992. Carbon Dioxide, Particulates and Subjective Human Responses in Office Buildings without Histories of Indoor Air Quality Problems. Appl. Occup. Environ. Hyg. 7(2): 101-111.

IDPH. Unknown. Illinois Department of Public Health Guidelines for Indoor Air Quality. Illinois Department of Public Health, Springfield, Il.
http://www.idph.state.il.us/envhealth/factsheets/indoorairqualityguide_fs.htm

Mendler, S. and Odell, W. 2003. Indoor Air Quality for the EPA. *ArchitectureWeek.* April 16, 2003. http://www.architectureweek.com/2003/0416/environment_1-2.html

NCOSP. 1998. Workplace Requirements for Safety & Health, Indoor Air Quality 3.3.3. NC Office of State Personnel, Raleigh, NC. www.osp.**state**.nc.us/emprsk/safety/handbook/5-9.pdf

NIOSH. 1987. Guidance for Indoor Air Quality Investigations. Cincinnati, OH. National Institute for Occupational Safety and Health, Hazards Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluation and Field Studies.

Norback, D.; Torgen, M.; and Edling, C. 1990. Volatile Organic Compounds, Respirable Dust, and Personal Factors Related to Prevalence and Incidence of Sick Building Syndrome in Primary Schools. British Journal of Industrial Medicine. 47:740.

OSHA. 1994. Occupational Safety and Health Administration. Indoor Air Quality (Proposed Regulation), Federal Register 59:15968-16039, (1994) 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.

Appendix C

Commonwealth of Massachusetts
Department of Public Health
Helping People Lead Healthy Lives In Healthy Communities

BUREAU OF ENVIRONMENTAL HEALTH

Indoor Air Quality Program

Methods Used to Reduce/Prevent Exposure to Construction/Renovation Generated Pollutants in Occupied Buildings

November 2006

Among the most serious indoor air quality health issues is the potential exposure to construction/renovation-generated pollutants in occupied buildings. The renovation of occupied buildings provides a number of potential exposure opportunities to pollutants. Demolition of the building materials can provide exposure to mold, asbestos, lead, bird waste and other respiratory irritants. The application of tile adhesive, roofing materials, paints and other products used during renovations provide point sources of volatile organic compounds (VOCs) and other irritating chemicals. Contractors frequently use fossil fueled construction and heating equipment in indoor areas undergoing renovations. Combustion products (e.g. carbon monoxide) can migrate into occupied areas. The impact of construction/renovation pollutants on occupied areas can be evaluated through air monitoring for VOCs, airborne particles and products of combustion. Preventing and/or minimizing exposure to construction/renovation-generated pollutants is essential to reduce indoor air-related symptoms in building occupants.

In 1999, the State Department of Education (DOE) amended their regulations to require that state funded construction projects follow established guidelines to prevent exposure of building occupants to construction/renovation pollutants. Subsequently, Chapter 208 of the Acts of 2004 transferred responsibility for the School Building Assistance Program from the DOE to the Massachusetts School Building Authority (MSBA). On September 6, 2006, the MSBA enacted regulations that require that schools receiving funds under the program for construction or renovation projects must confer with the most current edition of the "IAQ Guidelines for Occupied Buildings Under Construction" published by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA) 963 CMR 2.04(2)(c),(d).

The MDPH has prepared this guidance in order to prevent/reduce the migration of renovation-generated pollutants into occupied areas and their potential impact on indoor air quality. The MDPH suggests that the following steps be taken on any renovation project within a public building.

Physical Isolation of Occupied Areas from Renovation Areas

Renovations of buildings should be separated from occupied areas by constructing temporary physical barriers. These barriers are typically constructed of plywood and polyethylene plastic built in or over passageways between the construction area and the occupied spaces. Construction barriers should be sealed with polyethylene plastic and duct tape on the construction side as well as the occupied side to provide a duel barrier. Inspection of these barriers should be conducted daily prior to commencement of construction activities to ensure integrity. A log of the location and condition of each barrier should be maintained in a log book.

Other migratory pathways for pollutants to move between construction and occupied areas should be examined and sealed. These migratory pathways may include but are not limited to:

- Crawlspaces
- Electrical outlets and light switches in shared walls
- Pipe and electrical conduits between walls
- Ventilation system ductwork
- Holes in interior walls and/or spaces above interior walls and roof/floor decking (e.g., spaces above ceiling tile systems).

Outdoor construction-generated pollutants can migrate indoors under various conditions. The following are recommendations to reduce migration of *outdoor* pollutants to the indoor environment:

- Seal around exterior doors with weather stripping and door sweeps to prevent infiltration of outdoor construction-generated pollutants.
- Cover with tarps any dirt/debris piles in close proximity to the building or wet down dirt/debris to decrease aerosolization of particulates, when possible.
- Change HVAC filters more regularly in areas impacted by renovation activities. Upgrading to more efficient filters for these units should also be considered.
- Temporarily deactivate the HVAC system during construction generating high amounts of outdoor pollutants. If activity is longer than one day, alternative means of ventilation should be provided for the impacted areas. If not feasible, relocation of activities in these areas should be considered.

The Use of Pressurization/Depressurization Techniques

Construction sites should be isolated and depressurized compared with occupied areas to control for renovation pollutants. To achieve depressurization, use fans to draw air away from occupied areas. Use of the existing supply ventilation system to introduce fresh outside air into occupied space should be used to increase air pressure in occupied areas adjacent to construction activities. In order to assess whether depressurization has occurred, air pressure monitoring (using a micromanometer) to measure air pressure differential between occupied space and construction areas should be used. Monitoring should be done daily at each barrier to ensure appropriate pressurization. Results of the location, dates and results of air pressure monitoring should be kept in a log book. No construction work should occur in areas immediately adjacent to occupied areas if:

- Depressurization is not achieved,
- Air pressure monitoring has not been done that day, or
- Odor/construction related complaints have been made by occupants in adjacent areas.

Operation of the Existing Ventilation Systems

Precautions should be taken to avoid the *re-entrainment* of construction-related materials into the building's HVAC system. The design of each system must be assessed to determine how it may be impacted by renovation activities and contingency plans to maintain adequate supply of fresh air and temperature must also be developed and implemented to maintain building occupant safety and comfort. Specific HVAC protection requirements pertain to the return, central filtration and supply components of the ventilation system. This may entail shutting down systems (when possible) during periods of heavy construction and demolition, ensuring systems are isolated from contaminated environments, sealing ventilation openings with plastic and using filters with a higher dust spot efficiency where needed.

Administrative Management to Prevent Exposure to Construction Generated Pollutants

Various administrative actions can also prevent occupant exposures to construction/renovation-generated pollutants. The following measures should be used to prevent, eliminate or reduce occupant exposure to construction-generated pollutants:

- Schedule projects that produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.
- Develop a notification system for building occupants to report construction/renovation related odors and/or dust problems to the building administrator. These concerns should be relayed to the contractor in a manner to allow for a timely remediation of the problem.
- Disseminate scheduling itinerary to all affected parties; this can be done in the form of meetings, newsletters or weekly bulletins.
- Notify occupants about construction activities that may be conducted in close proximity to their work areas. In certain cases, HVAC equipment for areas adjacent to construction activities may need to be deactivated and windows closed periodically to prevent unfiltered air and vehicle exhaust from entering the building. For this reason, prior notification(s) should be made.
- If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of renovations.
- Keep Material Safety Data Sheets (MSDS) for all construction materials used during renovations in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act.

Appendix C

Control/Reduction of Pollutants in Occupied Areas

Frequently, renovations include the replacement of components of the HVAC system, rendering windows as the only source of fresh air. In this environment, removal of normally occurring pollutants as well as construction-generated pollutants must be enhanced to reduce exposure.

The following recommendations are made to reduce exposure under these circumstances:

- Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. This should include daily cleaning of occupied areas during the course of renovation work generating dust, fumes and other particulate materials.
- Consider increasing the number of personnel or work hours for existing staff (e.g., before school) to provide increased cleaning of dirt/dust accumulation in occupied areas due to construction/renovation activities.
- Control for dusts by using a high efficiency particulate air filter (HEPA) equipped vacuum cleaner in conjunction with wet wiping/mopping of all surfaces.
- Cover with tarps any dirt/debris piles (indoors and outdoors) in close proximity to the building or wet down dirt/debris (outdoors) to decrease aerosolization of particulates, when possible.
- Change HVAC filters more regularly in areas impacted by renovation activities. Upgrading to more efficient filters for these units should also be considered.

Inspection upon Request

The Massachusetts Department of Public Health, Bureau of Environmental Health, Indoor Air Quality Program, is available to inspect a public building upon receipt of a written request for inspection from and in cooperation with the appropriate government agency.

QUESTIONS

If you have any questions concerning these guidelines, please contact:

Massachusetts Department of Public Health
Bureau of Environmental Health, Indoor Air Quality Program
250 Washington Street, 7th Floor
Boston, MA 02108
Phone: (617) 624-5757 Fax: (617) 624-5777

Document Reviewed: August 2008