INDOOR AIR QUALITY ASSESSMENT

Boylston Elementary School
at the
Boylston Town Offices Building
221 Main Street
Boylston, Massachusetts

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

At the request of a parent, an indoor air quality assessment was done at the Boylston Elementary School at the Boylston Town Offices Building, 221 Main Street, Boylston, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA).

On March 14, 2000, Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA made a visit to this school, to conduct an indoor air quality assessment. Mr. Feeney was accompanied in part by Dennis Costello, Boylston Board of Health and Charles McCarthy, Principal of the Boylston Elementary School.

The Boylston Town Offices Building is a two-story steel frame structure built in 1973 on the campus of the Sheppard Knapp School. After the private school ceased operation, the building was used as office space by Digital Equipment Corporation (DEC). It appears that DEC modified the second floor rooms and cafeteria area. The Town of Boylston obtained the building after DEC ceased operation in the mid-1990s and the building was converted to space for town offices.

As part of a current renovation project, students from the Boylston Elementary School were temporarily moved into the first floor and two rooms on the second floor. Once the planned renovations are complete, students will be moved from this building and the space occupied by the school will revert back to town office space.

The remainder of the second floor is occupied by the Massachusetts Criminal Justice Training Council (MCJTC) who rents this space from the Town of Boylston and uses five rooms as offices and a training center for police officers and cadets. Alterations were made to the heating ventilation and air-conditioning (HVAC) system in the space occupied by the MCJTC that do not exist in other areas in the building. For this reason, the conditions in each area will be described in separate reports. The focus of this report is the space currently occupied by the Boylston Elementary School. The MCJTC will be the subject of a separate report. The section occupied by the school consists of classrooms, a gymnasium and a kitchen/cafeteria. Windows in the school section of the building are openable. The HVAC system is capable of providing both heat and chilled air. A chiller connected to the HVAC system is located at the rear of the building.

Methods

Air tests for carbon dioxide were taken with the Telaire, Carbon Dioxide Monitor and tests for temperature and relative humidity were taken with the Mannix, TH Pen PTH8708 Thermo-Hygrometer.

Results

The school has a student population of approximately 120 and a staff of over 20. Tests were taken under normal operating conditions. Test results appear in Tables 1-2.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in four of the fourteen areas surveyed, which is indicative of a ventilation problem in these areas. Fresh air in classrooms is supplied by a mechanical unit ventilator (univent) system. A univent draws fresh air from a vent on the exterior of the building and air from the classroom (called return air) through a vent in the base of the unit (see Figure 1). Fresh air and return air are mixed, filtered, heated and expelled into the classroom through a fresh air diffuser located in the top of the unit. All univents were operating during the assessment, with the exception of the Langlois and Wright classrooms. Classrooms with deactivated univents had carbon dioxide levels over 800 ppm. Obstructions to airflow, such as books and papers on top of univents; and bookcases, tables and desks in front of univent returns, were seen in a number of classrooms. To function as designed, univents and univent returns must remain free of obstructions. Importantly, these units must be activated and allowed to operate.

Fresh air in the cafeteria/kitchen area is provided by univents as well. It appears that the original structure of the building included the kitchen and inner cafeteria, which had univents beneath a large former exterior wall (see Picture 1). Subsequent renovations added the outer cafeteria area, which enclosed the original cafeteria/kitchen univent fresh air intakes indoors (see Picture 2). As a result, the cafeteria/kitchen does not appear to have a fresh air supply. The outer cafeteria has six univents with fresh air intakes (see Picture 3). It appears that the operation of these univents is inadequate to provide sufficient fresh air for the student population noted in this area (90+ students and staff), since carbon dioxide levels exceeded 800 ppm.

With the exception of restrooms, no mechanical exhaust ventilation system exists in the building. First floor classrooms have a passive non-mechanical exhaust vent (see Picture 4). In order to function, this ventilation system relies on positive pressure created by the univent to force air out of the passive vent. As the univent operates, air pressure increases and additional fresh air is introduced into the classroom (called positive pressure). As positive pressure increases, air is forced out of the room through wall and door spaces. The passive vent is designed to allow for slow release of air from classrooms by increasing positive pressure created by the univent. Each vent contains metal louvers on hinges, which should open to release air from the room through a vent on the exterior of the building (see Picture 5). The design of these exhaust vents requires that classroom hallway doors remain closed as much as practical in order to maintain positive pressure. With hallway doors open, classroom air would be forced into hallways. In addition, several of these passive vents were examined and noted to be backdrafting cold air into classrooms. Previous BEHA experience indicates that these types of systems tend to backdraft cold air during winter months. Without a mechanical system, these vents may not function to provide exhaust ventilation and can be a source of cold air during winter months. An examination of these vents reveals that the louvers are in various states of disrepair. In order for these vents to operate, routine cleaning and lubrication of the louvers would be necessary so that the louvers will readily rotate with minimum positive pressure in the classroom. With the absence of active mechanical exhaust ventilation, pollutants generated during building occupancy will tend to linger in classrooms.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing 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 (BOCA, 1993, SBBRS, 1997). 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. 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 occurs a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

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

Temperature readings ranged from 71^{0}F to 77 ^{0}F, which was within BEHA's recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{0}F to 78 ^{0}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.

The relative humidity in this building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 8 to 23 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during 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

Of concern to school officials, are linoleum sheets that were laid down over existing carpeting in several classrooms. Sheets of linoleum were affixed to the floor using duct tape (see Picture 6). This measure was employed to provide a physical barrier to carpet related pollutants. This measure appears to be of limited effectiveness, since the duct tape did not adhere to the existing carpeting to create an airtight seal. The linoleum created bubbles, which would expel air from beneath this barrier when compressed. This action can result in carpet-related pollutants being aerosolized. Of note was the absence of mold odors in these classrooms. A musty odor was noted in the foyer of the building. The exterior of the front door has carpet laid outdoors. This carpet can lead to water gathering near the door threshold, which can cross the threshold to moisten the interior carpet.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended.

Of note is the condition of the univents. Instead of installing univents as a complete metal case (see Picture 7 for a typical univent installation), it appears that the internal workings of a univent were encased in specially designed wooden cabinets. Within these cabinets are pipes clad with fiberglass insulation (See Picture 8). Since these univents can provide chilled air during warm months, moist air introduced into these wooden cabinets can result in the wetting of the insulation paper. It appears that mold may have colonized the insulation paper (see Picture 9). This colonization may be a source of spores and other mold-related particulates, which can be aerosolized by the univent. Other sources of mold colonization of pipe insulation exist in the gymnasium. Leaks from the heating system resulted in active mold growth on the exterior of the installation.

Each univent is equipped with drip pans to collect and drain condensation from cooling coils. The manufacturer of these univents provides a styrofoam liner to protect the drip pans from water damage. These styrofoam liners appear to have never been replaced since the installation of the univents in 1973. The accumulation of debris in these liners can serve as growth media for mold.

Each univent condensation drain terminates through the exterior wall of the building several feet above the ground (see Picture 10). This configuration exposes the wood of the exterior surface of the building. In one case, dripping condensation appears to have caused splaying of wood. Repeated water exposure from these drains can result in further damage to the exterior of the building. In addition, a leaking spigot at the rear of the building had moistened the exterior wall of the building (see Picture 11).

One classroom was noted to have a section of carpet beneath a fish tank (see Picture 12). Fish tanks can generate condensation under certain conditions. Under such conditions, the carpet section can become repeatedly moistened and serve as a medium for mold growth.

Water damage to gypsum fiberboard in the ceiling of the restrooms was noted. The source of the water damage appears to be plumbing leaks from the rest rooms of the second floor. Water damaged gypsum fiberboard can become a medium for mold growth.

Other Concerns

Wasp nests were found in the interior of the passive exhaust vents (see Picture 13). It is recommended that they be removed as soon as possible in a manner as to not introduce insects or chemical agents into the school via the ventilation system.

The exhaust fans in the boy's restroom were found to be drawing weakly. Exhaust ventilation in restrooms is necessary to prevent bathroom odors from penetrating into surrounding areas. In order for supply and exhaust systems to function as designed, vents must be unblocked and remain free of obstructions.

Several classrooms contained dry erase boards and dry erase board markers, and permanent markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

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

1. Operate univents while classrooms are occupied.
2. Remove all blockages from univents.
3. Repair/replace the exhaust vent louvers. Remove wasp nests from these vents in a manner as to not introduce insects or chemical agents into the school via the ventilation system.
4. Examine the feasibility of replacing drip pans in univents.
5. Replace water damaged pipe insulation.
6. Replace water damaged plasterboard in the ceiling of restrooms.
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 relative humidity is low. An increase in filter efficiency in the HVAC system

may also be advisable. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8. Consider extending the condensation drains to prevent water damage to the exterior wall of the building.

9. Consider removing the carpet installed outside of the front door of the building. Examine the carpet around the front door for mold growth and remove where necessary. Disinfect the nonporous surface and clean the area beneath the carpet.

10. Remove the carpet section beneath the fish tank.

11. Examine the feasibility of installing exhaust ventilation in the outer cafeteria.

12. Examine the feasibility to improve fresh air to the cafeteria/kitchen.

13. Inspect restroom exhaust motors for proper function, make repairs as necessary. Consider increasing restroom exhaust capabilities to remove moisture and/or odors.

References

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

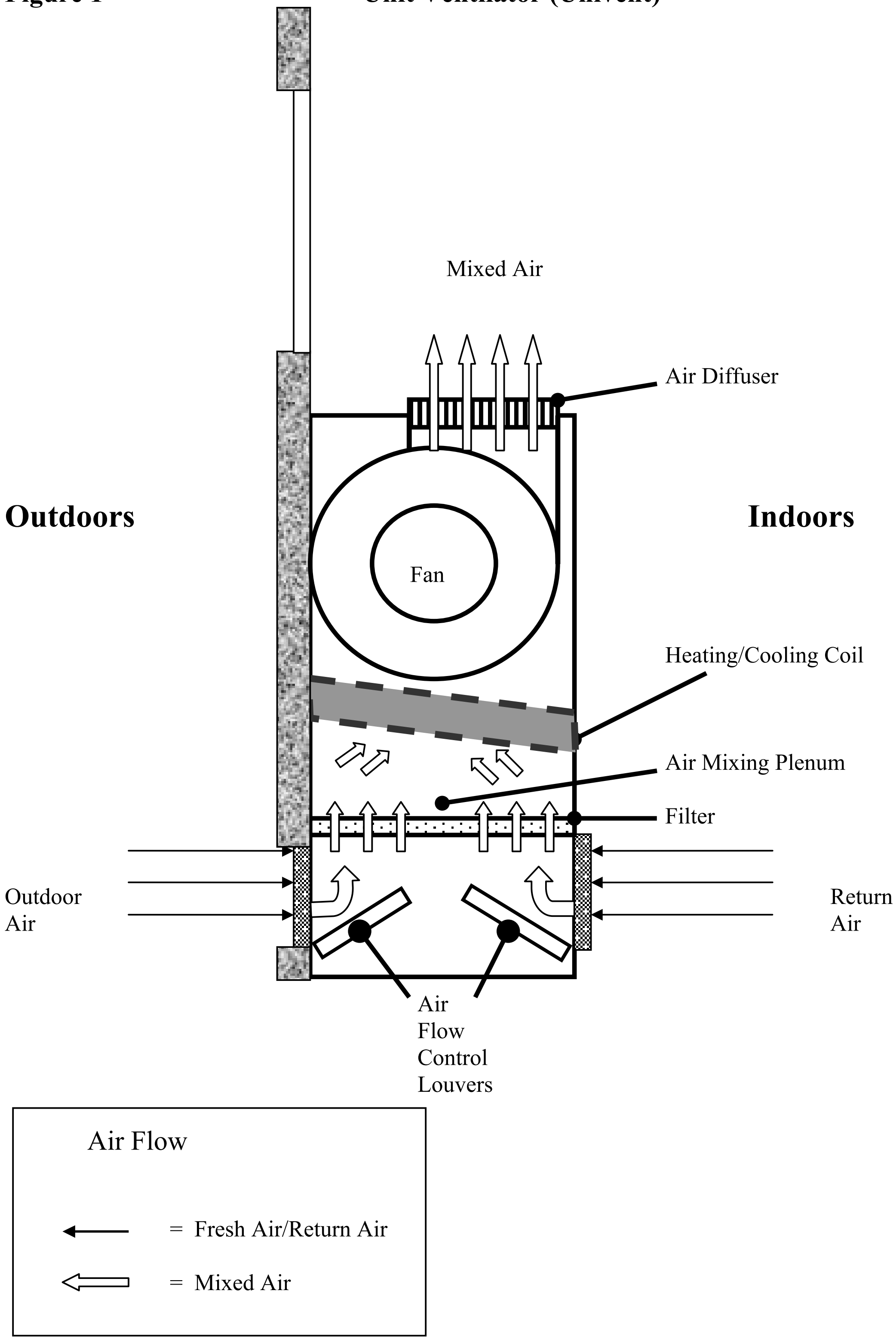
BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

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

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

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

Figure 1 **Unit Ventilator (Univent)**



Picture 1

Kitchen/Cafeteria Univent Fresh Air Supply Vent Sealed Indoor by Outer Cafeteria, Note Stone of Former Exterior Wall

Picture 2

Interior View of Kitchen/Cafeteria, Univent Fresh Air Intakes Sealed Indoors Are Located below Windows

Picture 3

Outer Cafeteria Fresh Air Intakes

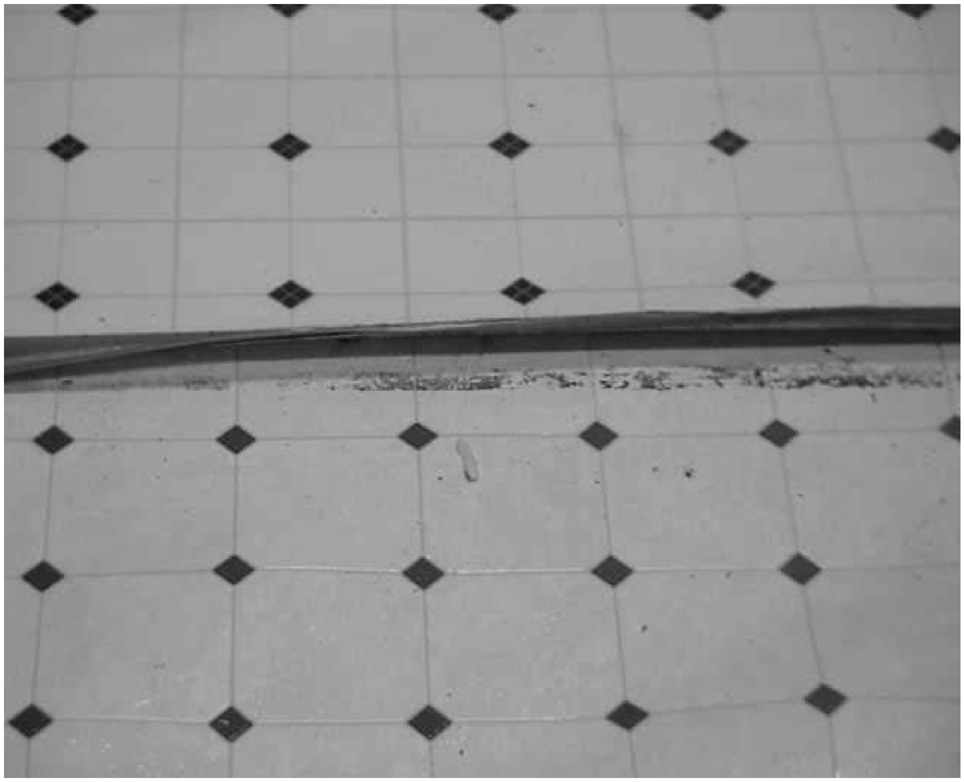
Picture 4

Louvered Exhaust Vent with Grille Cover Removed

Picture 5

Exhaust Vent with Louvers Fully Opened

Picture 6



Linoleum with Peeling Duct Tape

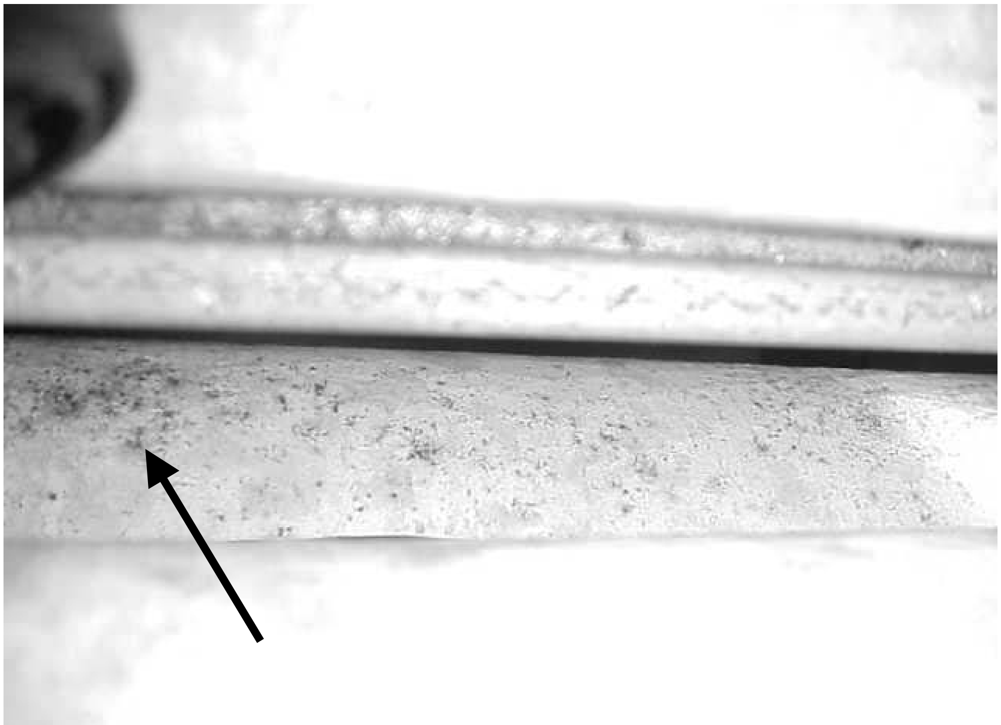
Picture 7

Univent in Wooden Casing

Picture 8

Insulated pipes in Wooden Univent Cabinet, Note Stains/Possible Mold Growth

Picture 9



Paper of Pipe Insulation, Note Possible Mold Colonies

Picture 10

Condensation Drain

Splayed Wood

Condensation Drain, Note Splayed Wood Immediately below Drain

Picture 11

Exterior Wall Water Damaged by Dripping Spigot

Picture 12

Carpet beneath Fish Tank

Picture 13

Wasp Nests in Exhaust Vent

TABLE 1

Indoor Air Test Results – Boylston Elementary School at the Boylston Town Offices Building, Boylston, MA
March 14, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	367	43	36					
O'Connor	647	73	10	15	yes	yes	yes	door open, permanent markers
Carter	648	74	9	16	yes	yes	yes	door open
Sabourn	654	76	11	17	yes	yes	yes	door open
Turpin	653	73	10	16	yes	yes	yes	door open, supply blocked by desk
Elizabeth Home Room	588	75	8	0	yes	yes	yes	door open
Sequeira	577	76	10	16	yes	yes	yes	door open
Wright	1257	76	13	14	yes	yes	yes	supply off
Nurse's Office	569	75	12	4	yes	yes	yes	
Cooper	563	73	10	16	yes	yes	yes	

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

Comfort Guidelines

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

TABLE 2

Indoor Air Test Results – Boylston Elementary School at the Boylston Town Offices Building, Boylston, MA
March 14, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Cafeteria	1566	74	21	90+	yes	yes	no	
Inner Cafeteria	1215	74	18	40+	no	yes	yes	stove exhaust, fiberglass ceiling tiles
Sink Room	1013	77	23	1	no	no	no	1 missing ceiling tile
Bearegard	765	71	13	17	yes	yes	yes	door open, ceiling fan
Langlois	804	73	17	15	yes	yes	yes	supply off-blocked by paper, ceiling fan, windex/409 cleaners

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

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