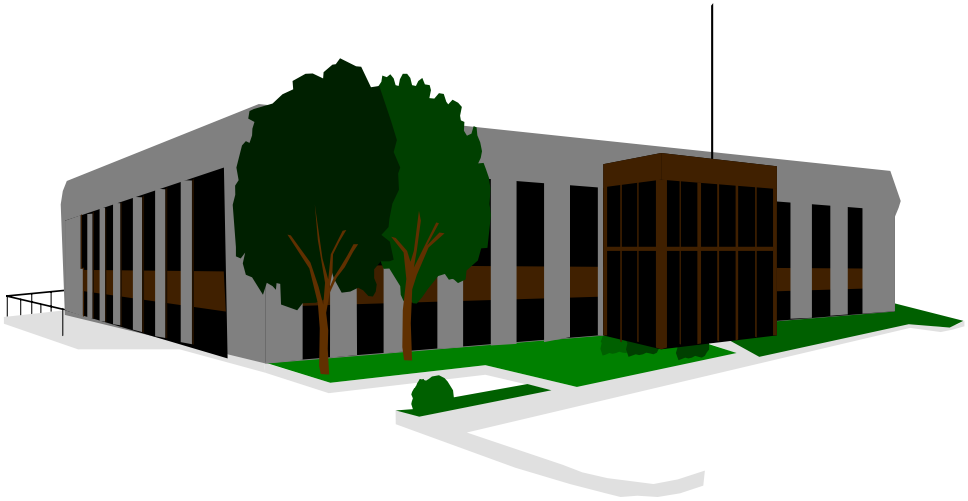
INDOOR AIR QUALITY ASSESSMENT

Cedar Elementary School
Hanover School District
265 Cedar Street
Hanover, Massachusetts



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

At the request of Jeanmarie Joyce, Health Agent of the Hanover Board of Health, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Cedar Elementary School in Hanover, Massachusetts. Symptoms were reported to be expressed from the beginning of the current school year in September 1999 until the present. Both teachers and students in this building reported headaches, respiratory symptoms, eye irritations and rashes.

On February 11, 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 by Alan Rugman, Chairman of the Hanover Board of Health and Ms. Joyce.

The school is a two-story brick building constructed in 1966. An addition to the north side of the building was under construction during the assessment. In addition, the library was being renovated. The school contains general classrooms, a cafeteria and offices for both students and administrative officials. Windows in the school are openable. The floor of the building is covered with floor tile, however a number of classrooms are carpeted.

Improved control measures to prevent renovation/construction generated pollutants from migrating into occupied areas of the building were previously recommended (MDPH, 2000). This correspondence is included with this report as Appendix A. Building occupants indicated that the symptoms that prompted the request for this assessment were originally confined to classrooms located in the western wing of the building (see Appendix B). Classrooms 3 through 13 are located in the western wing. Classrooms 19 through 29 are located in the eastern wing.

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 PTH Pen 8708 Thermo-hygrometer.

Results

This school has a student population of over 630 and a staff of approximately 60. The tests were taken during normal operations at the school. Test results appear in the Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million (ppm) in 27 of the 31 rooms surveyed, which indicates an overall ventilation problem in the school. Of note are classrooms 8, 9, 14, and 29 as well as the learning center and the upstairs storage room all of which had carbon dioxide measurements above 800 ppm with windows/doors open and/or no occupancy which can greatly contribute to reduced levels. These results indicate little or no air movement in these areas.

Classrooms have fresh air supplied by a 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 its case (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. Univents were deactivated in several classrooms. Obstructions to airflow, such as file cabinets, dividers, books and paper blocking univents were seen in a number of classrooms. In order for univents to provide fresh air as designed, fresh air diffusers and univent returns must be unblocked and remain free of obstructions.

Exhaust ventilation in exterior classrooms is provided by a mechanical system. The exhaust ventilation in classrooms consists of wall-mounted, ducted vents (see Picture 1). These exhaust vents were functioning in the eastern wing of the building, as noted by the dry roof rock ballast beneath the rooftop exhaust vent motors (see Picture 2). Exhaust vents in the western wing were not drawing air, with the exception of the local exhaust vents in restrooms. All rooftop exhaust vent motors above the western wing of the building were deactivated. Please note that the roof rock ballast remained wet (see Picture 3), indicting no air movement from this equipment. Exhaust ventilation is necessary to remove environmental pollutants from classrooms. Without exhaust ventilation, environmental pollutants that exist in a building can accumulate and cause irritant symptoms. A number of exhaust vents throughout the school were blocked by shelves and other items. Exhaust vents must remain clear of obstructions in order to function appropriately.

A roof top fresh air intake that services the kitchen and teacher's lunchroom is located on the roof above the kitchen (see Picture 4). Fresh air is distributed to the kitchen and teacher's room by ceiling-mounted air diffusers. A combination of wall and ceiling–mounted return vents is connected by ductwork to the AHU. Both supply and return vents were operating during the assessment. The conference room, learning center, guidance counselor's office and the upstairs storage room do not have fresh air supplies or exhaust vents.

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 univent and exhaust system, these systems should also 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 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 (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. 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 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 recorded during the assessment were in a range of 66 ^{o} F to 76 ^{o} F, which is slightly below BEHA's recommended comfort range. Three classrooms and the gymnasium were outside of this comfort range. The BEHA 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.

Relative humidity measurements ranged from 20 to 30 percent, which is below BEHA guidelines. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Moisture/Microbial Concerns

A book storeroom near the boy's restroom in the west wing had heavily water damaged shelving. It appears a water leak from a pipe in this room moistened this shelf, which resulted in mold colonization of the wood (see Picture 5). Water penetration into plywood and particleboard of the cabinet can cause these materials to swell and serve as a growth medium for mold.

One classroom had water-damaged ceiling tiles which can indicate leaks from the roof. Water-damaged walls and ceiling tiles can also provide a medium for mold and mildew growth and should be replaced after a water leak is discovered and repaired.

Several classrooms had a number of plants (see Picture 6). In some classrooms flowering plants were observed on univent air diffusers. Several classrooms contained plants in window

planters without drip pans. Window planters are designed to be mounted on the outside of windows and therefore do not have drip pans. The lack of drip pans can lead to water pooling and mold growth on windowsills when used indoors. Moistened plant soil, drip pans and standing water can serve as a source of mold growth. Plants should be equipped with drip pans and over watering should be avoided. In addition, plants should be located away from univents to prevent aerosolization of dirt, pollen or mold.

Plants were noted growing in the junction between the exterior wall and tarmac outside classrooms 7 through 10 (see Picture 7). Water can gather in the wall/tarmac seam where these plants are growing. Freezing and thawing of gathered water can result in damage to the exterior wall, which can result in water penetration into the building. Plants growing near fresh air intakes can result in pollen and other plant related particulates being entrained by the univent and distributed into classrooms.

Other Concerns

With this building under renovation, the introduction of particulates, gases and vapors can adversely impact indoor air quality in occupied areas of the school if not properly contained. As mentioned earlier, conditions noted by BEHA staff concerning containment of renovations were made in previous correspondence that is included as Appendix A of this report. Conditions aside from the renovation in this building were noted that can have an affect on indoor air quality.

Classrooms 8 and 9 had a detectable odor, which was traced to inflatable furniture that exists in these classrooms (Picture 8). The odor was noted in the west wing near classroom 3 after students returned to these rooms. Teachers opened windows upon returning to these

classrooms after lunch. The opening of these windows created airflow into the classrooms, which flowed into the hallway through open hallway doors. Plastic can have unpleasant odors, which can be irritating to the eyes, nose and throat.

A pretreated floor mop was noted in the hallway beneath a fan coil unit (see Picture 9). The fan coil unit has a return air vent through which hallway air is drawn, heated and distributed through the air diffusers of this unit. Any odors or dusts from the mop can be drawn into the return air vent and aerosolized by the fan coil unit.

Of note is the prolific use of cleaning materials in this building by teachers (see Picture 10). Cleaning materials frequently contain ammonium compounds or sodium hypochlorite (bleach-products), which are alkaline materials. It was also reported that the custodial staff used ammonia to clean hallway floors in order to remove accumulated salt stains from student traffic. Ammonium containing materials in spray cans were reportedly used to disinfect telephone receivers. The use of disinfectants in this manner can expose an individual to ammonium compound vapors, which can lead to irritation of the eyes, nose or respiratory tract.

The air intake for the teacher's room was partially covered with a tarpaulin. Stored beneath this tarpaulin were roofing materials, including adhesives that contain volatile organic compounds (VOC) (see Picture 11). VOCs can readily evaporate and can be irritating to the eyes, nose and throat. Entrainment of VOCs and roofing material odors should be avoided.

Classrooms either has dry erase boards with dry erase board markers or chalkboards. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999). Some rooms were noted to have excessive chalk dust. Dry erase markers and chalk dust can be irritating to the eyes, nose or throat when aerosolized.

Several offices contained window-mounted air conditioners. The filters of this equipment do not appear to have been cleaned for some time. Portable air-conditioning units are normally equipped with filters, which should be cleaned or changed as per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

Automobiles parked in close proximity to univent fresh air intakes were noted along the front classrooms of the east wing (see Picture 12), which can result in the entrainment of vehicle exhaust into the building, which may, in turn, provide opportunities for exposure to compounds such as carbon monoxide. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL, 1996).

Conclusions/Recommendations

The conditions noted at Hanover Middle School raise a number of complex issues. The combination of the renovations, building design, maintenance and other conditions in the building present factors that can influence indoor air quality in the building. For these reasons a two-phase approach is required, consisting of immediate measures (**short-term**) to improve air quality within Cedar Elementary School and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns. In view of the findings at the time of this visit, the following recommendations are made:

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

1. Implement the corrective actions recommended concerning renovations in the building (see Appendix A) (MDPH, 2000).

2. Ascertain whether the exhaust vent motors over the west wing are operable. If operable, activate these motors to provide exhaust ventilation for these classrooms. Repair the exhaust vent motors if necessary.
3. Remove inflatable furniture from classrooms 8 and 9.
4. Remove roofing products from fresh air intake on roof.
5. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Operate univents while classrooms are occupied. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide. If univent dampers cannot be readily adjusted, consider using windows to supplement fresh air in classrooms.
6. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
7. Once both the fresh air supply and the exhaust ventilation are functioning, the ventilation system should be balanced by an HVAC engineer.
8. Reduce the use of cleaning materials that contain respiratory irritants (ammonia related compounds) on floors and in classrooms. Do not use these materials to disinfect equipment that comes into close contact with the respiratory system (e.g., telephones). Substitute plain soap and hot water for ammonia related cleaning products. Only use ammonia related cleaning products where necessary. If ammonia containing cleaning products are used, rinse the area of application with water to remove residue.
9. Remove moldy shelving from storeroom in Picture 5. Identify the source of water leaking from the pipe above this water damage and repair. Examine areas beneath for mold growth and disinfect nonporous materials with an appropriate antimicrobial agent.

10. Clean air filters for window-mounted air conditioners in accordance with manufacturer's recommendations.

11. Have a chemical inventory done in all storage areas and classrooms. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Follow proper procedures for storing and securing hazardous materials. Obtain Material Safety Data Sheets (MSDS') for chemicals from manufacturers or suppliers.

12. Maintain MSDS' and train individuals in the science department in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (M.G.L., 1983).

13. Move plants away from univents in classrooms. Examine drip pans for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants in certain areas.

14. Prevent parking of cars along the front of the east wing to prevent vehicle exhaust entrainment by univents.

15. Clean chalkboards and chalk trays regularly to prevent the build-up of excessive chalk dust.

16. 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. Implement a dust control procedure. Institute wet mopping and wet wiping of horizontal surfaces (sweeping and dusting can stir up fine particulates). Consider using a vacuum cleaner equipped with a high efficiency particulate arrestance

(HEPA) filter to reduce the aerosolization of respirable dusts. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

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

1. Consider consulting a ventilation engineer concerning installing mechanical exhaust ventilation in the learning center, counselor rooms, conference room and upstairs storeroom if these areas are to be used for classrooms.

References

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

MDPH. 2000. Letter to Jeanmarie Joyce, Hanover Board of Health from Suzanne Condon, Director, Bureau of Environmental Health Assessment concerning Renovations at the Hanover Middle School, Dated February 22, 2000. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA.

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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

Picture 1

Wall-Mounted Exhaust Vent Obscured by Shelf

Picture 2

Exhaust Vents above the Eastern Wing, Note Dry Roof Rock Ballast Dried By Exhaust Air from These Vents

Picture 3

Exhaust Vents Above The West Wing, Note Wet Roof Rock Ballast Around Vents

Picture 4

Fresh Air Intake above Kitchen

Picture 5

Mold Colonized Wood Shelves in Book Storeroom near Boy's Restroom in West Wing

Picture 6

Plants over Air Diffusers of This Classroom's Univent

Picture 7

Plants Growing in the Exterior Wall/Tarmac Junction outside Classrooms 7-10

Picture 8

Odorous Inflatable Plastic Furniture Noted In Classroom 8

Picture 9

Floor Mops beneath Fan Coil Unit in West Wing

Picture 10

An Example of Cleaning Products Found in Classrooms

Picture 11

Open Containers of Roofing Materials beneath Tarpaulin next to Rooftop Fresh Air Intake

Picture 12

East Wing Fresh Air Intake near Parked Cars

TABLE 1

Indoor Air Test Results –Cedar Elementary School, Hanover, MA – February 11, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	462	46	62					
Room 25	937	71	25	18	yes	yes	yes	window open
Room 24	1043	72	24	17	yes	yes	yes	permanent magic marker, door open
Room 29A	1312	72	30	27	yes	yes	yes	univent off - blocked by box
Room 23	1328	72	27	23	yes	yes	yes	
Room 22	1298	73	25	19	yes	yes	yes	plant over univent, exhaust off
Room 21	1390	72	28	22	yes	yes	yes	exhaust off
Room 20	771	69	29	22	yes	yes	yes	window and door open, exhaust off
Room 19	821	72	27	16	yes	yes	yes	window open
Learning Center	844	71	27	0	no	no	no	
Counselor's Office	1082	70	30	1	no	no	no	Cleaning product odor - used on phone, air conditioner – filter

*** 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 –Cedar Elementary School, Hanover, MA – February 11, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Upstairs Storage-Left	830	66	33	0	no	no	no	
Room 13	1488	71	27	23	yes	yes	yes	univent blocked by file cabinet, exhaust off, door open
Room 12	1219	71	28	18	yes	yes	yes	exhaust off
Room 11	941	69	25	20	yes	yes	yes	univent blocked by file cabinet, exhaust off
Room 10	1125	71	24	17	yes	yes	yes	
Room 9	698	72	24	18	yes	yes	yes	exhaust blocked by shelf, window and door open
Room 8	1109	72	25	22	yes	yes	yes	exhaust off, window and door open
Room 28	1277	73	28	23	yes	yes	yes	books on univent, HEPA - air purifier
Room 27	1202	72	25	22	yes	yes	yes	univent blocked by shelf, door open
Room 26	1070	73	27	24	yes	yes	yes	plant/basket over univent, door open
Room 28A	1139	72	24	2	yes	yes	yes	

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CT = water-damaged ceiling tiles

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

TABLE 3

Indoor Air Test Results –Cedar Elementary School, Hanover, MA – February 11, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 29	1208	71	26	0	yes	yes	yes	door open
Room 3	1611	72	25	20	yes	yes	yes	paper/cleaning product on univent, exhaust off, dry erase board, door open
Room 4	1604	71	24	16	yes	yes	yes	exhaust off, CT, door open
Room 5	1656	72	28	23	yes	yes	yes	exhaust off, door open
Room 6	1264	72	21	23	yes	yes	yes	plants on univent, exhaust off, door open, 7 plants
North End Corridor	785	71	21					cardboard odors
Room 7	786	73	20	4	yes	yes	yes	univent blocked by divider, exhaust not functioning, door open
Room 8	937	71	22	0	yes	yes	yes	
Room 9	973	76	20	0	yes	yes	yes	
Cafeteria	1699	73	29	200+	yes	yes	yes	exhaust blocked by felt
Room 20				21	yes	yes		

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CT = water-damaged ceiling tiles

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results –Cedar Elementary School, Hanover, MA – February 11, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 14		71	24	0	no	no	yes	3 photocopiers

*** 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%