INDOOR AIR QUALITY REASSESSMENT

Johnson Elementary School
290 Castle Road
Nahant, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program

August 2003

Background/Introduction

At the request of Cecilia DiBella, Superintendent of Nahant Public Schools, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Johnson Elementary School, 290 Castle Road, Nahant, Massachusetts. The school was previously visited in December 2000 and in December of 2001 by BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program. A letter (MDPH, 2000a) and two reports (MDPH, 2001; MDPH, 2002) describing conditions of the building at that time were issued. The letter and reports gave recommendations concerning remediation of conditions noted in the building.

On February 11, 2003, Cory Holmes, Environmental Analyst of BEHA's ER/IAQ program visited the school to conduct an indoor air quality reassessment. This reassessment was conducted in preparation of plans for major renovations to the JMS. On May 10, 2003 the town of Nahant held a special election and passed a Proposition 2 ½ override, providing 6.9 million dollars for renovations to the JMS.

Actions on Recommendations Previously Made by MDPH

As mentioned, BEHA staff had previously visited the school in December of 2000 and again in December of 2001 and issued two reports and a letter that made recommendations to improve indoor air quality (MDPH, 2000; MDPH, 2001; MDPH, 2002). A summary of actions taken on previous recommendations as well as plans to improve conditions listed in a report provided by the Johnson School Renovation Committee, are included as Appendix I of this reassessment.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school houses grades K-6. It has a student population of over 200 and a staff of approximately 40. Tests were taken during normal operations and results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in six of twenty areas surveyed, indicating adequate air exchange in the majority of areas surveyed during the assessment. The school department has reportedly spent a substantial amount of money over the last several years to replace parts to the mechanical ventilation system. However, occupants reported that many univents lacked temperature control, subsequently overheating classrooms.

Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building covered by vertical slats (see Picture 1). Return air is provided through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and a heating coil, and is subsequently expelled from the univent by motorized fans through fresh air diffusers (see Figure 1). Univents were found deactivated or in the "off-cycle" in many areas.

Univents do not run continuously but are activated by thermostats once room temperatures drop below a set level called "cycling". When the room temperature exceeds the thermostat setting, univents deactivate (off-cycle). Without mechanical ventilation running continuously, fresh air cannot be introduced into classrooms on a consistent basis. Further, in order for univents to provide fresh air as designed, air intakes and diffusers must remain free of obstructions. Obstructions to airflow, such as paper and boxes stored on univent air diffusers and desks in front of univent return vents, were noted in classrooms (see Picture 2). The efficiency of air intake by univents can also be limited by the vertical slats decreasing surface area by almost fifty percent.

The mechanical exhaust ventilation system in each classroom consists of ducted, grated wall vents powered by rooftop exhaust motors. A number of vents were deactivated and backdrafting in classrooms, indicating exhaust motors were off or non-functional. As with the univents, a number of exhaust vents were obstructed by tables, chairs, boxes and other items (see Picture 3). Without adequate exhaust ventilation, excess heat and environmental pollutants can build up and lead to indoor air complaints.

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, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air in schools or that each room have openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The 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. For more information concerning carbon dioxide, please refer to Appendix II.

Temperature readings in occupied areas ranged from 66° F to 73 ° F, which were below the BEHA recommended range in a number of areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. As explained earlier, the school has been experiencing problems controlling heat flow into classrooms via the univent system. It is difficult to control temperature and maintain comfort without the HVAC equipment operating as designed. 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 measured in the building ranged from 12 to 23 percent, which was below the BEHA recommended comfort range in all areas. 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

Several classrooms contained a number of plants. Plant soil and drip pans can serve as sources of mold growth. Plants should also be located away from univents and exhaust ventilation to prevent aerosolization of dirt, pollen or mold.

Other Concerns

Of note was the amount of materials stored inside classrooms. In several areas, items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g. papers, folders, and boxes) make it difficult for custodial staff to clean in and around these areas. Dust can be irritating to the eyes, nose and respiratory tract. Items should be relocated and/or cleaned periodically to avoid excessive dust build up. In addition, a number of exhaust vents in classrooms were noted with accumulated dust (see Picture 4). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles.

Conclusions/Recommendations

The Nahant School Department and Town Officials, working in conjunction with Johnson Elementary School staff, have taken steps to improve indoor air quality at the school by implementing several of the BEHA's previous recommendations. While a number of issues remain to be addressed, the School Department is taking major steps to further remedy IAQ problems. Proposed renovations to the building including roof repairs/replacement, replacement of unit ventilators, plumbing and temperature controls should greatly improve air quality. In addition to those recommendations made in the previous reports, the following additional recommendations are suggested to further improve indoor air quality:

1. Continue with plans to replace HVAC components including unit ventilators, exhaust fans, plumbing and temperature controls.

2. Once renovations are complete, contact the BEHA IAQ Program to conduct a reassessment.
3. In order to maintain a good indoor air quality environment on the building, consideration should be give to adopting the US EPA document, "Tools for Schools", which can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
4. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

Construction/Renovations

The following recommendations should be implemented in order to reduce the migration of renovation-generated pollutants into occupied areas and the potential impact on indoor air quality. We suggest that these steps be taken on any renovation project within a public building.

1. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation related odors and/or dusts problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.
2. When possible, schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.
3. Disseminate scheduling itinerary to all affected parties, this can be done in the form of meetings, newsletters or weekly bulletins.

4. Obtain Material Safety Data Sheets (MSDS) for all construction materials used during renovations and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).
5. Consult MSDSs for any material applied to the effected area during renovation(s) including any sealant, carpet adhesive, tile mastic, flooring and/or roofing materials. Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.
6. Use local exhaust ventilation and isolation techniques to control for renovation pollutants. Precautions should be taken to avoid the re-entrainment of these 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. 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 utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).
7. Seal utility holes, spaces in roof decking and temporary walls to eliminate pollutant paths of migration. Seal holes created by missing tiles in ceiling temporarily to prevent renovation pollutant migration.

8. Where applicable, seal construction barriers with polyethylene plastic and duct tape to create a secondary barrier to prevent migration of renovation generated pollutants into occupied areas.
9. Inspect classrooms for cleanliness and construction barriers for integrity daily prior to the opening of school. Consideration should also be considered to inspect construction barriers at the end of the school day prior to construction work. In addition, encourage staff to report any breaches in construction barriers immediately.
10. If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g. hypersensitivity, asthma) away from areas of renovations.
11. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. This may include constructing barriers, sealing off areas, and temporarily relocating furniture and supplies. To control for dusts, a high efficiency particulate air filter (HEPA) equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended.
12. Prevent renovation generated pollutants from entering the building. Occupants in classrooms in close proximity to construction areas should be aware of outside construction activities and keep windows closed during periods which generate heavy dust and/or odors. As previously noted, if air intakes are in close proximity to vehicles/products of combustion occupants should determine the appropriateness of opening windows and/or temporarily limiting fresh air intake.

13. Consider changing univent filters more regularly in areas impacted by renovation activities. Examine the feasibility of acquiring more efficient filters for these units.

References

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

MDPH. 2002. Indoor Air Quality Reassessment, Johnson Elementary School, Nahant, MA. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA. February 2002.

MDPH. 2001. Indoor Air Quality Assessment, Johnson Elementary School, Nahant, MA. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA. March 2001.

MDPH. 2000. Letter to Cecilia DiBella, Superintendent, Nahant Public Schools, Regarding Indoor Air Quality Issues at the Johnson Elementary School, Nahant, MA. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA. December 22, 2000.

MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

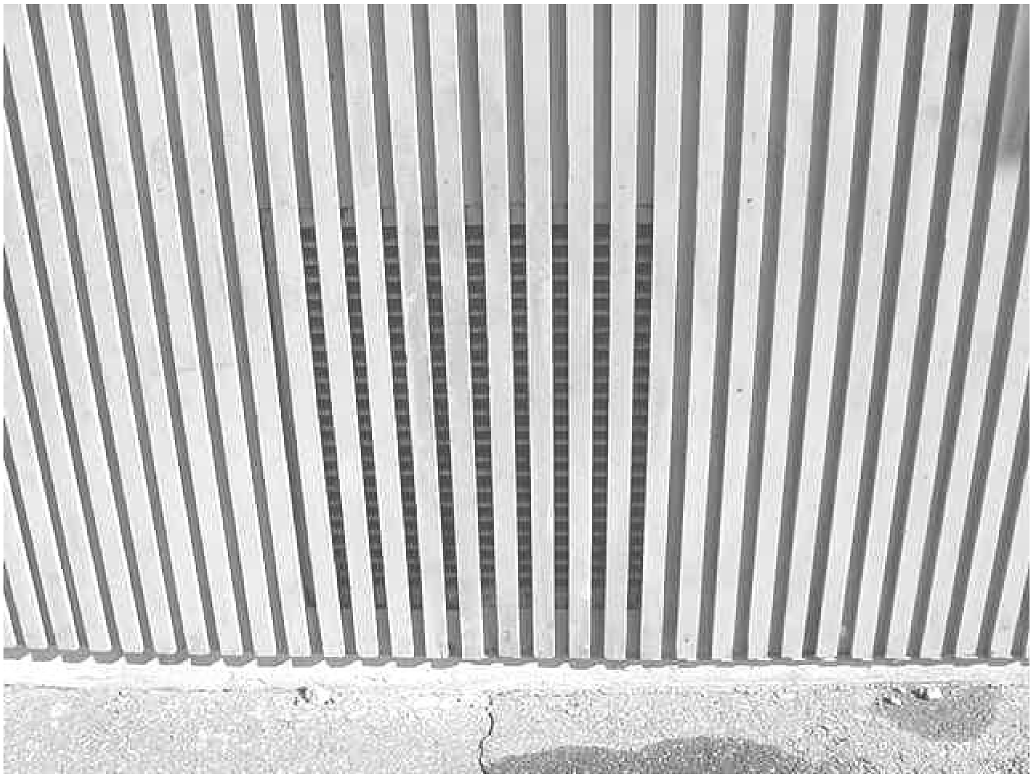
OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

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

SMACNA. 1995. IAQ Guidelines for Occupied Buildings Under Construction. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

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

Picture 1



Univent Fresh Air Intake Covered by Vertical Slats

Picture 2

Univent Obstructed by Items on and in Front of Unit

Picture 3

Exhaust Vent

Classroom Exhaust Vent Blocked by Various Items

Picture 4

Accumulated Items in Classroom

TABLE 1

Indoor Air Test Results –Johnson Elementary School - Nahant MA February 11, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outdoors (Background)	360	32	13					Clear skies – NW wind 15-20 mph Gusts 25
Room 4	523	71	18	1	Y	Y	Y	13 occupants gone 30 min. plants
Room 3	885	73	21	13	Y	Y	Y	UV fan off (cycling) Exhaust partly blocked/off
Room 2	860	72	18	10	Y	Y	Y	UV off (cycling) Door open
Room 1	721	72	16	12	Y	Y	Y	UV off (cycling)
Gym	557	69	13	18	N	Y	Y	Vent off (thermostat) Exhaust partially blocked
Art Room	632	72	15	16	Y	Y	Y	Plants
McKenna	612	66	12	17	Y	Y	Y	Exhaust off/blocked Door open, UV off
Room 5	571	71	16	14	Y	Y	Y	Items on/blocked, door open, air flow obstructed by shelves/ furniture in front of exhaust vent, dust/dirt accumulated on exhaust vent
Room 6	1178	71	23	0	Y	Y	Y	UV deactivated (2) exhaust vents

*** ppm = parts per million parts of air**
UV = Univent

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 1

Indoor Air Test Results –Johnson Elementary School - Nahant MA **February 11, 2003**

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
								off (noise), Items in front of UV return
Dunlon's Office	815	73	18	16	Y	Y	Y	Door open UV off
Hennessea	730	71	17	12	Y	Y	Y	Door open UV off
Brady	894	72	18	14	Y	Y	Y	Plants, door open Exhaust vent partly obstructed
Theriault	635	72	14	7	Y	Y	Y	UV off (Cycling)
Sylvia	685	71	17	17	Y	Y	Y	Door open, UV off (cycling) Exhaust partially blocked
Sylvia (12)	650	69	15	12	Y	Y	Y	UV off (cycling)
Salt	715	67	14	17	Y	Y	Y	UV off (cycling)
Preschool	718	69	19	20	Y	Y	Y	Window AC (2) 2 UVs
Music Room 9	993	70	19	15	Y	Y	Y	
Cafeteria	492	70	20	100	N	Y	Y	Exhaust on

*** ppm = parts per million parts of air**
UV = Univent

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%

Appendix I

The following is a status report of action(s) taken on previous BEHA recommendations based on reports from building staff, documents, photographs and BEHA staff observations. Previous recommendations appear in bold.

1. **Continue working with HVAC engineering firm to resolve heating issues. Once heating issues are resolved, operate univents continuously during periods of school occupation, independent of classroom thermostats, to provide a constant source of outside air.**

   Action taken: Univents and controls will reportedly be repaired/replaced during subsequent renovations.

2. **Use openable windows to supplement fresh air supply in the building until control of heat is restored.**

   Action taken: Windows were being used by occupants to control comfort.

3. **Continue with plans to conduct feasibility study to determine the long-term facility needs of the school (e.g., HVAC, windows, roof, drainage).**

   Action taken: Feasibility study was conducted by Flansburgh Associates and provided to the school on April 4, 2002.

4. **Consider obtaining a HEPA filtered vacuum cleaner to control for dusts.**

   Action taken: The school has purchased two vacuums with HEPA filtration.