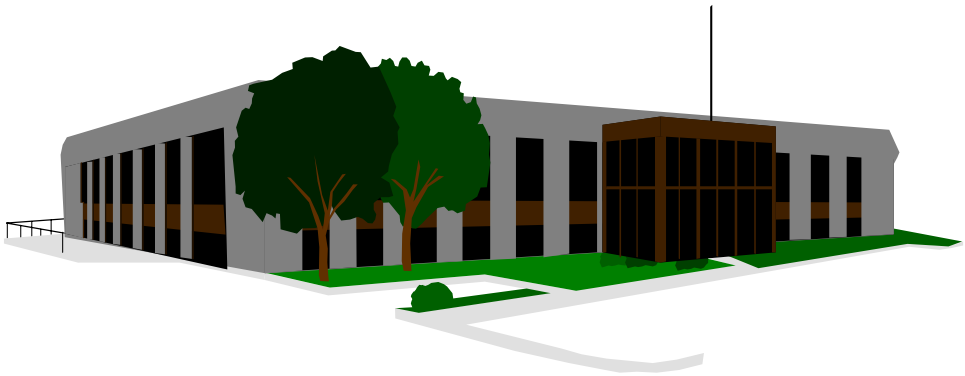
INDOOR AIR QUALITY ASSESSMENT

Francis T. Bresnahan Elementary School
333 High Street
Newburyport, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
February, 2000

Background/Introduction

At the request of a building occupant, the Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality issues and health concerns at the Bresnahan Elementary School in Newburyport, Massachusetts. On December 3, 1999, a visit was made to this school by Cory Holmes, Environmental Analyst, of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program to initiate an indoor air quality assessment. Mr. Holmes returned to the school on January 21, 2000 to complete the assessment of the rear wing and crawlspace.

The school houses kindergarten through 4th grade students. The original building, constructed in 1957, is a one-story red brick building that rests on a concrete slab. The building consists of a main central corridor flanked by classrooms, a cafeteria, a gymnasium and office space. A series of modular classrooms (added in the mid 1970's) house the art room as well as general classrooms. The original building was renovated during the 1980s. These renovations converted locker rooms to a series of small special education classrooms. Two more modular classrooms were added in 1999.

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. Wind speed and direction were measured with a Davis, Wind Wizard, Wind Speed Indicator.

Results

This school has a student population of 515 and a staff of approximately 55. The tests were taken during normal operations. Test results appear in Tables 1-5.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in twenty-six of thirty-four areas surveyed, which is indicative of an overall ventilation problem in the school. Of note were classrooms 10 and 12, which had levels of carbon dioxide in excess of 2,000 ppm, which indicates little or no air exchange. Also of note were Mr. Foley's room, Ms. Puia's room and classrooms 18 and 31, which all had carbon dioxide levels over 800 ppm without occupancy.

Fresh air in most classrooms is supplied by a unit ventilator (univent) system (see Figure 1). Univents were found off or not functioning in a number of classrooms surveyed. Several of these units were re-activated by BEHA staff to observe function (see Tables). According to classroom occupants, the motor in the univent supplying fresh air to Mr. Foley and Ms. Bennett's rooms had burnt out and a new motor was on order. Obstructions to airflow, such as books, papers and posters on univent fresh air diffusers; and bookcases, tables and desks in front of univent return vents were seen in a number of classrooms (see Pictures 1 & 2). In order for univents to provide fresh air as designed, all vents must remain free of obstructions. More importantly, univents must be activated and allowed to operate. It should be noted that Ms. Puia's room had no mechanical ventilation.

Mechanical ventilation in most of the modular classrooms is provided by rooftop air-handling units (AHUs), via ceiling-mounted air diffusers and exhaust vents. The AHUs for the 1999 modular classrooms are mounted on the exterior wall of the building outside of their respective rooms. A thermostat controls the heating, ventilating and air conditioning (HVAC) system. Thermostats have settings of "on" and "automatic". Thermostats were set to the "automatic" setting in all of the modular rooms surveyed during the assessment. The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once a preset temperature is measured by the thermostat, the HVAC system is deactivated. Therefore no mechanical ventilation is provided until the thermostat re-activates the system.

The mechanical exhaust system in classrooms consists of ducted, grated wall vents and/or exhaust vents mounted in the ceiling of coat closets. Coat closet exhaust vents and exhaust vents in the library are equipped with pull chains to adjust a flue located in the ductwork (see Picture 3). Exhaust ventilation was off or drawing weakly in many of the classrooms surveyed. In addition, exhaust vents were missing pull chains, had louvers closed or were obstructed by bookcases, storage bins and other items (see Pictures 4 & 5). As with the univents, exhaust vents must be activated and be allowed to operate free of obstruction in order to function as designed.

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 room while removing stale air from the room. The date of the last servicing and balancing of the systems was not available at the time of the assessment.

Ventilation complaints were reported in the gymnasium. Fresh air to the gymnasium is provided by an AHU mounted in the stage area at the rear of the gym (see Picture 6). During the assessment a gym class was being conducted, the AHU was not

operating and elevated levels of carbon dioxide were recorded (i.e., over 800 ppm). Exhaust ventilation for the gym is provided by a large, wall-mounted exhaust vent. The grille of the exhaust vent was damaged. The system appeared to not have been activated for some time, as evidenced by accumulations of dirt, debris and food noted within the vent (see Pictures 7 & 8). Elevated levels of carbon dioxide were also recorded in the cafeteria during lunch hours. As with the gymnasium, both the supply and exhaust ventilation were deactivated during occupancy.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997). 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.

Temperature readings were within a range of 69° F to 79 ° F, on the December 3rd visit and from 68° F to 70 ° F during the January, 21st visit which were close to the BEHA guidelines. 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. 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. Complaints of excessive heat were expressed in the councilor's office and Ms. Bennett's room. The exhaust vent in the councilor's room was deactivated, which can lead to heat build-up in this area. The thermostat for Ms. Bennett's room is reportedly located in the corridor outside of the room. As cold outside air enters the hallway, the thermostat detects cold air and activates the univent in Ms. Bennett's room. Continuous activation of the univent heating coil can increase temperature and make the room uncomfortable.

The relative humidity in the building was below the BEHA recommended comfort range in all areas sampled on both visits. Relative humidity measurements ranged from 22 to 38 percent on the December 3rd visit and from 10 to 14 percent during the January 21st visit. 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.

Microbial/Moisture Concerns

A number of classrooms have water-damaged ceiling tiles which can indicate leaks from either the roof or plumbing system (see Picture 9). Water-damaged tiles can

provide a medium for mold and mildew growth and should be replaced after a water leak is discovered and repaired.

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be a respiratory irritant for some individuals. Plants should be properly maintained and be equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

A musty odor was detected in the crawl space beneath the building. The crawl space consists of a dirt floor and provides access to utilities beneath classrooms. Visible mold growth was observed on cardboard on the floor of the crawlspace. A number of other cardboard and paper items (e.g., lightbulb boxes) were also seen on the floor throughout the crawl space. No water pooling was observed in the crawl space during the assessment.

A broken window was observed in classroom 10. Missing and/or damaged window caulking was noted in rear-wing classrooms (18-22). Water penetration through broken windows and window frames can lead to mold growth under certain conditions. Repair of broken windows and window leaks are necessary to prevent water penetration.

Other Concerns

A number of other conditions that can potentially affect indoor air quality were identified at the time of the assessment. Cleaning products and flammable materials were found on countertops and underneath sinks in a number of classrooms. Many of the sinks had cabinet doors open or were missing doors entirely (see Picture 10), allowing easy student access. Cleaning products and flammables contain chemicals such as volatile organic compounds (VOCs), which can be irritating to the eyes, nose and throat. These materials should be stored properly and kept out of reach of students.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999). A strong odor of deodorizer was detected upon entry into the men's and women's restrooms in the 1999 modular classroom wing. The source was identified as wall-mounted, time-released air fresheners. Air fresheners and cleaning products contain chemicals that can be irritating to certain sensitive individuals. In addition, air fresheners do not remove materials causing odors, but rather mask odors which may be present in the area.

The mailroom contained two photocopiers. Photocopiers can produce ozone, waste heat and other pollutants, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). No mechanical exhaust ventilation is provided for this room. Without mechanical exhaust ventilation, pollutants produced by office equipment can build up. Mechanical exhaust ventilation should be installed in this area to help reduce odors, pollutants and excess heat.

Several areas contained window-mounted air conditioners. Classroom 14 contained a portable air purifier. These items 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. Several classrooms contained excessive chalk dust. Chalk dust can become easily aerosolized and also serve as an eye and respiratory irritant. The occupational therapy area located in the stage area of the gymnasium had missing ceiling tiles (see Picture 11). Missing ceiling tiles can provide an egress for dirt, dust and particulate matter into occupied areas. These materials can be irritating for certain individuals.

Conclusions/Recommendations

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

1. 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. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
2. Examine exhaust motors for function, increase exhaust if necessary. Operate exhaust ventilation during occupancy. Ensure exhaust flues are opened to facilitate air exchange. Repair and/or replace missing/damaged pull chains.
3. Examine the feasibility of providing mechanical ventilation to Ms. Puia's room. If not feasible consider installing a passive door vent to facilitate airflow.
4. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
5. Operate mechanical ventilation in gymnasium and cafeteria during occupancy.
6. Consider setting thermostat controls in modular classrooms to the "on" position to provide constant supply and exhaust ventilation during periods of occupancy.
7. Once both the fresh air supply and the exhaust ventilation are functioning, the ventilation systems should be balanced.
8. Consider re-locating thermostat for Ms. Bennett's classroom to provide better control for comfort.
9. 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 HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is

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

10. Repair any water leaks and replace any water-stained wall and ceiling tiles. Examine the area above and behind these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial where necessary.
11. Move plants away from univents in classrooms. Ensure plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
12. Remove moldy cardboard from crawlspace. Inspect area for other potential mold growth media (e.g., paper, cardboard, cloth materials, etc.) and remove if found. Ensure all utility holes are sealed to avoid the penetration of particulates and/or crawlspace odors into occupied areas.
13. Replace broken windows and seal window frames to prevent water penetration.
14. Refrain from using strong scented materials in classrooms and restrooms.
15. Properly store chemicals and cleaning products and keep out of the reach of students. Consider replacing cabinets or installing lockable doors on existing cabinets.
16. Store flammable materials in flameproof cabinets consistent with local and state fire codes.
17. Consider installing local exhaust ventilation in the mailroom to help reduce odors, pollutants and excess heat.
18. Acquire current Material Safety Data Sheets for all products that contain hazardous Materials and are used within the building, including office supplies, in conformance with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL., 1983).

19. Change/clean filters for window-mounted air conditioners and portable air purifiers as per the manufacturer's instructions to prevent the re-aerosolization of dirt, dust and particulate matter.
20. Clean chalk boards and chalk trays regularly to avoid the excessive build-up of chalk dust.
21. Replace missing ceiling tiles in occupational therapy area.

References

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.

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

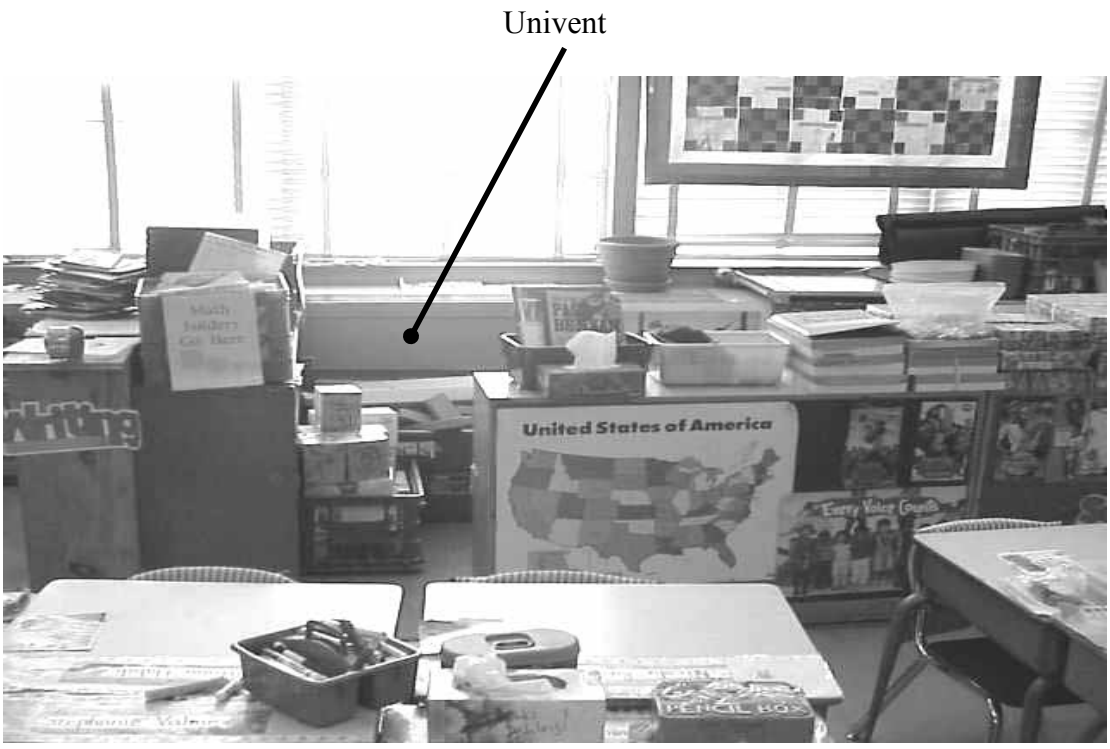
SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

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

Picture 1

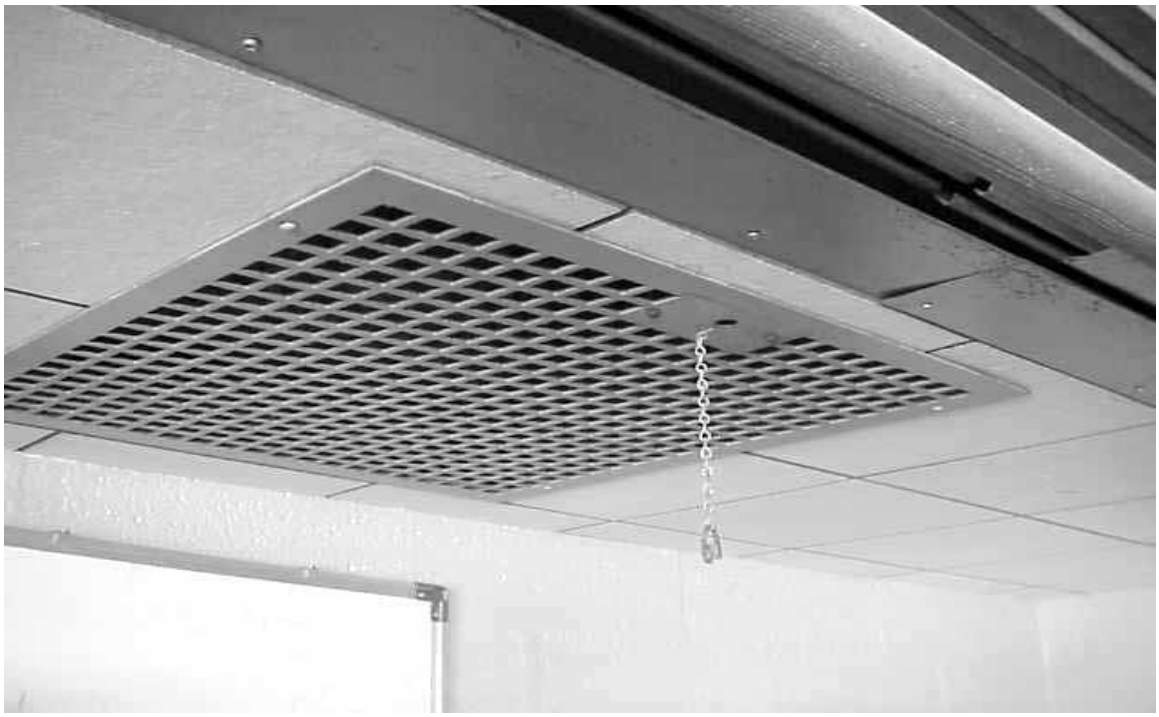
Univent Return Vent Blocked by Storage Bin and Poster

Picture 2



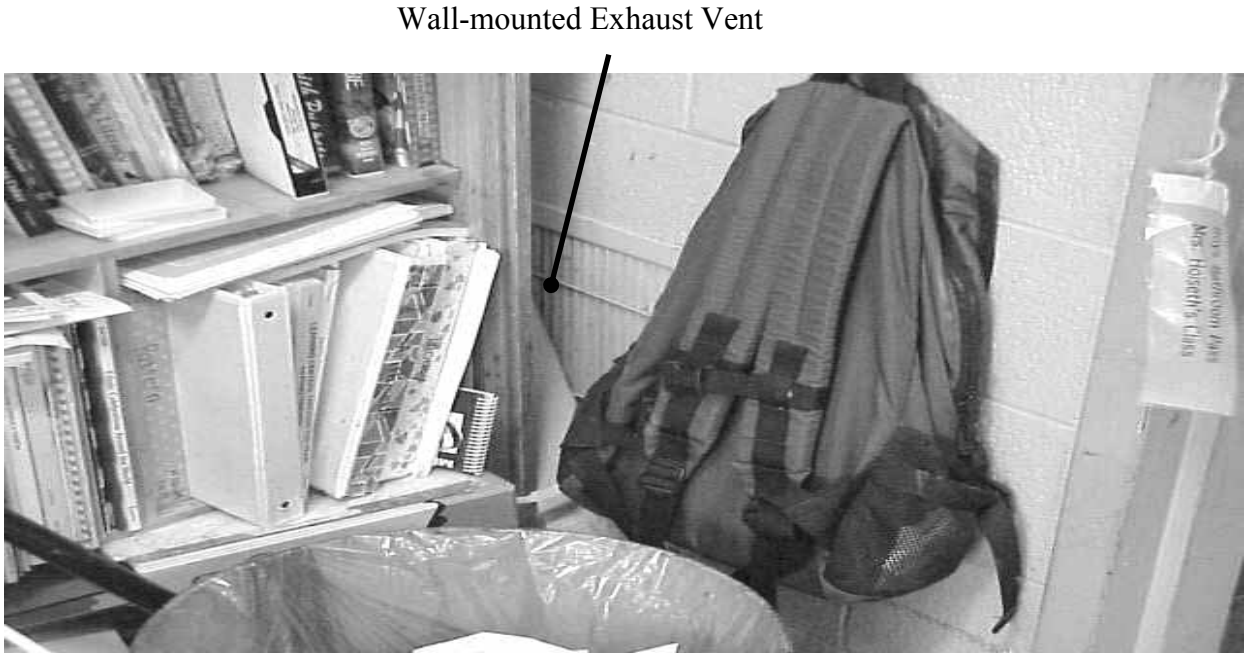
Classroom Configuration Note Amount of Materials around Univent Inhibiting Airflow

Picture 3



Ceiling-mounted Exhaust Vent in Coat Closet Note Pull Chain Which Controls Flue inside Duct

Picture 4

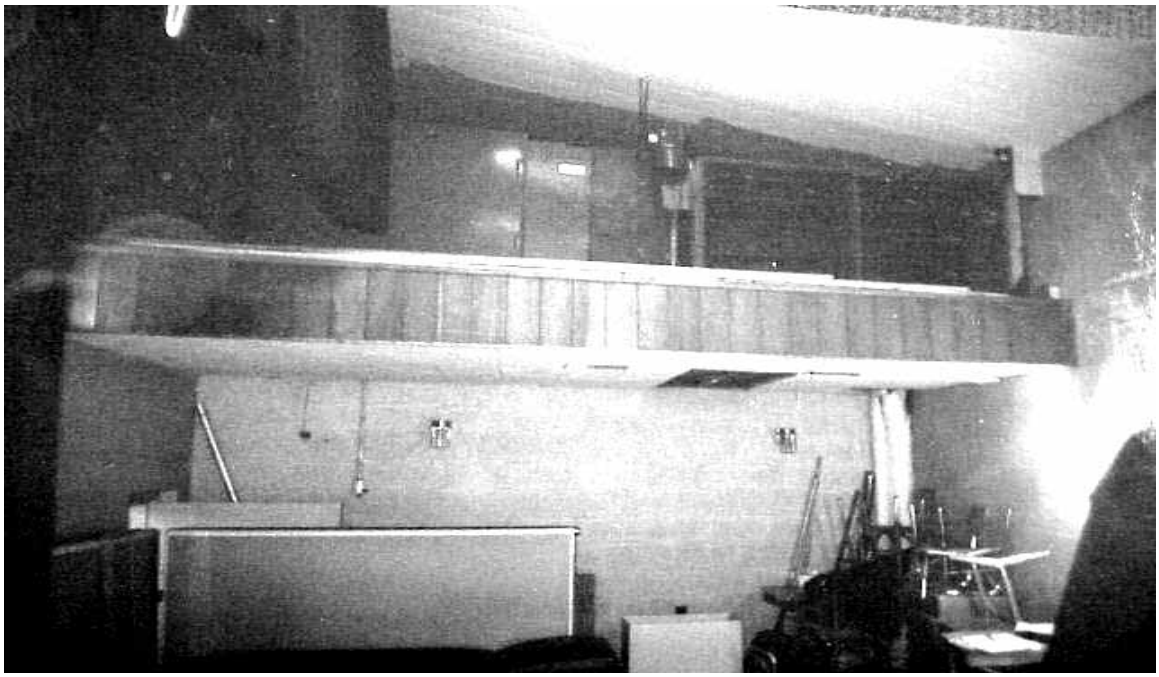


Wall-Mounted Exhaust Vent Obstructed by Bookcase and Bookbag

Picture 5

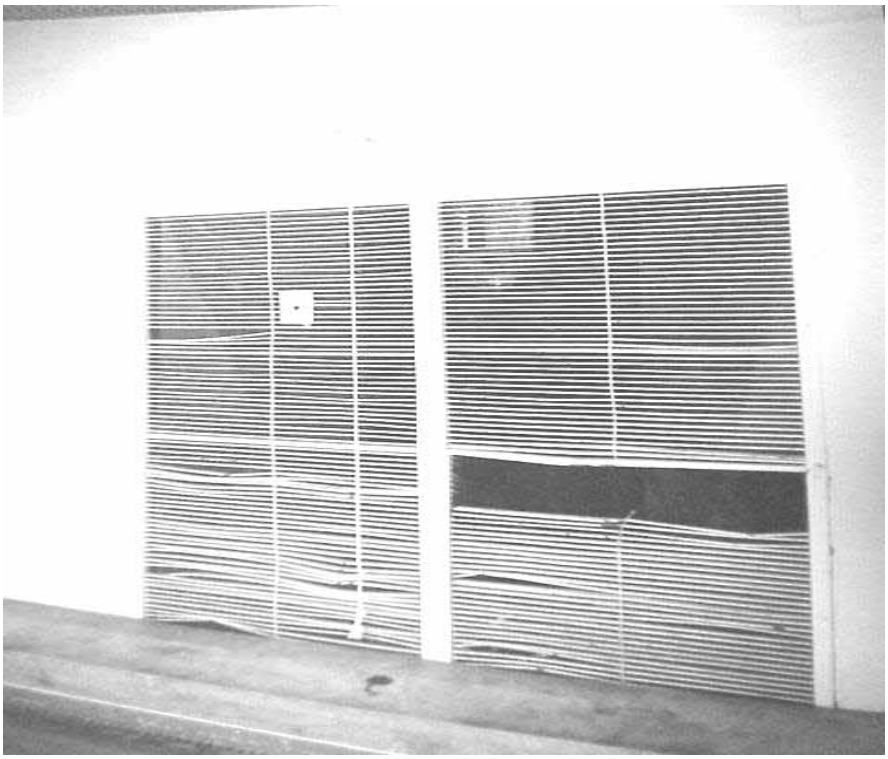
Wall-mounted Exhaust Vent Obstructed by File Cabinet

Picture 6



AHU Servicing Gymnasium Located Behind Stage Area

Picture 7



Damaged Exhaust Grille Noted in Gymnasium

Picture 8

Accumulated Dirt, Dust and Debris Noted in Inactive Gymnasium Exhaust Vent Picture Taken through Damaged Exhaust Grille (see above)

Picture 9

Water-Damaged Ceiling Tiles Noted in Classroom

Picture 10

Classroom Cabinet Containing Cleaning Products and Flammable Material
Note Missing Door on Cabinet

Picture 11

Missing Ceiling Tiles Noted behind Stage in Occupational Therapy Area

TABLE 1

Indoor Air Test Results –Breshnahan Elementary School, Newburyport, MA – December 3, 1999

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	425	50	34					weather conditions: overcast, slight breeze
Mailroom					no	no	no	2 photocopiers, 20+ CT
Room 0	564	75	22	10	yes	yes	yes	exhaust blocked, window open
Gym	946	74	31	18	yes	yes	yes	exhaust not active-dirt, dust food noted inside vent-grill damaged, numerous CT AHU not operating
Stage Area	949	74	31	2	no	no	no	area used for physical therapy, new curtain
Cafeteria	1349	72	34	~150	yes	yes	yes	supply and exhaust-off
Library (11:50 am)	1055	73	28	16	yes	yes	yes	univent-off (activated), exhaust-no pull chain-damper closed (opened-works)
Foley Room	905	74	27	0	no	yes	yes	supply-off - univent motor burnt out, 13 CT, 8 plants
Bennett Room	776	71	37	4	no	yes	yes	supply-off – univent motor on order, thermostat in hallway, 3 CT
Room 10 (unoccupied)	1225	75	33	0	yes	yes	yes	occupants gone ~35 min., exhaust blocked by file cabinet, cleaning products in cabinet near sink, area carpet, broken window, chalk dust,

*** 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 –Breshnahan Elementary School, Newburyport, MA – December 3, 1999

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
								2 CT, door open
Councilor's Office	1087	79	27	3	no	yes	yes	exhaust-off-in closet, temperature complaints (heat)
Case Room	700	77	24	2	yes	yes	yes	exhaust-off, 3 CT, 11 computers
Girl's Restroom (across from rm. 2)							yes	exhaust-off
Boy's Restroom							yes	exhaust-off, radiator-hissing noise
Main Office								window mounted air conditioner
Puia Room	900	72	36	0	no	yes	yes	supply-off, door open
Room 10 (occupied)	2000+	76	38	21	yes	yes	yes	supply-off, musty odors
Room 13	931	70	28	18	yes	yes	yes	exhaust-no draw-missing pull chain-partially blocked by cart, univent return blocked, 1 plant
Room 12	2000+	71	38	23	yes	yes	yes	univent-off-return blocked by cooler-missing control dial; exhaust-damper shut-no draw-opened by BEHA staff

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Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results –Breshnahan Elementary School, Newburyport, MA – December 3, 1999

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 14	1430	72	31	15	yes	yes	yes	exhaust-missing pull chain-partially blocked by desk & storage bins, air purifier, window mounted air conditioner
Room 15	1389	78	26	20	yes	yes	yes	
Room 17	882	74	22	15	yes	yes	yes	closet exhaust vent & wall mounted vent, univent return blocked by storage bin, 4 plants
Room 31	848	72	30	0	yes	yes	yes	supply and exhaust-off, control box on "auto", temporarily activated by BEHA staff to observe function
Room 30	1120	75	33	20	yes	yes	yes	supply and exhaust-off, control on "auto"
Room 16	750	70	26	22	yes	yes	yes	1 CT
Room 23	1090	69	27	16	yes	yes	yes	ceiling supply vents, wall exhaust vent-partially blocked
Room 1	857	71	29	19	yes	yes	yes	supply-off, closet exhaust-off-damper shut, 20+ CT, window open
Room 2	1400	72	34	19	yes	yes	yes	supply and exhaust-off, cleaning product on countertop, door open

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Comfort Guidelines

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

TABLE 4

Indoor Air Test Results –Breshnahan Elementary School, Newburyport, MA – December 3, 1999

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 3	1139	73	37	1	yes	yes	yes	occupants gone ~30 min., supply-off, exhaust-no pull-damper shut (opened)
Room 4	1080	72	31	2	yes	yes	yes	supply-off, exhaust-on-damper shut-no pull
Room 5	1350	74	34	17	yes	yes	yes	exhaust-off, plant on windowsill-no drip pan, musty odors
Room 6	1322	73	33	20	yes	yes	yes	exhaust-off-damper shut-pull chain broken, univent return blocked by desk, items on univent, subterranean air intake for univent
Room 7	1400	73	35	17	yes	yes	yes	exhaust-off-damper shut, door open
Room 8	1600	74	34	17	yes	yes	yes	exhaust-off
Room 18	1200	74	27	0		yes	yes	occupants gone <5 min., univent and exhaust vent blocked by cabinets

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Comfort Guidelines

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

TABLE 5

Indoor Air Test Results –Breshnahan Elementary School, Newburyport, MA – January 21, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	384	15	8					weather conditions: overcast, wind-NW-10-15 mph, gusts up to 20 mph
Room 21	842	68	13	18	yes	yes	yes	exhaust-blocked, bookcase in front of univent return, cleaning product under sink, window and door open
Room 22	615	70	10	4	yes	yes	yes	exhaust-blocked, cleaning products under sink and on countertop, damaged window caulking, door open
Room 19	725	68	14	2	yes	yes	yes	univent blocked by storage bin and posters, exhaust blocked by bookcase, trash can and book bag, cleaning products and flammables under sink-no door on cabinet, door open
Room 18	590	70	13	3	yes	yes	yes	univent blocked by bookcase and storage bin, exhaust vent completely blocked by cabinet, cleaning products on sink and under cabinet, flammable product on sink
Boy's Restroom					yes	yes	yes	passive supply
Crawl Space								dry, mold odors-visible mold growth on cardboard

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Comfort Guidelines

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Relative Humidity -	40 - 60%

TABLE 6

Indoor Air Test Results –Breshnahan Elementary School, Newburyport, MA – January 21, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	

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CT = water-damaged ceiling tiles

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	> 800 ppm = indicative of ventilation problems
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Relative Humidity -	40 - 60%