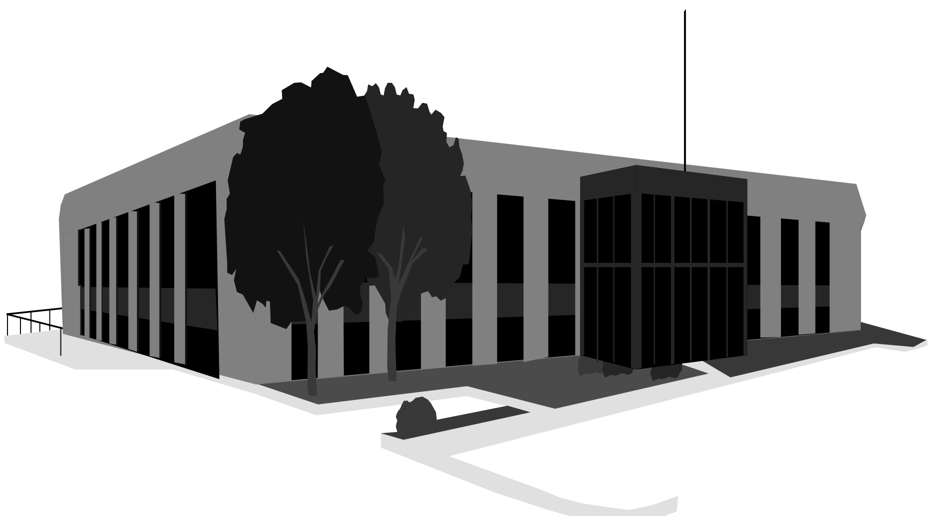
INDOOR AIR QUALITY ASSESSMENT

Edward B. Newton Elementary School
45 Pauline Street
Winthrop, Massachusetts



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

Background/Introduction

At the request of Paul Frazier, Director, Winthrop Board of Health, the Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality issues and health concerns at the E. B. Newton Elementary School in Winthrop, MA.

On February 4, 2000, a visit was made to this school by Cory Holmes of the Emergency Response/Indoor Air Quality (ER/IAQ) Program, BEHA, to conduct an indoor air quality assessment. Skip Cali, Senior Custodian, accompanied Mr. Holmes for portions of the assessment. This request was prompted by reports of health effects (e.g., stuffiness, respiratory irritation, exacerbation of asthma) suspected of being associated with poor indoor air quality in the building.

The school is a three-story red brick building, built in 1908 and is not equipped with mechanical ventilation. The third floor contains a physical therapy room, teacher's lounge, a large assembly room/auditorium and a room that has been subdivided and is currently being used as the school library and computer room. The second floor is made up of general classrooms. The first floor contains the main office, nurse's office, the Superintendent's and Business Managers offices and four classrooms. Located on the basement level are several pre-school rooms, restrooms and the school custodian's office. Double-paned windows were installed in the early 1990's to reduce interior noise from Logan Airport.

The school was previously visited by BEHA personnel March 25, 1995, to conduct an indoor air assessment. The following recommendations were made at the time of the assessment to improve indoor air quality:

1. provide each classroom with mechanical ventilation or openable windows;
2. provide openable windows for rest rooms;
3. provide even heating; and

4. replace water damaged ceiling tiles. (MDPH, 1995).

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

This school has a student population of 266 and a staff of approximately 40. The tests were taken under normal operating conditions. Test results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million (ppm) in two of sixteen areas surveyed, which indicates adequate air exchange in most areas. This building does not have a modern mechanical ventilation system, but uses a gravity/natural ventilation system to provide airflow to classrooms in combination with openable windows.

Ventilation is provided by a series of louvered vents. Each classroom has an approximately 3’ x 3’ grated air vent in the center of an interior wall near the ceiling (see Picture 1), which is connected by ductwork to a “hearth”-like opening in the basement (see Picture 2). A corresponding 3’ x 3’ vent exists in each room near the classroom doorway that is connected to an exhaust ventilation shaft that runs through the roof to the basement.

These vents are sealed with plywood (see Picture 3). Classrooms were constructed around these shafts to provide exhaust ventilation.

Air movement is provided by the stack effect. The heating elements warm the air, which rises up the hot air ventilation shafts. As the heated air rises, negative pressure is created, which draws cold air from the basement area into the heating elements. This system was designed to draw air from two sources in the basement: fresh air from a hinged window-pulley system on the exterior wall of the building and return air from the exhaust ventilation shafts. These sources of air are mixed in the basement prior to being drawn into the heating elements. The percentage of fresh air to return air was controlled by the hinged window-pulley system. The chains of the pulley system were designed to be set to lock the hinged window at a desired angle to limit fresh air intake. Non-openable windows have replaced the hinged window-pulley system; therefore no fresh, cool air can be introduced into the system. However according to Mr. Cali, heating elements are still activated to supplement radiators in providing heat to classrooms throughout the building. A mechanical fan installed in the base of one of the airshafts (see Picture 2) to enhance airflow by mechanical means.

The negative pressure created by the fresh air supply system also provided classroom exhaust ventilation. Each classroom is connected by ductwork to the basement beneath the heating elements in a hearth-like structure. As the heating elements draw air into the hot air ducts, return air is drawn from the "hearths" at the bottom of the exhaust ventilation shafts. Negative pressure is created in these shafts, which in turn draw air into the exhaust vents of each classroom. The draw of air into these cool air vents is controlled by a draw chain pulley system. As mentioned previously, exhaust vents were sealed with plywood in classrooms, therefore no means of exhaust ventilation exists. In addition, many of the control mechanisms for the natural ventilation system are not operable or missing (i.e., pull chains and louvers) and the window systems that provide fresh air in the basement are unopenable.

Unless the original ventilation system is restored to its original design by restoring control systems, openable basement windows and unsealing of exhaust vents, the sole source of ventilation in the building is openable windows. Each classroom window has a double sash. In many areas of the school, building occupants open windows to provide fresh air to classrooms. The inner sash is raised with the outer sash closed (see Picture 4). Spaces in the window frames allow for fresh outdoor air to infiltrate into classrooms. This method allows some fresh air infiltration while limiting penetration of moisture and direct air drafts into classrooms.

The Massachusetts Building Code requires a minimum mechanical 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 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.

Temperature readings on the day of the assessment were within a range of 70^{o} F to 80^{o} F, which was slightly above the BEHA recommended range for comfort. 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.

Heat complaints were reported to BEHA staff in a number of areas. Temperature control is difficult in an old building without a functioning ventilation system. A heating system was installed on the third floor. Heat is provided by an air-handling unit (AHU) in the attic. Heated air is distributed to rooms on the third floor by ceiling-mounted air diffusers and ducted return vents (see Pictures 5 & 6). As reported by Mr. Cali, this is a closed loop system, therefore no cool outside air is supplied, which can lead to increased temperatures.

The relative humidity in the building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 12 to 19 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40-60 percent. Relative humidity levels in the building would be expected to drop during the 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

A number of rooms had water-stained ceiling tiles, which are evidence of roof and/or plumbing leaks (see Picture 7). Water-damaged ceiling tiles can provide a source of mold and mildew growth, especially if they are moistened repeatedly. These tiles should be replaced after a water leak is discovered and repaired.

Water-damaged wall plaster was noted around the window in the business office, which may be evidence of a current or historic leak (see Picture 8). Water intrusion was evident by the presence of efflorescence (e.g., mineral deposits) and water-damaged plaster. Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As this solution moves to the surface of the brick or mortar, the water evaporates, leaving behind white, powdery mineral deposits. Water-damaged wall plaster, if wetted repeatedly, can be a medium for mold growth.

Several classrooms contained plants; in classroom 8 plants were observed suspended above carpeted areas. In classroom 20, plants were observed in trays of standing water. 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. Two fishbowls containing standing water were noted in classroom 8. Standing water can become stagnant, grow mold and bacteria and provide a source of unpleasant odors.

Water coolers were observed on the carpet in the business office and in the north basement classroom. To avoid water damage to carpeting and/or potential mold growth, a water-resistant material such as plastic or rubber matting should be installed beneath this water cooler.

An inspection of the exterior of the school was conducted to identify possible sources of water entry. The building's roof drainage system collects water and directs it into a series of downspouts. Several downspouts had missing or dislodged elbow extensions at their bases (see Picture 9), which allows rainwater to pool on the ground against the building. The freezing and thawing action of water during the winter months can create cracks and fissures in the foundation. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building.

Other Concerns

Several other conditions that can potentially affect indoor air quality were also identified. A container of windshield washer fluid was noted on the carpet of the physical therapy room. Cleaning products can contain chemicals, which can be irritating to the eyes, nose and throat. These materials should be stored properly and kept out of reach of students.

The teacher's lounge contained a photocopier and a lamination machine. (see Picture 10). Lamination machines can give off heat and odors. Volatile organic compounds (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, 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.

A number of areas had open utility holes around pipes and missing and/or damaged ceiling tiles. Open utility holes can provide a means of egress for odors, fumes, dusts and vapors between rooms and floors. The movement of ceiling tiles can introduce dirt, dust and particulate matter into occupied areas of the school. These materials can be irritating to certain individuals.

The teacher's lounge contained a damaged ceiling tile with exposed fiberglass insulation. In addition, the girl's restroom in the basement contained a damaged pipe exposing a fiberglass insulation material (see Picture 11). Fiberglass can serve as a skin, eye and respiratory irritant to sensitive individuals. Mr. Cali reported that the school was planning to encapsulate the damaged pipe insulation in the girl's restroom with a metal barrier.

The north basement classroom contained a window-mounted air conditioner. Portable air conditioners 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.

The basement restroom was being used to store a gas-powered snow blower (see Picture 12). It was reported to BEHA staff that the fuel tank was emptied prior to storage. However, this still may provide a source of possible odors and off gassing of volatile organic compounds (VOCs) found in gasoline, which can have an adverse effect on indoor air quality.

Conclusions/Recommendations

Symptoms and complaints reported to the BEHA are consistent with what might be expected in an environment with a poorly operating or non-existent mechanical ventilation system. The absence of a mechanical supply and exhaust ventilation system prevents the dilution and/or removal of environmental pollutants from the building. This can result in a buildup of dust, dirt, odors and other pollutants in the indoor environment. In order to provide ventilation, windows are used to introduce air into the building. If windows are shut, inadequate ventilation in school areas exists. In view of the findings at the time of this visit, the following recommendations are made:

1. Consider consulting a ventilation engineer concerning the feasibility of restoring the original gravity feed ventilation system with a ventilation engineer. This may entail repair or replacement of heating elements located in ventilation shafts; repair of broken or missing warm air and cool air pulley chain/louver door systems to provide ventilation in this building as designed; repair of the hinged-pulley system or installation of openable windows in basement area to provide fresh air to classrooms. If these systems are not to be restored, ensure exhaust vents are sealed on the roof and in classrooms to prevent the egress of dirt, dust and drafts into occupied areas. Regulate airflow in classrooms with the use openable windows to control for comfort. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
2. 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. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

3. Consider contacting a ventilation-engineering firm to examine the possibility of providing fresh, outside air to the third floor heating system.
4. Repair and/or replace thermostats as necessary to maintain control of comfort.
5. Consider having exterior brick repointed and waterproofed to prevent further water intrusion. Repair water damaged ceilings, walls and wall-plaster as necessary.
6. Repair any existing water leaks and replace any remaining water-stained ceiling tiles. Examine the areas above these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial as needed.
7. Repair/replace downspouts to divert water away from the foundation of the building.
8. Ensure plants are equipped with drip pans. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial where necessary.
9. Relocate or place tile or rubber matting underneath water coolers in carpeted areas.
10. Clean and maintain fish bowls and aquariums to prevent bacterial/mold growth and/or odors.
11. Store cleaning products and other chemicals properly and out of reach of students.
12. Seal utility holes and replace missing/damaged-ceiling tiles to avoid the aerosolization of dirt, dust and particulates in occupied areas. Continue with plans to encapsulate damaged pipe insulation in the girl's basement restroom to avoid the aerosolization of fiberglass fibers.
13. Change/clean filters for window-mounted air conditioners as per the manufacturer's instructions to prevent the re-aerosolization of dirt, dust and particulate matter.

14. Consider installing local exhaust ventilation in the teacher's lounge to help reduce heat and odors.

15. Consider removing snow blowers from inside the building or relocating to a well-ventilated area.

References

MDPH. 1995. Indoor Air Quality Assessment. E.B. Newton Elementary School, Winthrop, MA. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA.

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.

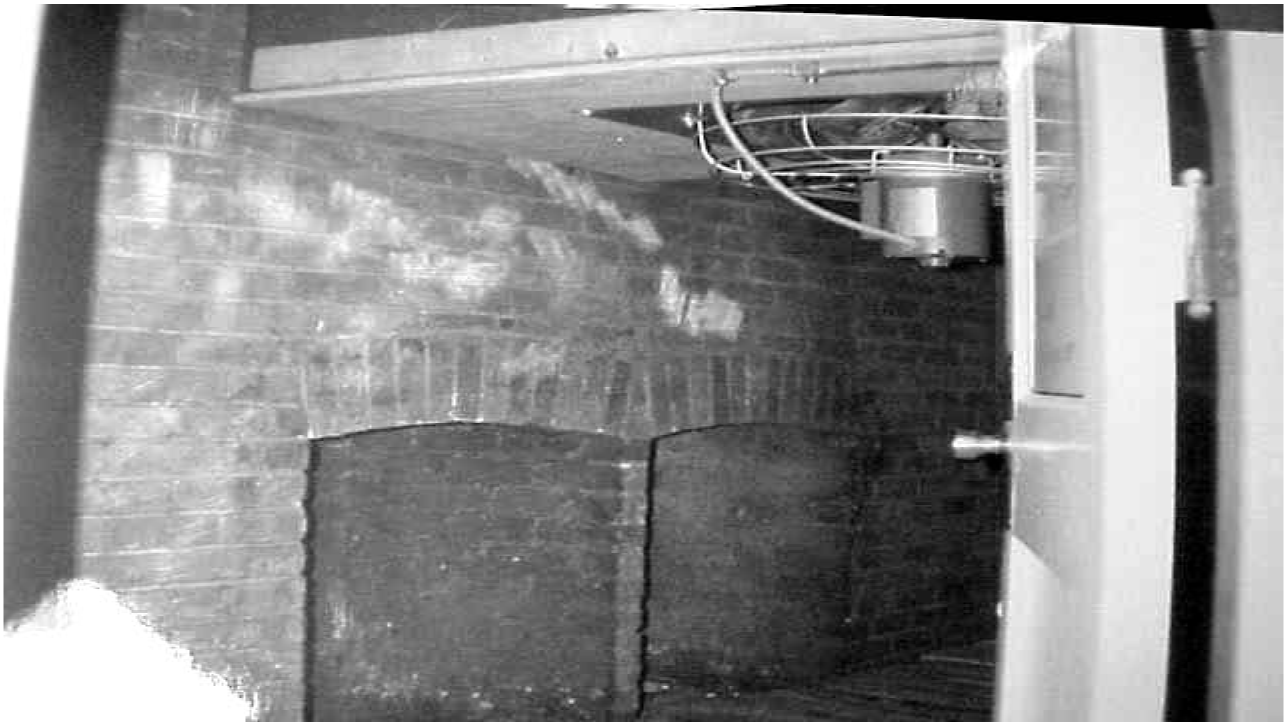
SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

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

Picture 1

Natural/Gravity Feed Supply Vent in Classroom

Picture 2



Hearth-like opening for Airshafts in Basement
Note Mechanical Fan Installed in Ventilation Shaft

Picture 3

Sealed Natural/Gravity Feed Exhaust Vent Noted in Classroom

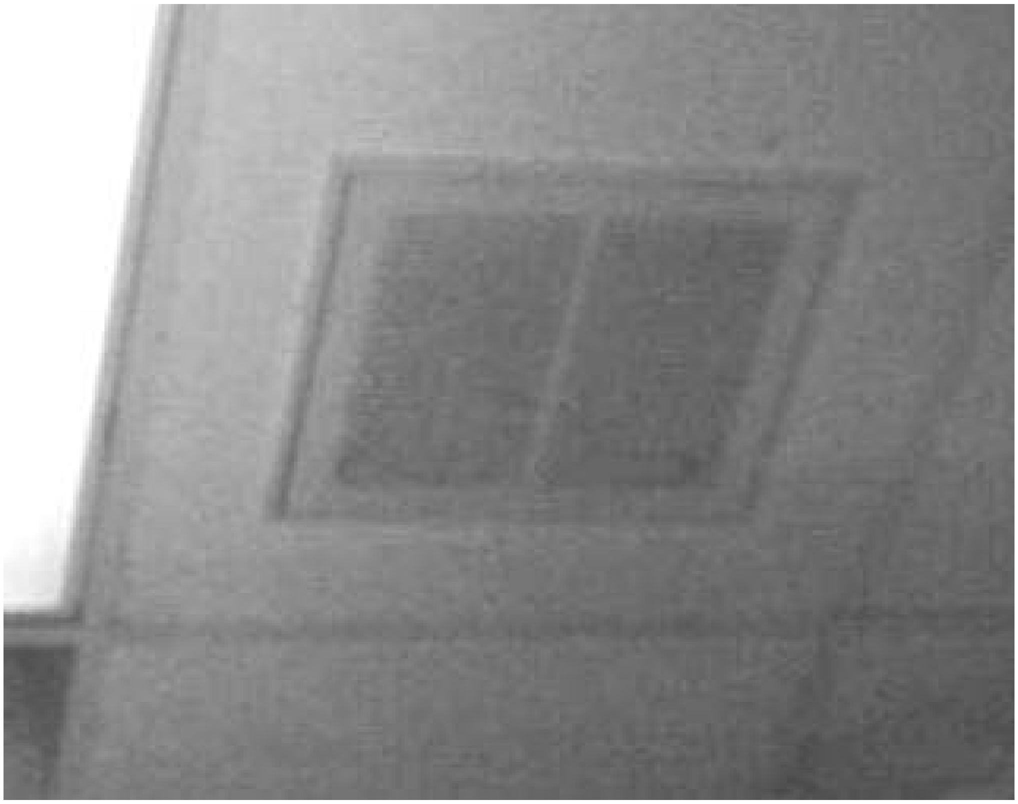
Picture 4

Double-paned Windows Note Inner Window is Opened to Allow for Air Infiltration

Picture 5

Ceiling-Mounted Air Diffuser Noted on Third Floor

Picture 6

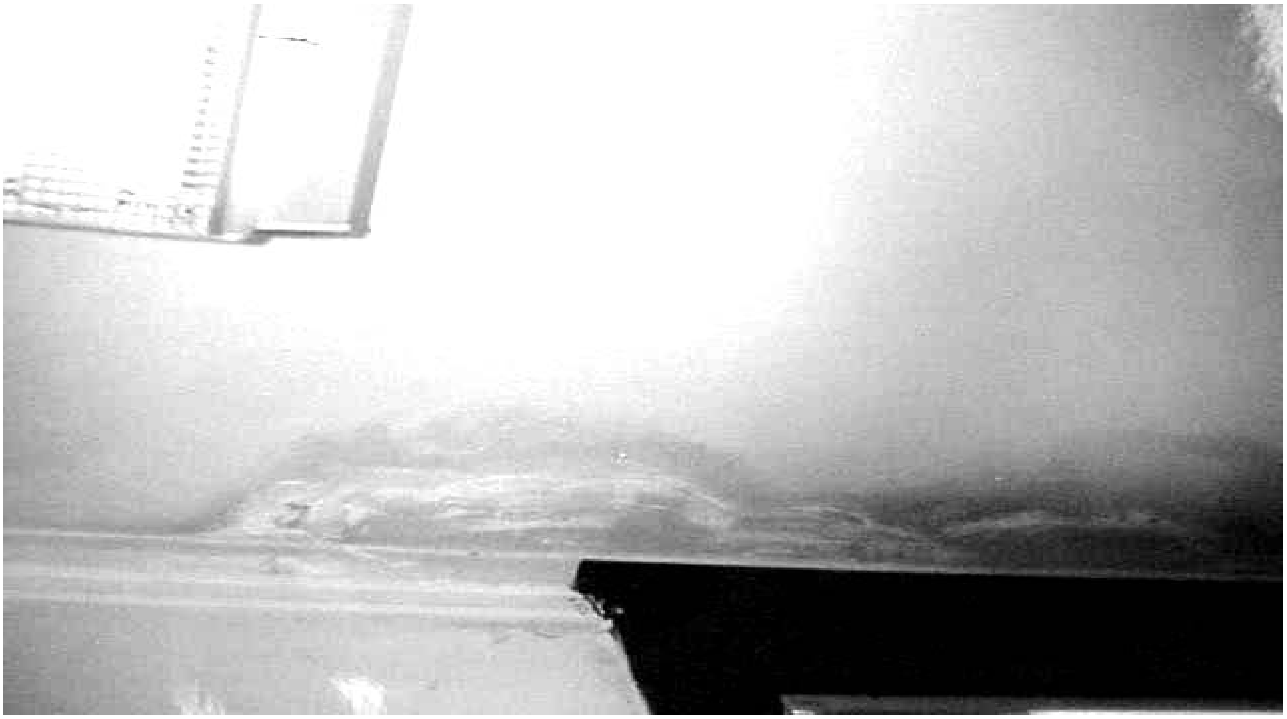


Ceiling-mounted Return Vent Noted on Third Floor

Picture 7

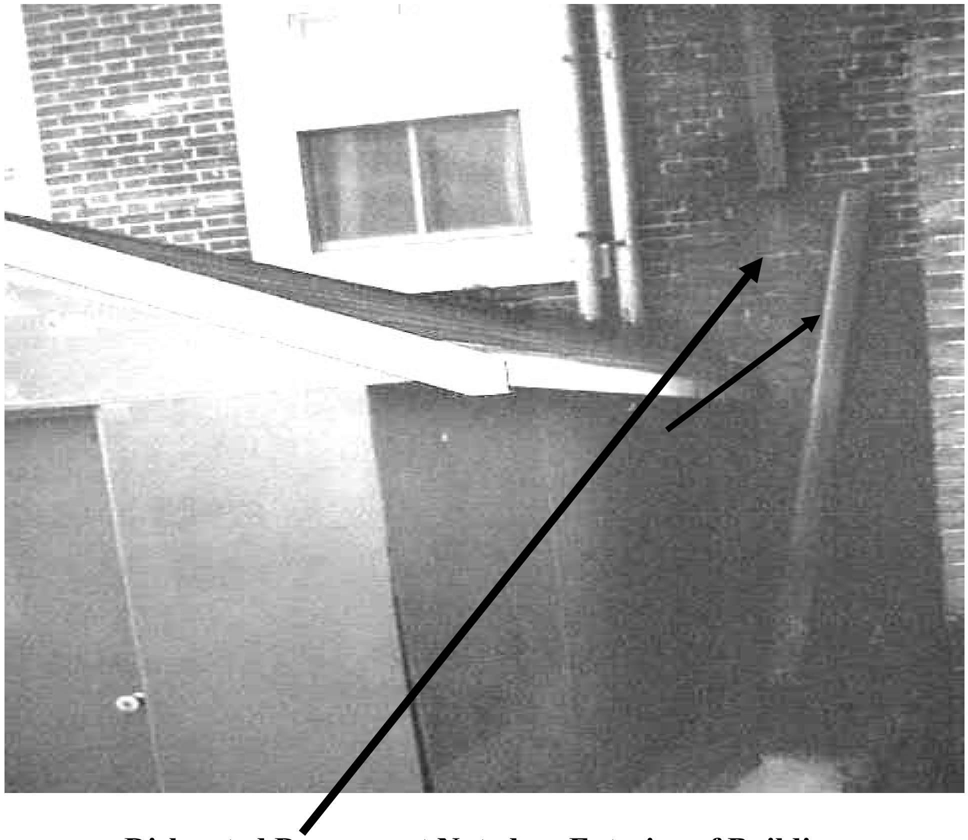
Water-Stained Ceiling Tiles Noted on Third Floor

Picture 8



Water-Damaged Ceiling Plaster Noted in Business Office

Picture 9

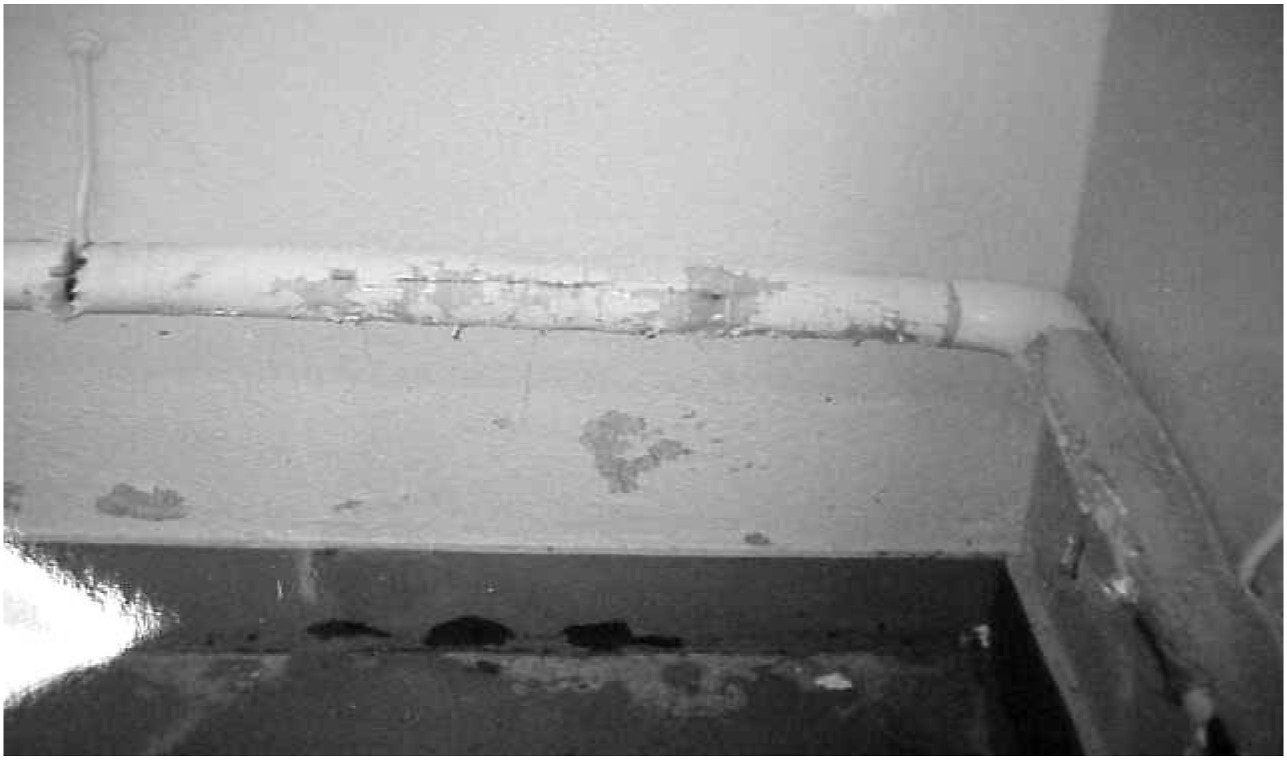


Dislocated Downspout Noted on Exterior of Building

Picture 10

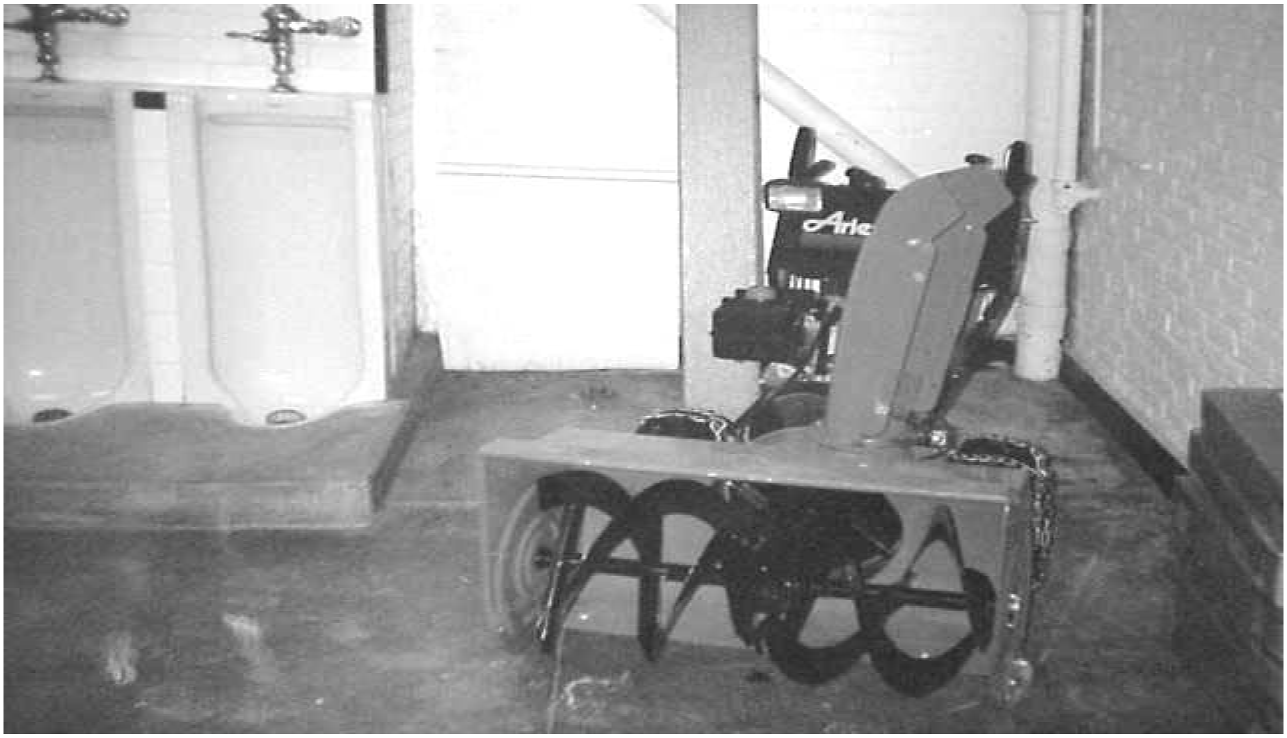
Photocopier and Lamination Machine Noted in Teacher's Lounge Note No Mechanical Exhaust Ventilation is Provided in This Area

Picture 11



Damaged Fiberglass Pipe Insulation Noted in Girl's Basement Restroom

Picture 12



Snow Blower Noted in Basement Restroom

TABLE 1

Indoor Air Test Results –E. B. Newton Elementary School, Winthrop, MA – February 4, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	420	34	40					weather conditions: overcast, slight breeze
Room 3	524	79	17	0	yes	no	no	door open
Teacher's Lounge	606	78	18	0	yes	no	no	dislodged ceiling tile-fiberglass, photocopier, lamination machine, 3 water stained ceiling tiles
Library	920	78	16	7	yes	no	no	6 CT-1 with hole
Computer Office	700	70	16	0	yes	no	no	3 CT, window open
Physical Therapy Room	664	78	12	0	yes	no	no	6 CT, windshield fluid on carpet
Room 15	638	79	12	0	yes	no	no	2 CT, 2 damaged CT, ceiling fan
Room 11	601	77	14	12	yes	no	no	window open
Room 9	821	78	16	15	yes	no	no	heat complaints
Room 8	771	74	19	17	yes	no	no	2 hanging plants over carpet, 2 fishbowls with standing water-cloudy

*** 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 –E. B. Newton Elementary School, Winthrop, MA – February 4, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
North Basement Classroom	777	78	13	13	yes	no	no	window mounted air conditioner, water cooler on carpet, door open
Basement Restroom							yes	stored snow blower
Business Office	647	80	13	5	yes	no	no	water cooler on carpet
3rd Floor Assembly Room	675	71	16	0	yes	no	no	window open, window mounted air conditioner
Room 10	607	70	17	13	yes	no	no	window and door open
Handicapped Restroom					yes	no	no	window open, utility holes around pipes
Room 7	572	74	15	10	yes	no	no	6 CT, historic leak around window frame, door open
Room 6	576	72	16	17	yes	no	no	6 CT, 1 plant
Basement Girl's Restroom							yes	damaged fiberglass insulation
Faculty Lounge Hallway						no	no	photocopier
Superintendent's Office	529	74	17	0	yes	no	no	

*** 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 3

Indoor Air Test Results –E. B. Newton Elementary School, Winthrop, MA – February 4, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Perimeter								dislodged downspouts, downspouts missing elbows

*** 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%