# INDOOR AIR QUALITY ASSESSMENT

**Brockton Public Library West Branch**
**540 Forest Avenue**
**Brockton, Massachusetts**


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

At the request of Mr. Harry Williams, Director of the Brockton Public Library, the Massachusetts Department of Public Health (MDPH)'s Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality concerns at the West Branch of the Brockton Public Library (WBBPL), located at 540 Forest Avenue, Brockton, Massachusetts. On December 15, 2004, a visit to conduct an assessment was made to the WBBPL by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. For portions of the assessment, Mr. Holmes was accompanied by Karen Arnold, Branch Director; Ed Gingilsky, Custodian and Mr. Williams.

The WBBPL is a one-story brick structure built in 1969. Library officials reported that other than the installation of a handicap access ramp, no major renovations have been conducted. The majority of building materials were original (e.g., carpeting, heating and ventilation components, ceiling tiles systems). The main floor of the library contains the circulation desk, main office, open stack areas, restrooms, and computer stations. The finished basement contains an auditorium, kitchen/break room, boiler room and storage area. Windows on the main floor are openable; however, occupants reported that many are difficult to open/operate. For security reasons, the majority of windows in the basement have been temporarily sealed with plexiglass.

## Methods

BEHA staff performed a visual inspection of building materials for water damage and/or microbial growth. Moisture content of porous building materials (e.g., carpeting, insulation, ceiling tiles) was measured with Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe. Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity with the TSI, Q-TRAK™ IAQ Monitor, Model 8551.

## Results

The WBBPL has 4-6 employees, with up to 200 members of the public visiting on a daily basis. Tests were taken during normal operations and results appear in Table 1.

## Discussion

### Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed, indicating adequate ventilation at the time of the assessment. However, it is important to note that most areas were sparsely populated, which would contribute to reduced carbon dioxide levels. Carbon dioxide levels would be expected to rise during full occupation, especially given the current condition and lack of operation of some components of the mechanical ventilation system.

Fresh air is mechanically provided to the building through unit ventilator (univent) systems (Pictures 1 and 2). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 3). Fresh air intakes for basement level univents are located in concrete-lined subterranean pits (Picture 4). Return air is drawn in through an air intake located at the base of each unit (Figure 1). Fresh and return air are mixed, filtered, cooled/heated and provided to occupied areas through an air diffuser located in the top of the unit. Univents have manual fan control settings of low, medium and high for fan speed adjustments. Several univents were found deactivated or inoperable (Table 1). Univents are reportedly original equipment, approximately 30-35 years old. Univents of this age can be difficult to maintain because replacement parts are often unavailable. In order for univents to provide fresh air as designed, they must be activated and allowed to operate while rooms are occupied.

The mechanical exhaust ventilation system consists of ceiling and/or wall-mounted vents (Pictures 5 to 7) ducted to motors located above the ceiling tile system or in the attic. At the time of the assessment, a number of exhaust vents were not operating (Table 1), which can indicate that they were deactivated or not operable. Without dilution by the introduction of fresh air via univents and removal by the exhaust ventilation system, normally occurring environmental pollutants can build up and lead to indoor air/comfort complaints.

Openable windows are additional sources for fresh air to the library. Occupants reported that windows in several areas are in disrepair or have been temporarily sealed for security reasons (Picture 8). In a number of cases, openable windows have been eliminated with the permanent installation of window-mounted air conditioners. The air conditioners are equipped with a “fan only” or “exhaust open” settings (Picture 9). In this mode of operation, air conditioning units can provide air circulation by delivering outside air without cooling (i.e., air provided by unit equals that of outside temperature).

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 date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (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, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature measurements ranged from 69° F to 72° F, which were within the BEHA comfort 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. Temperature control complaints in a number of areas were expressed to BEHA staff during the assessment. 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. It is also difficult to maintain temperature without operating the ventilation system as designed (e.g., univents and exhaust fans deactivated/not operable) and with windows sealed or in disrepair.

The relative humidity measured in the building ranged from 16 to 23 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. 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**

Water-damaged ceiling tiles were observed in the children's section on the main floor. Such damage can indicate leaks from the roof or plumbing system (Picture 10). Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

As discussed, several subterranean pits are located along the perimeter of the building (Picture 4). These pits allow air to flow into below grade air intakes for the mechanical ventilation system. Leaves, papers and other debris were observed on the bottom of the pits. Such materials can provide a source of mold growth. Mold odors and growth can subsequently be entrained into the ventilation system and distributed to occupied areas.

The basement contains a storeroom with a cement floor. BEHA staff observed a large number of cardboard boxes and other porous items stored on the floor (Picture 11). These items should be elevated off the floor (e.g., on pallets, tables) to prevent water damage and potential mold growth.

Plants were noted in several areas (Picture 12). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

The basement contained several dehumidifiers. Dehumidifiers and/or humidifiers contain a reservoir that holds standing water. This equipment should be cleaned/maintained as per the manufactures instructions to prevent mold/bacterial growth and associated odors.

**Other Concerns**

Several other conditions that can affect indoor air quality were noted during the assessment. Libraries in general have a large number of flat and irregular surfaces (e.g., book shelves, books) that provide a source for dusts to accumulate and are difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be removed and/or be cleaned periodically to avoid excessive dust build up.

Carpeting in several areas was extremely worn and damaged (Picture 12). The carpet was reportedly installed during the original construction of the building, which would make it over thirty years old. Disintegrating textiles can be a source of particulates, which can be irritating to the eyes, nose and throat. Carpet fibers/particulate matter can also be entrained and suspended in air by the mechanical ventilation system.

Finally, as discussed several areas contained window-mounted air conditioners. These units are 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.

## Conclusions/Recommendations

The solution to the indoor air quality problems at the West Branch of the Brockton Public Library warrants attention in several areas. General building conditions, maintenance, work hygiene practices and the age/condition of ventilation equipment, if considered individually, present conditions that can degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required. This approach consists of **short-term** measures to improve air quality and **long-term** measures requiring planning and resources to adequately address overall indoor air quality concerns.

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

1. Operate all ventilation systems throughout the building continuously during periods of occupancy. To increase airflow during full occupancy, set univent controls to "high".

2. Contact an HVAC engineer to evaluate the ventilation control system and survey univents for function. Consider having univent fresh air control dampers calibrated building-wide.
3. Restore the general exhaust ventilation system. Inspect exhaust motors and belts for proper function, repair and replace as necessary.
4. Use openable windows and operate air conditioners in the "Fan Only" setting to introduce outside air as measures to supplement air flow.
5. Work with staff to determine which windows are unopenable/difficult to operate and make repairs. Consider removing plexiglass from auditorium windows.
6. Balance mechanical ventilation systems every five years, as recommended by ventilation industrial standards (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of the ventilation systems.
7. Work with city officials to develop a preventative maintenance program for all HVAC equipment system wide.
8. Change filters for window-mounted air conditioners and air-handling equipment as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.
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 high efficiency particulate

arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

10. Ensure roof/plumbing leaks are repaired and replace any remaining water-damaged ceiling tiles and fiberglass insulation. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial as necessary. Conduct work above ceiling tiles during *unoccupied* periods or periods of low occupancy. Once work is completed wet wipe and/or vacuum area with a HEPA filtered vacuum cleaner to clean up all residual dirt, dust and particulates.
11. Remove leaves and debris from subterranean pits seasonally.
12. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
13. Refrain from storing porous materials directly on cement floor in basement storage room. Inspect and discard any water damaged cardboard boxes. Disinfect any areas of microbial growth with a one in ten bleach in water solution; wipe clean surfaces with soap and water after disinfection.
14. Clean and maintain dehumidifiers as per the manufactures instructions.
15. Consult "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (2001) for further information on mold. Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.

16. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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

1. Consider contacting an HVAC engineering firm to fully evaluate the ventilation systems. Based on the age, physical deterioration and availability of parts for ventilation components, BEHA strongly recommends this measure.
2. Consider replacing damaged/worn carpeting throughout the library to prevent the aerosolization of carpet fibers.
3. Repair/replace loose/broken windowpanes and missing or damaged window caulking building-wide to prevent water penetration through window frames.
4. Repair and/or replace thermostats and controls as necessary to maintain control of thermal comfort. Consider contacting an HVAC engineer concerning the repair and calibration of thermostats and ventilation controls building-wide.

## References


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BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-1601 et al.

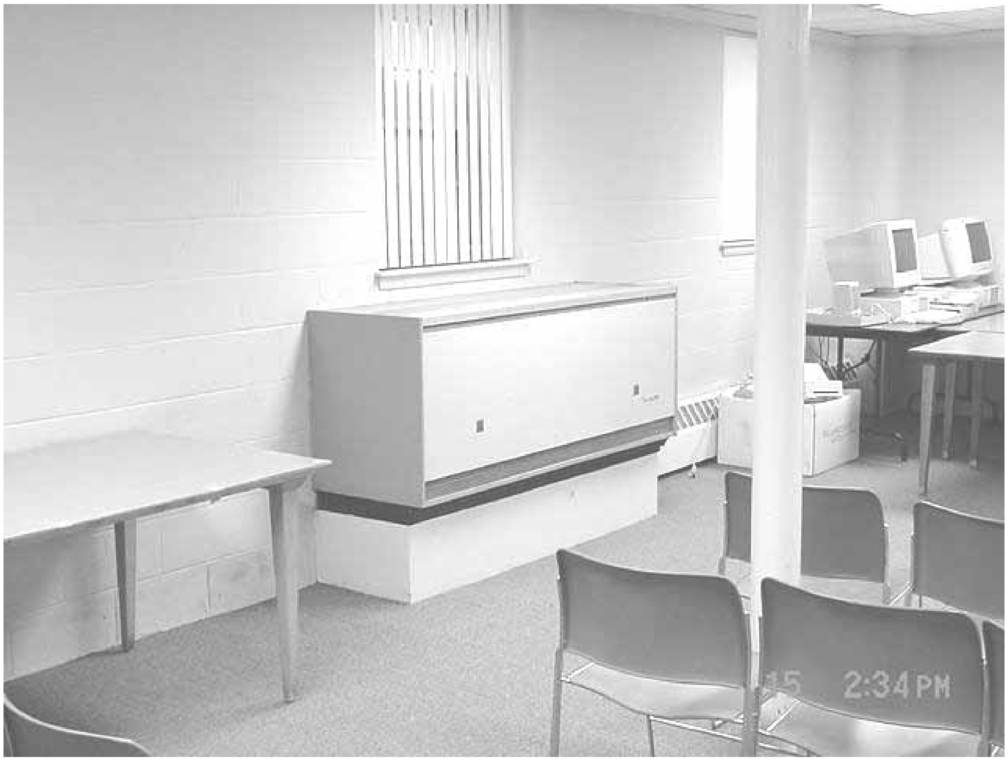
OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

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

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

US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001.

**Picture 1**




**One of Two Basement Unit Ventilators**

**Picture 2**

**Example of Unit Ventilator on Main Floor**

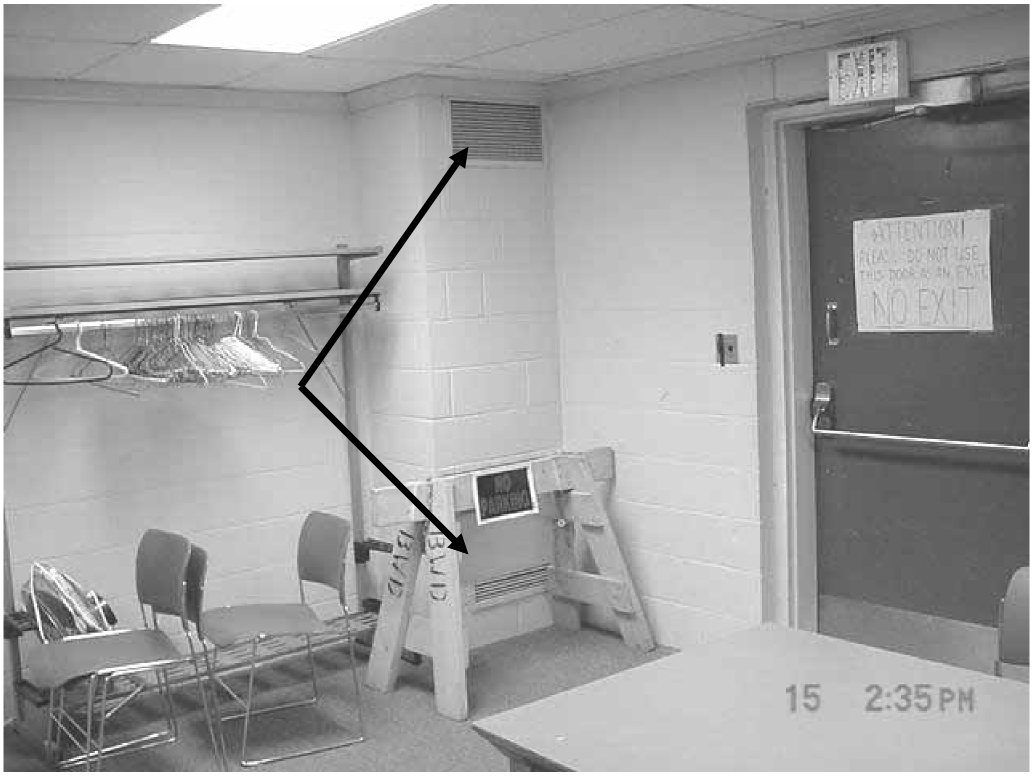
**Picture 3**


**Univent Fresh Air Intake**

**Picture 4**

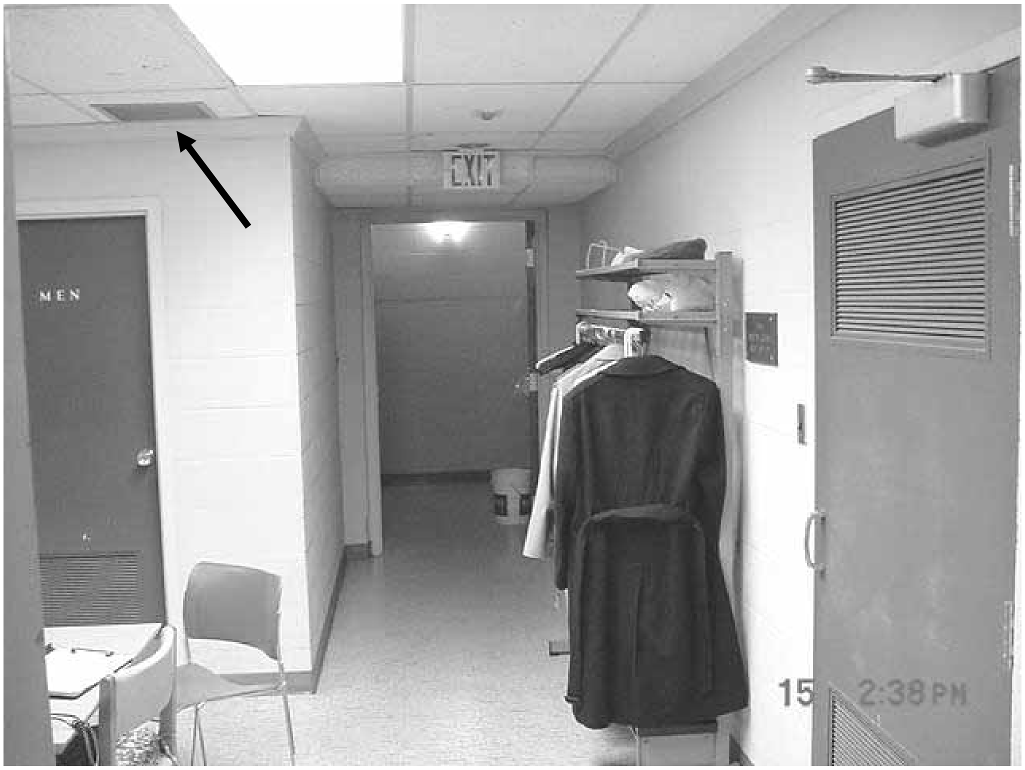
**Subterranean Concrete-Lined Pit for Basement Univent Air Intake**

**Picture 5**




**Wall-Mounted Exhaust Vents in Basement Auditorium**

**Picture 6**




**Ceiling-Mounted Exhaust Vent in Basement Breakroom**

**Picture 7**


**Ceiling-Mounted Exhaust Vent in Main Office**

**Picture 8**


**Basement Window Sealed With Plexi-Glass**

**Picture 9**

**Portable Air Conditioning Unit Installed in Window**

**Picture 10**

**Water Damaged Ceiling Tile**

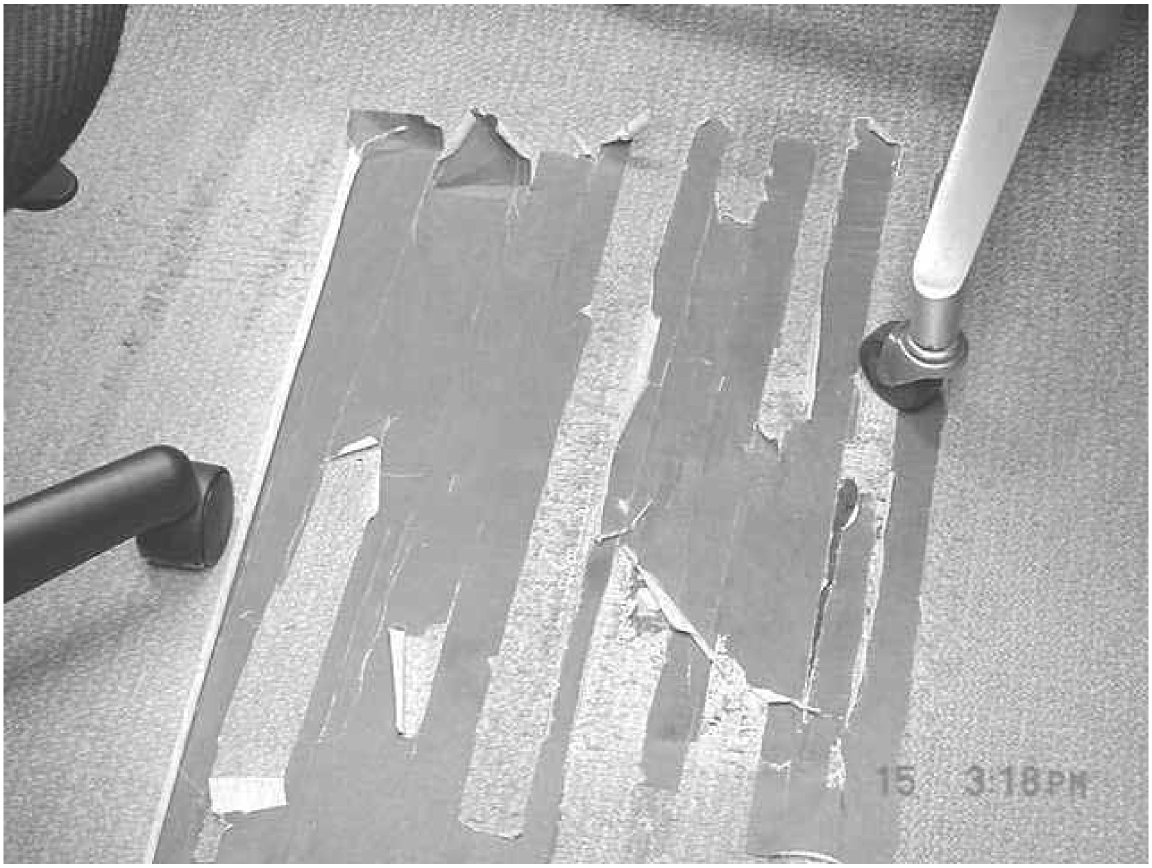
**Picture 11**


**Cardboard Boxes on Cement Floor in Basement Storeroom**

**Picture 12**

**Plants on Bookshelves**

**Picture 13**




**Damaged Carpeting in Circulation Area**

**TABLE 1**

## Indoor Air Test Results – Brockton Public Library West Branch, 540 Forest Ave., Brockton, MA – December 15, 2004

| Location | Carbon Dioxide (*ppm) | Temp (°F) | Relative Humidity (%) | Occupants in Room | Windows Openable | Ventilation | | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Supply | Exhaust | |
| Background | 370 | 36 | 19 | | | | | Clear, sunny and cold, NW winds 10-15 mph |
| Storeroom | 709 | 69 | 23 | 0 | N | Y | Y | Passive door vent |
| Break Room | 560 | 70 | 18 | 4 | N | Y | N | Passive door vent, exhaust vent not activated |
| Auditorium | 548 | 70 | 16 | 0 | N | Y | Y | 2 dehumidifiers, 2 UV and exhaust not activated |
| Fiction H-N | 720 | 71 | 18 | 3 | Y | Y | N | UV-off sign "do not touch", plants |
| Children's' Picture Books | 677 | 72 | 17 | 1 | Y | Y | N | |
| Main Office | 635 | 71 | 17 | 1 | N | Y | Y | Passive door vent, exhaust not activated, damaged/deteriorating carpet |
| Circulation Desk | 624 | 72 | 17 | 2 | N | N | Y | Damaged/deteriorating carpet |
| Large Print | 563 | 72 | 16 | 1 | Y | Y | N | |
| Mysteries | 562 | 71 | 16 | 0 | Y | Y | N | UV-deactivated/inoperable |

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

**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 – Brockton Public Library West Branch, 540 Forest Ave., Brockton, MA – December 15, 2004

| Location | Carbon Dioxide (*ppm) | Temp (°F) | Relative Humidity (%) | Occupants in Room | Windows Openable | Ventilation | | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Supply | Exhaust | |
| Biographies | 558 | 71 | 16 | 1 | Y | Y | N | |
| Men's Restroom | | | | | | Y | Y | Exhaust vent not operating |

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

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