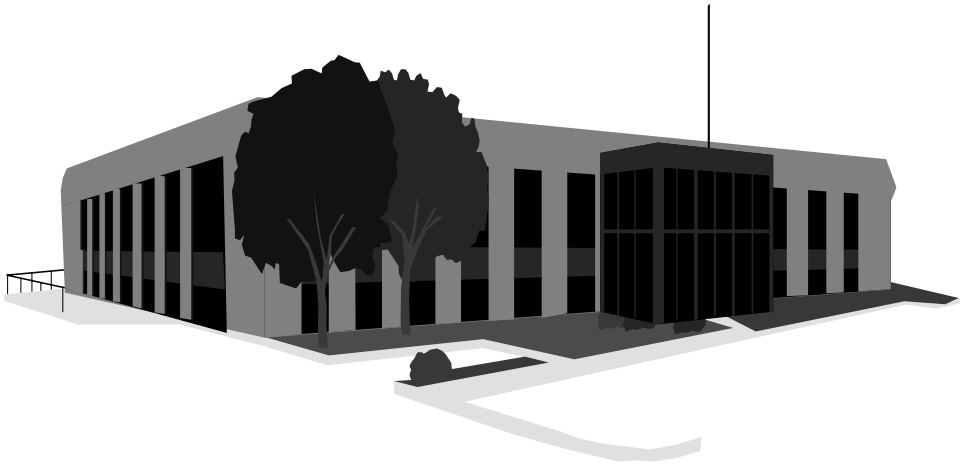
INDOOR AIR QUALITY ASSESSMENT

Martha M. Burnell Campus School
66 Hooper Street
Bridgewater, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
December, 2001

Background/Introduction

At the request of a parent, an indoor air quality assessment was done at the Burnell Campus School located on the Bridgewater State College (BSC) campus in Bridgewater, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA). The request was prompted by indoor air quality complaints believed to be associated with water penetration problems and suspected mold in the building.

On October 9, 2001, a visit was made to this school by Cory Holmes, Environmental Analyst, Emergency Response/Indoor Air Quality (ER/IAQ), BEHA to conduct an indoor air quality assessment. Patricia Delaney, BSC Environmental Health & Safety Officer and Brenda Chickering, School Secretary accompanied Mr. Holmes.

The school is a one-story brick building built in the late 1970's. The school functions under contractual agreement with the Bridgewater-Raynham Regional School District; the facilities are owned and maintained by BSC. The school contains general classrooms, art room, library, cafeteria, music room and office space.

Methods

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

Results

This school houses grades kindergarten through sixth, consisting of a student population of 375-400 and a staff of 30-40. Tests were taken under normal operating conditions and results appear in Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that the carbon dioxide levels were elevated above 800 ppm (parts per million) in five of thirty areas surveyed, indicating adequate airflow in most areas of the school. Areas that measured above 800 ppm were the cafeteria at full capacity (approximately 250-300 individuals), the gymnasium, main office, music room and classroom 135. Also of note were rooms 128 A, D and I, which had carbon dioxide measurements ranging from 750 to 778 with one or no occupants, indicating poor air exchange.

Mechanical ventilation is provided by rooftop air handling units (AHUs), which are ducted to slot air diffusers installed in the drop ceiling to the rear of classrooms (see Pictures 1 & 2). Air is returned to the units via ceiling mounted return grills connected by ducts back to the units. Classrooms are also equipped with a second return vent attached to a variable air volume (VAV) box, which recirculates classroom air once a pre-set temperature is read by the thermostat. Complaints of poor airflow, temperature extremes and stuffiness were reported in the music room, which can indicate a mechanical problem with thermostatic control and/or operation of the VAV box. Rooms 128 A, D and I have fresh air supplies, but no exhaust vents. Lack of exhaust ventilation can result in accumulation of indoors environmental pollutants in these rooms.

Ventilation in the gymnasium is provided by two ceiling-mounted AHUs and two ceiling-mounted exhaust vents. School maintenance staff reported that the physical education instructor deactivates the mechanical ventilation system for the gym after the space is warmed-up. BEHA staff visited the gymnasium in the afternoon, after repeated use over the course of the day. Without dilution and removal by the mechanical

ventilation system, normally occurring environmental pollutants (e.g., carbon dioxide, moisture and odors) 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, the systems must also be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from a room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

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 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 70° F to 77 ° F, which were within 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.

The relative humidity in the building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 24 to 33 percent. 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 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 common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The building has experienced historical roof leaks. Several areas had water damaged ceiling tiles. On-going leaks were reported in the Dean's office file room (128-I) (see Picture 3). Possible mold growth was observed on a ceiling tile in classroom 122 (see Picture 4). Stained ceiling tiles and efflorescence (e.g., mineral deposits) (see Picture 5) in the library also indicate water penetration. Efflorescence is a characteristic

sign of water damage to building materials such as brick or plaster, 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 the solution moves to the surface of the brick or mortar, water evaporates, leaving behind white, powdery mineral deposits. Water-damaged ceiling tiles, wallboard and other porous building materials can provide a source of mold and mildew and should be replaced after a water leak is discovered. Mold can be an eye and respiratory irritant to sensitive individuals.

Reportedly, once roof/ceiling leaks are identified, the building's roofing contractor is contacted by building maintenance personnel to determine the origin of and repair the leak. Once leaks are identified and repaired, ceiling tiles are replaced by campus maintenance staff. BEHA staff examined conditions on the roof. Two areas had roof ballast/gravel removed to identify and isolate current leaks (see Picture 6). Replacement of the roof is reportedly on the BSCs deferred maintenance list for future consideration.

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

In a number of classrooms, spaces between the sink countertop and backsplash were noted (see Picture 7). Repeated leakage or improper drainage/overflow can lead to water penetration of countertop wood, the cabinet interior and behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth. A pungent odor was noted upon opening the cabinet beneath the sink in classroom 105, emanating from water-damaged contact paper that was

colonized with mold growth (see Picture 8). Porous items (e.g., cardboard and paper) should not be kept beneath sinks. These types of materials should be removed and discarded if moldy.

Several areas contained dehumidifiers. Dehumidifiers should be emptied and cleaned as per the manufacturer's instructions to prevent bacterial and mold growth. Also noted in the school were water coolers and fountains installed over carpeting. Spills from water coolers/fountains can result in wetting of the carpet, which can lead to mold growth especially if wetted repeatedly. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Mold colonized carpeting cannot be adequately cleaned to remove microbial growth.

The teacher's lounge contains a refrigerator equipped with a drip pan to catch condensation. BEHA staff removed the drip pan for inspection and found it coated with debris and possible mold growth (see Picture 9). Drip pans should be emptied and cleaned regularly to avoid bacterial/microbial growth and associated odors.

Other Concerns

A number of other conditions were noted during the assessment, which can effect indoor air quality. The art room contained a pottery kiln, which was connected to a laboratory vent hood by flexible hose. Pottery kilns can produce carbon monoxide and sulfur dioxide, which can cause respiratory symptoms in exposed individuals. Flexible ductwork connecting the kiln to the vent hood was found pinched at one end (near the vent hood) and damaged at the point where it connects to the kiln (see Pictures 10 & 11).

Operating the kiln with the ductwork in this condition can allow kiln-generated pollutants to enter the classroom.

Photocopiers and lamination machines were noted in the production room located in the library. No exhaust ventilation is provided for this area. 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). Lamination machines can give off heat and odors. The off gassing of VOCs and associated odors can be irritating to the eyes, nose and throat. Strong odors of melted plastic from the lamination machine were noted during the assessment.

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). Cleaning products, nail polish remover and other spray products were found on counter tops and underneath sinks in a number of classrooms (see Picture 12). These items should be stored properly and out of reach of students. Cleaning products, dry erase markers and dry erase board cleaners can contain chemicals, which can be irritating to the eyes, nose and throat.

Also of note was the amount of materials stored inside classrooms. In several areas, items were seen piled on windowsills, tabletops, counters, bookcases and desks. The large amount of items stored provides a means for dusts, dirt and other potential respiratory irritants to accumulate. These stored items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. Stored items should be relocated and/or cleaned periodically to avoid excessive dust build up. Specific maintenance complaints were reported by staff in the Dean's office.

Ant infestation during the spring months was reported by a number of occupants. The presence of ants was reported most commonly along baseboards and underneath carpeting in classrooms. Under current Massachusetts law (effective November 1, 2001) the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). A copy of the IPM guide is attached as Appendix A. Pesticide use indoors can introduce chemicals into the indoor environment that can be a source of eye, nose and throat irritation. The reduction/elimination of pathways/food sources that are attracting these insects should be the first step taken to eliminate this infestation.

Conclusions/Recommendations

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

1. Examine each AHU for function. Survey areas with elevated carbon dioxide levels/poor airflow complaints (e.g., the music room, cafeteria, main office and classroom 135) to ascertain if an adequate air supply exists for each room; an increase of fresh air intake may be necessary. Operate all AHUs, including the gymnasium, during hours of school occupation.
2. Consider installing local exhaust ventilation in the library production room, or relocate photocopiers and lamination machines to an area equipped with local exhaust.
3. Consider having the ventilation system balanced by a ventilation-engineering firm.

4. 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).

5. Continue to work with roofing contractor to identify and isolate leaks. Once repaired, replace any remaining water-stained ceiling tiles. Examine the areas above and behind these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial, wipe surfaces with soap and water.

6. Continue with plans for future roof replacement to maintain building envelope integrity.

7. Keep plants away from vents in classrooms. Ensure plants have drip pans and examine drip pans for mold growth. Disinfect areas with an appropriate antimicrobial where necessary.

8. Remove and discard water-damaged/mold colonized materials beneath sinks in classrooms (e.g., classroom 105). Relocate porous items to a dry environment. Disinfect areas of water leaks with an appropriate antimicrobial, wipe surfaces with soap and water.

9. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect wallboard for water-damage and mold/mildew growth, repair/replace as necessary. Disinfect areas of microbial growth with an appropriate antimicrobial as needed. Wipe surfaces with soap and water.

10. Install rubber/plastic matting below water fountains/coolers to prevent water damage to carpeting and subsequent mold growth.
11. Clean humidifiers and dehumidifiers regularly and maintain as per the manufacturer's instructions to prevent microbial growth.
12. Clean refrigerator drip pans regularly to prevent microbial growth.
13. Store chemicals and cleaning products properly and out of the reach of students. Ensure all containers are properly labeled for identification in the event of an emergency.
14. Discontinue use of pottery kiln until damaged flexible ductwork is replaced.
15. Use IPM to remove pests from the building. A copy of the IPM recommendations is included with this report as Appendix A (MDFA, 1996). Activities that can be used to eliminate pest infestation may include the following activities.
    i) Consult a licensed pesticide applicator on the most appropriate method to end infestation.
    ii) Reduction/elimination of pathways/food sources that are attracting pests.
    iii) Reduce harborages (plants/cardboard boxes) where pests may reside.
16. In addition to the previous recommendations faculty and staff are encouraged to report any complaints concerning preventive maintenance issues to the BSC Facilities Department in the form of a Work Order. These work orders are reportedly provided by the school maintenance staff and/or administration.
17. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

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

Mass. Act. 2000. An Act Protecting Children and families from Harmful Pesticides. 2000 Mass Acts c. 85 sec. 6E.

MDFA. 1996. Integrated Pest Management Kit for Building Managers. Massachusetts Department of Food and Agriculture, Pesticide Bureau, 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.

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

Picture 1

Rooftop AHUs

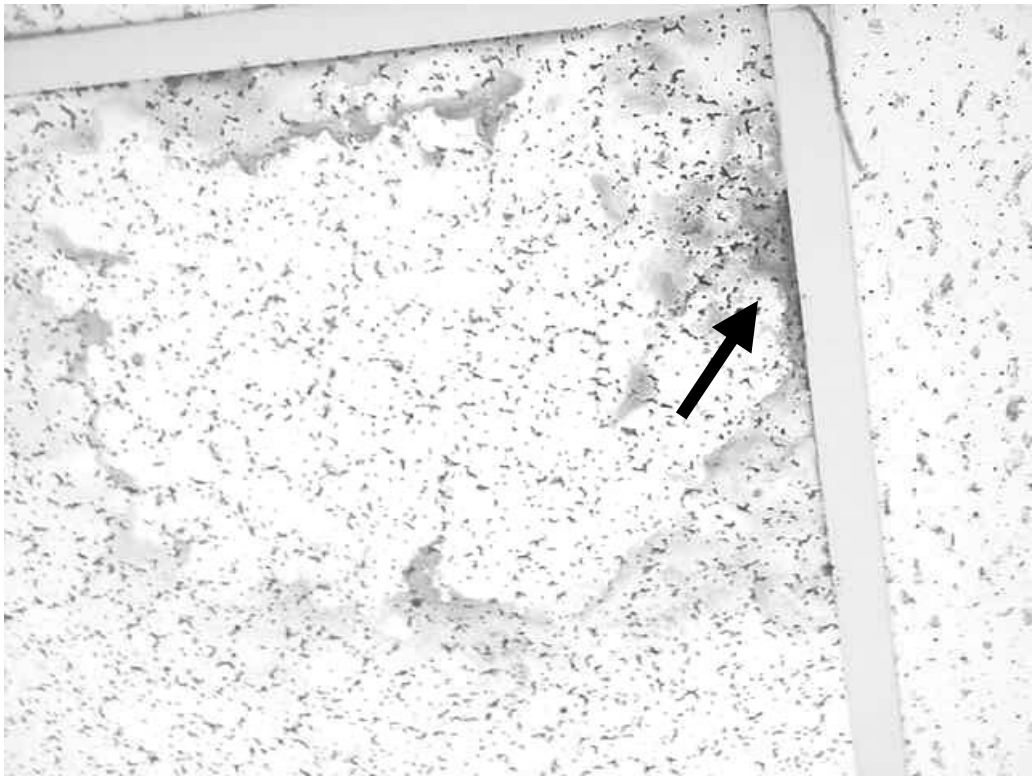
Picture 2

Slotted Air Diffuser in Classroom

Picture 3

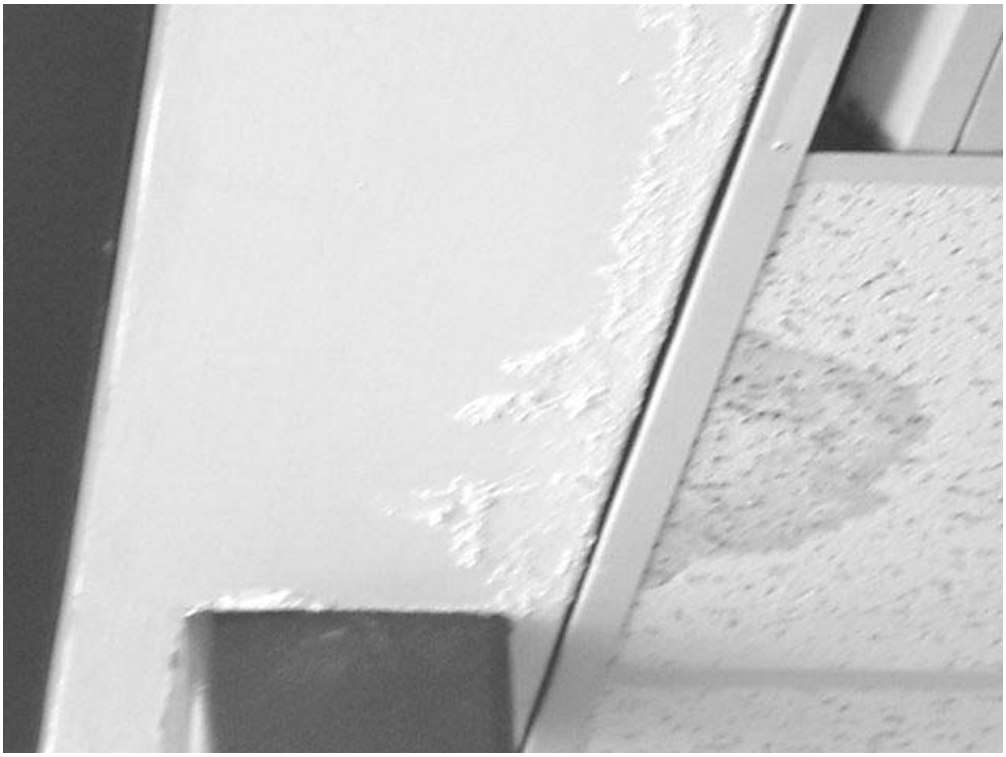
Water Damage Ceiling Tiles in area 128-I Dean's Office File Room, Note Water Stains on Wall

Picture 4



Water Stained Ceiling Tile with Possible Mold Growth in Classroom 122

Picture 5

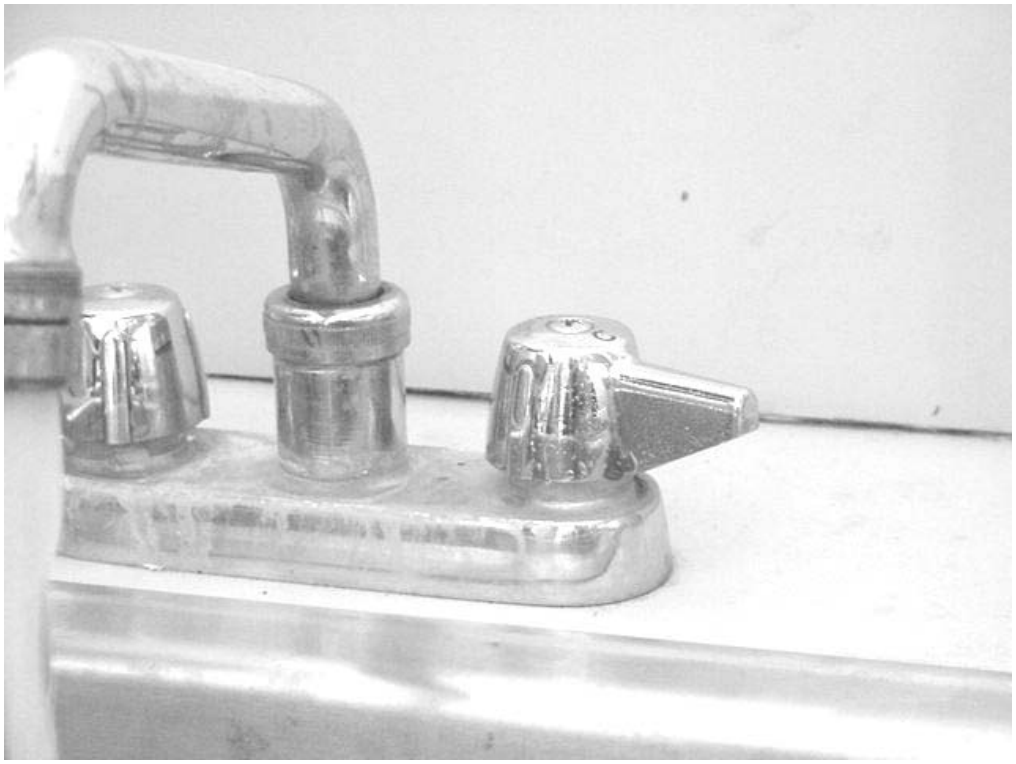


Efflorescence (e.g., mineral deposits) and Stained Ceiling Tile in Library

Picture 6

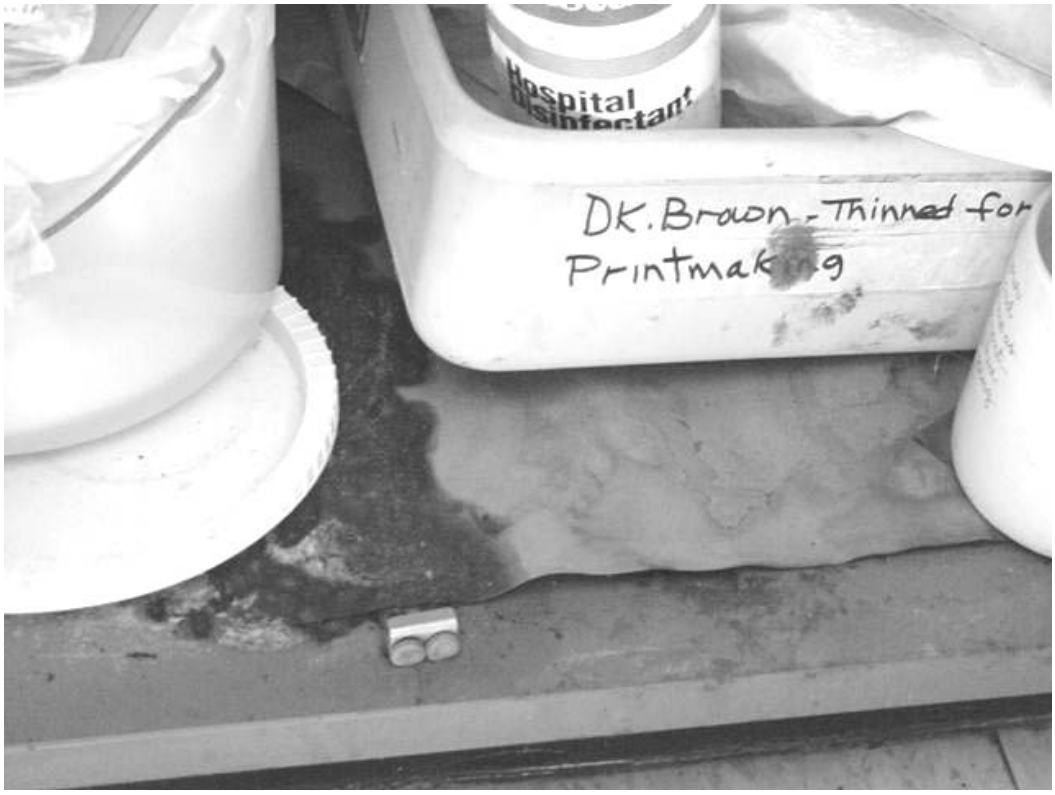
Area on Roof Cleared Away to Isolate and Repair Leak

Picture 7



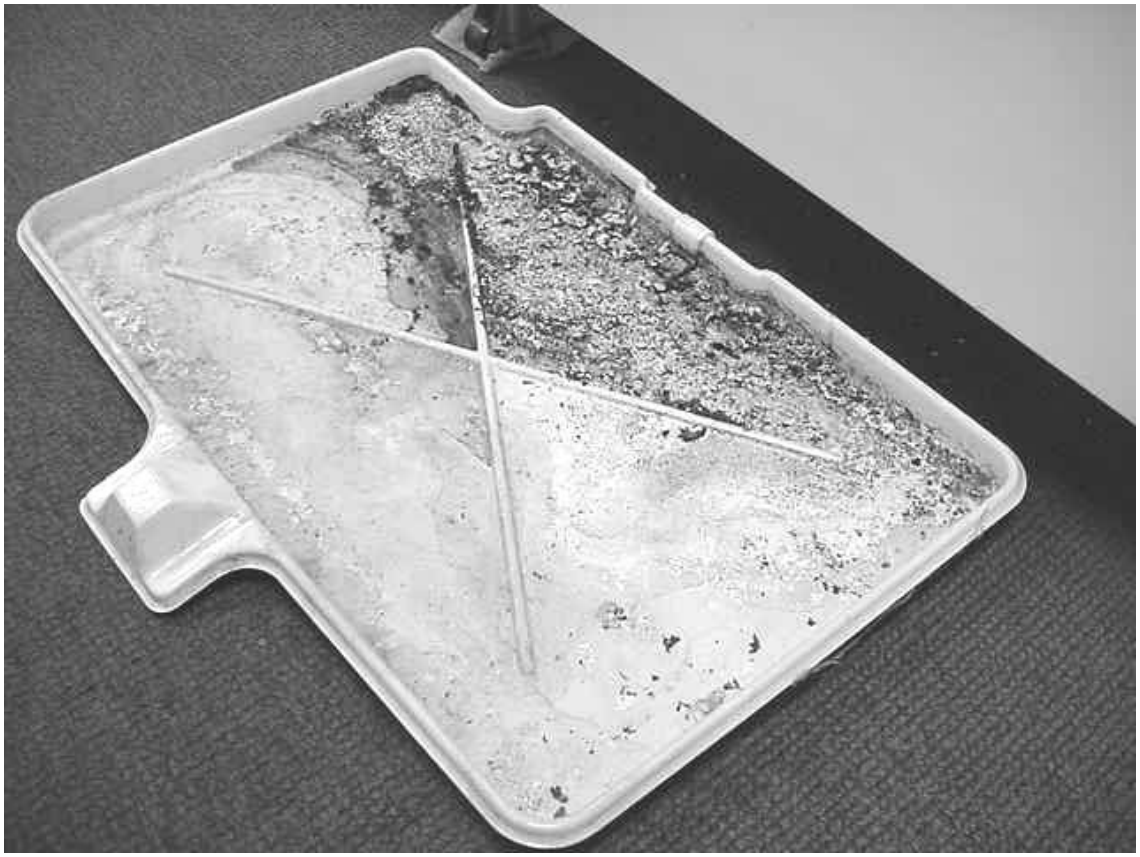
Spaces between Backsplash and Sink Countertop

Picture 8



Mold Colonized/Water-Damaged Contact Paper under Sink in Classroom

Picture 9



Mold Colonized Refrigerator Drip Pan in Teacher's Lounge

Picture 10

“Pinched” Flexible Ductwork Venting Kiln out of Laboratory Vent Hood

Picture 11

Damaged Ductwork to Kiln

Picture 12

Spray Cleaning Products and Nail Polish beneath Sink in Classroom

TABLE 1

Indoor Air Test Results – Burnell Elementary School, Bridgewater, MA – October 9, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	372	67	24					Weather conditions: clear, sunny, light breeze
Classroom 106	742	70	32	26	Yes	Yes	Yes	Spaces around sink/countertop, cleaning product/nail polish remover under sink, 2 water damaged CT-corner near hallway door, door open, short carpeting
Classroom 105	726	72	29	28	Yes	Yes	Yes	Water damaged/moldy contact paper under sink, unlabled spray cleaning product, 3 water damaged CT-corner near hallway door, door open
Classroom 104	718	74	29	23	Yes	Yes	Yes	Cleaning product/paint under sink, 3 water damaged CT, door open
Classroom 107	679	74	29	19	Yes	Yes	Yes	Ants reported-enter through coat closet baseboard, spaces around sink, door open
Classroom 108	775	71	26	30	Yes	Yes	Yes	
Hallway								Water fountain over carpeting

*** ppm = parts per million parts of air**
CT = 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 – Burnell Elementary School, Bridgewater, MA – October 9, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Classroom 109	540	70	27	0	Yes	Yes	Yes	Door open
Classroom 112	728	73	28	30	Yes	Yes	Yes	3 water damaged CT, 2 painted CT, door open
Boys'/Girls' Restrooms						Yes	Yes	Passive supply vent, exhaust on
Classroom 111	697	75	26	22	Yes	Yes	Yes	Window and door open, broken window, spray disinfectants on sink
Classroom 110	589	76	26	8	Yes	Yes	Yes	Spaces around sink, 1 water damaged CT-trash bag above CT, door open
Library	613	74	26	~20	Yes	Yes	Yes	Several water damaged CT, efflorescence near support beam
AV Storage Room	485	71	24	1	No	Yes	Yes	1 water damaged CT
Production Room (113)	614	71	26	3	No	Yes (4)	No	2 photocopiers, 1 lmaination machine
Classroom 103	377	77	25	0	Yes	Yes	Yes	Spaces around sink-paper towels/cleaning product under, door open

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Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Burnell Elementary School, Bridgewater, MA – October 9, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Classroom 102	513	73	25	2	Yes	Yes	Yes	Spaces around sink-cleaning product on, door open
Classroom 101	496	73	26	1	Yes	Yes	Yes	Spaces around sink, door open
Teacher's Lounge	660	73	28	0	No	Yes		Refrigerator drip pan-dirty/debris/possible mold growth
Classroom 121	535	73	25	22	Yes	Yes	Yes	Dehumidifier, spaces around sink-spray cleaner under
Classroom 122	472	73	25	3	Yes	Yes	Yes	Dehumidifier (full), 2 water damaged CT-possible mold growth, door open
Classroom 125	511	72	25	8	Yes	Yes	Yes	
Art Storage	497	72	27	0	No	Yes	No	4 water damaged CT
Art Room 123	485	74	24	0	Yes	Yes	Yes	Kiln-flex-ducted into lab hood-flex duct hanger on floor-"pinched"
Main Office	871	72	29	3	Yes	Yes	No	3 water damaged CT-around ceiling vents
Principal's Office (119B)	780	73	29	1	Yes	Yes	No	4 plants

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CT = 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 – Burnell Elementary School, Bridgewater, MA – October 9, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 128D	750	71	31	1	Yes	Yes	No	5 plants, maintenance complaints, feather duster
Room 128I	752	70	31	0	No	Yes	No	Reported roof leak-down wall, carpeting, ductwork reinsulated
Room 128A	778	71	31	0	No	Yes	No	Photocopier
Gym	950	70	33	0	No	Yes		2 AHUs – off
Cafeteria	1168	71	33	250-300	Yes	Yes	Yes	2 water damaged CT, broken window
Classroom 135	1080	74	33	~15	Yes	Yes	Yes	
Music Room	951	74	30	1	No	Yes	Yes	Floor fans to circulate air, heat/temperature complaints

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