INDOOR AIR QUALITY ASSESSMENT

Beachmont School
15 Everard Street
Revere Massachusetts

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

At the request of a parent, an indoor air quality assessment was done at the Beachmont School, Revere, Massachusetts by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA). Concerns of headaches and flu-like symptoms related to fuel oil odors prompted the request.

On November 15, 2002 Michael Ciarlone, Director of Buildings and Grounds, Revere Public Schools, visited the school in response to occupant complaints of fuel odors. Mr. Ciarlone reportedly discovered a pool of # 2 fuel oil in the crawlspace beneath classroom 123. A contractor, Commonwealth Tank, was hired to initiate recovery of fuel oil. City of Revere officials notified the Massachusetts Department of Environmental Protection (MADEP) of the fuel release. MADEP officials responded to the release and required that an Imminent Hazard Evaluation and Critical Exposure Pathway evaluation be conducted. ECS Marin, an environmental firm was retained as the Licensed Site Professional (LSP) to oversee the oil spill cleanup. MADEP officials working with Commonwealth Tank and ECS Marin staff reportedly implemented a number of remedial measures to mitigate fuel odors from penetrating into the building (ECS Marin, 2003). These methods will be discussed in further detail in the **Petroleum/Fuel Odors** section of this report. On-site investigators believed that the most likely cause of the release was a leaking underground storage tank, which was removed and replaced by a temporary above ground storage tank.

BEHA staff were contacted by a concerned parent on January 27, 2003 to provide technical assistance regarding lingering odors due to the fuel leak. Cory Holmes an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program conducted a site visit on February 11, 2003 to conduct an indoor air quality assessment. Mr. Holmes was accompanied by Albert Baquet and Michael Doran of Commonwealth Tank and Mr. Ciarlone during the assessment.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series, Photo Ionization Detector (PID). Tests for TVOCs were taken at several locations inside the building believed to be impacted by odors as well as areas inside and outside not impacted by odors, for comparison to indoor levels.

Results

The school houses grades K-8 and has a student population of approximately 900 and a staff of approximately 150. Tests were taken during normal operations at the school and results appear in Tables 1-2. No levels of carbon monoxide or TVOCs above background levels were measured in the building.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in four of eight classrooms surveyed, indicating inadequate air exchange in these areas. Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents have three controls: low, high and off. Obstructions to airflow, such as papers and books stored on univents and bookcases, carts and desks in front of univent returns were seen in a number of classrooms (see Picture 2). In order for univents to provide fresh air as designed, intakes must remain free of obstructions.

Exhaust ventilation in classrooms is provided by a mechanical system. The exhaust system in each classroom consists of grated ceiling vents (see Picture 3) connected via ductwork to rooftop motors. No draw of air was detected in several of the classroom vents, which indicates that they were either deactivated or that rooftop motors were inoperable. Without exhaust ventilation functioning properly, environmental pollutants can build up and lead to indoor air quality/comfort complaints. Mr. Ciarlone stated that work to repair the rooftop exhaust motors was to begin within the next several weeks. [Note: Subsequent to the BEHA staff visit, Honeywell, an HVAC firm reportedly visited the building and determined that at least 10 of the rooftop exhaust motors were not operating]. Univents were also reportedly cleaned out; filters changed and outside air intake was increased.

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 mechanical supply 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. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC 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 (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

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

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings were measured in a range of 68° F to 78 ° F, which were very close to 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. 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. Temperature control can also be difficult without the mechanical ventilation system operating as designed (e.g. exhaust vents deactivated).

Specific heat complaints were expressed in room 120, which is an interior room that has no windows to supplement mechanical ventilation. Room 120 also contains a mechanical closet with louvered doors containing heat-generating machinery with no local exhaust vent (see Picture 4). Without exhaust ventilation, heat from this equipment can raise the temperature within room 120 independent of the HVAC system. This type of equipment was not found in other classrooms.

The relative humidity in the building ranged from 12 to 20 percent, which is below the BEHA recommended comfort range. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels would be expected to drop during the winter months due to heating and decreased outdoor relative humidity concentrations. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several classrooms had water-stained ceiling tiles and/or water damaged wall plaster, which are evidence of roof and/or plumbing leaks. The occupant in classroom 101 reported roof leaks that continue to occur intermittently. Water-damaged building materials can provide a source of mold and mildew growth, especially if wetted repeatedly and should be replaced after a leak is discovered.

Petroluem/Fuel Odors

As discussed, this assessment was initiated due to concerns of symptoms believed to be related to petroleum odors in the building. To prevent the fuel odor migration, barriers of polyethylene plastic were used to seal the crawlspace as well as any areas impacted by the fuel release that had a strong oil odor, including the gymnasium and locker rooms (see Pictures 5-8). To draw odors away from occupied areas, local mechanical ventilation was installed in the crawlspace and hard ducted up the side of the building to a height of approximately 12 feet above the top of the roof (see Picture 9).

In addition to mitigation measures taken, TVOC levels are monitored throughout the building, by Commonwealth Tank staff three times a day (five days a week). Results of this testing are posted daily in the main office. Eight hour sampling of indoor air with SUMA canisters is also conducted and analyzed weekly under the direction of the LSP.

Air monitoring conducted by BEHA staff found no measurable levels of TVOCs in any of the areas surveyed. A slight residual oil odor was detected in the auditorium (which has reportedly been restricted to students) and in classroom 119. Commonwealth Tank staff had reported that utility holes for univent piping in this classroom were sealed in the crawlspace the day prior to the BEHA visit. BEHA staff recommended additional sealing of the holes in the crawlspace as well as sealing of holes from the classroom side. BEHA staff opened the univent cabinet in room 119. This univent was operating on "low" setting. In order to introduce more outdoor fresh air to dilute oil odors, this univent was reset to operate in the "high" mode.

As previously discussed, a number of classroom exhaust vents were not operating, including room 119. The deactivation of these components of the mechanical ventilation system can lead to an increased concentration of normally occurring pollutants generated during occupancy, as well as any oil vapor related odors that may be present. The operation of ventilation system components can serve to reduce concentration and accumulation of oil vapors, as well as general classroom pollutants, for the following reasons:

- Univents introduce fresh air into classrooms. Introduction of fresh air can serve to dilute airborne concentrations of pollutants.
- Univents are equipped with filters that can strain airborne particles from air. The operation of univents can serve as a constantly operating, stationary "vacuum cleaner" that can assist in removing airborne dust and particulates.
- The exhaust ventilation system provides a means to remove stale air and other pollutants from a room. The exhaust vents assist in removing oil odor and normally occurring odor pollutants from the building.

For these reasons, operation of the existing ventilation system can aid in the overall reduction of odors and/or general pollutants within occupied areas of the building.

As described by school officials and on-scene remediation staff, a system has been instituted to respond to occupant complaints/concerns regarding fuel odors. Occupants are directed to report odor complaints directly to the main office. The main office would then contact the Commonwealth Tank representative in the building. Rooms in question are then evacuated and tested using hand-held, real-time monitoring equipment. Rooms are visually inspected for sources of fuel and/or possible pathways for migration of odors into the room. Rooms are reoccupied only after areas are investigated, re-mediated and determined to be odor free.

Conclusions/Recommendations

Air testing results and observations made during the assessment indicate that containment barriers and mitigation activities were fairly successful in preventing pollutant migration into occupied areas. However, further steps should be taken to seal off pathways for oil odors (e.g. sealing of utility holes). Univents and classroom exhaust vents should be activated in occupied classrooms to maximize air exchange. General exhaust ventilation should be reduced to maintain a slightly positive air pressure in classrooms.

In subsequent conversations with MADEP and ECS Marin representatives, the MADEP has issued a Conditional Approval of Immediate Response Action Plan. This plan requires an upgrade to the existing crawlspace ventilation system to intercept oil vapors and to minimize odors in the building (MADEP, 2003).

In addition to the existing building mitigation efforts, the following recommendations should be implemented in order to reduce the migration of fuel odors and their potential impact on indoor air quality:

1. Continue working with MADEP, ECS Marin and Commonwealth Tank to evaluate, optimize and upgrade sub-slab mechanical ventilation system.

2. Continue working with on-site remediation staff to monitor indoor air quality. Continue working with school staff to identify and mitigate areas of odor complaints/concerns.
3. Seal all utility holes penetrating from the crawlspace into occupied areas, particularly heating pipes to univent systems. Seal areas around pipes in the crawlspace as well as in classrooms if possible.
4. Continue with current methods of isolating areas of heavy odor detection with polyethylene plastic barriers. Consider creating duel barriers by installing polyethylene on both sides of the barrier. Inspect these areas regularly for integrity as remediation efforts progress.
5. If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of remediation.
6. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control. If univents are on a timer, consider adjusting the timer so that univents activate two hours prior to the start of each school day.
7. 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. To increase airflow, set univent controls to “high”. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
8. Inspect exhaust motors and belts for proper function, repair and replace as necessary.
9. Remove all blockages from univents and exhaust vents.

10. Consider having the systems re-balanced every five years by an HVAC engineering firm.

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

12. Identify source of leakage in room 101 and make repairs as needed.

13. Replace/repair any remaining water-stained ceiling tiles and building materials. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

14. In order to maintain a good indoor air quality environment on the building, consideration should be give to adopting the US EPA document, "Tools for Schools", which can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

15. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

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Picture 1

Classroom Univent

Picture 2

Classroom Univent Obstructed by Various Items

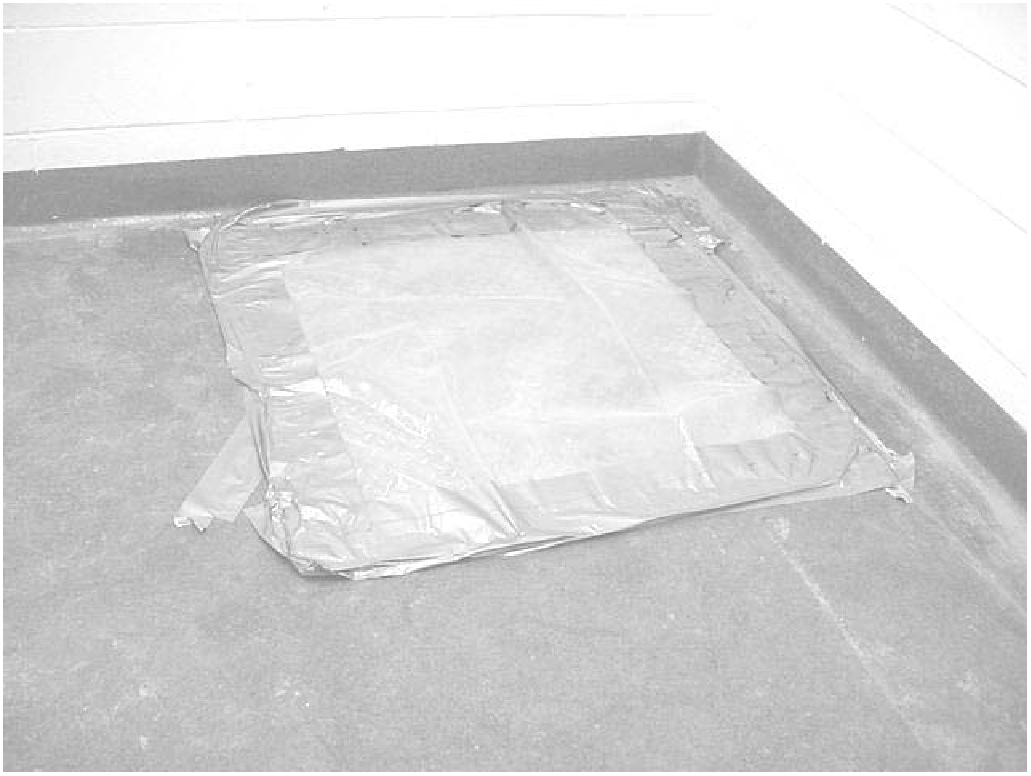
Picture 3

Classroom Exhaust Vent

Picture 4

Heat Generating Electrical Equipment in Mechanical Closet in Classroom 120

Picture 5



Crawlspace Access Hatch (Room 123) Sealed with Plastic and Duct Tape, Note Crawlspace is Sealed inside as well

Picture 6

Containment Walls Constructed around Crawlspace Hatch in Room 123

Picture 7

Ceiling Vent Sealed with Plastic and Duct Tape in Classroom 123

Picture 8

Plastic Poly Containment Wall, Note also Sealed on Interior Side

Picture 9

Crawlspace Ventilation System

TABLE 1

Indoor Air Test Results – Beachmont School – Revere – February 11, 2003

Location	Carbon Dioxide *ppm	TVOC	Carbon Monoxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
								Intake	Exhaust	
Outside (Background)	365	0.0-0.2	0-1	32	18					Scattered clouds - Gusts 25 MPH NW wind 20 MPH
Room 105	1114	0.0-0.2	0	68	20	18	Y	Y	Y	Door open Exhaust not working
Room 101	1244	0.0-0.2	0	70	20	19	Y	Y	Y	CT and water damaged wall plaster, periodic leaks reported Exhaust off – door open
Room 103	1300	0.0-0.2	0	71	19	25	Y	Y	Y	Door open
Auditorium	404	0.0-0.2	0	67	12	2	N	Y	Y	Slight fuel odors Door sealed with polyethylene plastic sheeting
Hallway Gym	544	0.0-0.2		68	14	--	--	--	--	Double poly plastic
Room 123	505	0.0-0.2		69	18	--	N			
Room 119	550	0.0-0.2		70	14	3	Y	Y	Y	Exhaust off Slight odors UV on low reset to high
Room 121 A	640	0.0-0.2		73	14	3	N	Y	Y	CT 2
Room 122	836	0.0-0.2		74	17	20	Y	Y	Y	Items on Univent air diffuser

*** 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 – Beachmont School – Revere – February 11, 2003

Location	Carbon Dioxide *ppm	TVOC	Carbon Monoxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
								Intake	Exhaust	
Room 120	580	0.0-0.2		78	13	1	N	Y	Y	Health complaints Much equipment

*** 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%