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October 19, 2010

Paul B. Ash, Ph.D., Superintendent, Lexington Public Schools
146 Maple Street
Lexington, MA 02420

Patrick Goddard, Director of Facilities
Town of Lexington
201 Bedford Street
Lexington, MA 02420

**RE: Remaining Emissions of PCBs in Indoor Air of Estabrook Elementary School (EH&E 17228)**

Dear Dr. Ash and Mr. Goddard:

Environmental Health & Engineering, Inc. (EH&E) presents four hypotheses (H1 – H4) about sources and mitigation of polychlorinated biphenyls (PCBs) remaining in the indoor air of Rooms 1 – 6. The hypotheses were developed based on previous information and additional building assessments conducted on October 14 – 15, 2010.

The hypotheses are stated and described in Attachment 1. Approaches to testing the hypotheses are described in Attachment 2. A matrix of the hypotheses and corresponding trials being conducted the week of October 18, 2010, is shown in Attachment 3.

If you have any questions regarding this letter, please do not hesitate to contact me at 1-800-TALK EHE (1-800-825-5343).

Sincerely,

David L. MacIntosh, Sc.D.
Principal Scientist

Attachments

# ATTACHMENT 1
# HYPOTHESES

## H1: Release of PCBs from the Curtain Walls (Window Assembly) Continue to Contribute to PCB Levels in Indoor Air.

Potential sources associated with a curtain wall include release of PCBs from (i) within cavities of aluminum frames and I-beams in contact with transite panels; (ii) weather sealant under the base of the curtain wall, (iii) encapsulated caulk; and possibly other points or materials. Observations made on October 15, 2010, support this hypothesis. Channels formed by aluminum framing on curtain wall and I-beams cavities was positively pressurized with respect to the room when there was no outdoor air flow through the unit ventilator. The pressure differential was neutral when the outdoor air damper of the unit ventilator was in its minimum position (250 – 350 cubic feet per minute [cfm]). Observations made on September 4, 2010, also support this hypothesis. Prior to removing occluded debris screens from within intakes of unit ventilators, outdoor air flow rates were approximately 150 cfm, while exhaust flow rates may have been in the range they are currently, approximately 300 cfm per room, in which case rooms may have been negatively pressurized with respect to the curtain wall cavities when windows and doors were closed. A secondary hypothesis is that emissions of PCBs from the curtain wall in some rooms are modified by operation of fin tube radiators and convective units. This hypothesis is supported by observations made on October 15, 2010. Surface temperatures of the aluminum channel frame within 12 inches of the convective heater increased by approximately 10 degrees Fahrenheit (°F) when steam was flowing through the heater.

The *curtain wall hypothesis* will be tested by Trial A and Trial B.

The objective of Trial A is to assess flux of PCBs from a curtain wall assembly in both a heated and unheated zone. In brief, the west-facing curtain wall and south-facing curtain wall will be isolated from the remainder of the space in Room 2. The unit ventilator will operate as normal.

The objective of Trial B is to assess a practical way to control emissions of PCBs from the curtain wall. Pathways for communication between the occupied space and curtain wall cavities, caulk on interior joints of aluminum frame, and curtain wall base will be sealed. The unit ventilator will operate as normal.

**H2: Release of PCBs from within the Unit Ventilator Cabinets Contribute to PCB Levels in Indoor Air**

Potential sources within unit ventilator cabinets include caulk, insulating oils in original components (transformer, capacitor, motor), or secondary PCBs in insulation or debris. A bulk sample obtained from within a unit ventilator previously provides support for this hypothesis. A secondary hypothesis is that emissions of PCBs from within unit ventilators are modified during heating. Results from the Round 6 air sampling provide indirect support for the secondary hypothesis.

The *unit ventilator hypothesis* will be tested by Trial C and Trial D.

The objective of Trial C is to assess concentrations of PCBs in air within unheated unit ventilators with (i) original motors and electrical components (likely to contain PCB insulating fluids) and (ii) new motors and electrical components. In brief, the unit ventilators will be isolated from the remainder of the space in Room 1 and Room 4. The unit ventilators will not be heated, but will be warm from the steam pipe stub located within the cabinet.

The objective of Trial D is to assess concentrations of PCBs in air discharged by heated unit ventilators with (i) original motors and electrical components and (ii) new motors and electrical components. In brief, discharge air from the unit ventilators in Rooms 2, 3, and 5 will be sampled during normal heating operation of the unit ventilators.

**H3: In-room Filtration Units can Decrease Concentrations of PCBs in Indoor Air.**

Portable air cleaners have been shown to be effective at removing contaminants from indoor air of spaces that are well-mixed.[1] With octanol-water partition coefficients ranging from $10^4$ to $10^7$, PCB homologs present in indoor air of the school have a high affinity for activated charcoal and other materials enriched in organic carbon. Therefore, portable air cleaners equipped with activated charcoal filters and operated at flow rates that achieve several air changes per hour may be effective at controlling concentrations of PCBs in indoor air.

The *air cleaner hypothesis* will be tested by Trial E.

[1] MacIntosh DL, Ludwig JF, Baker BJ, Suh HH, Myatt, TA, Spengler JD. 2008. Whole house particle removal and clean air delivery rates for in-duct and portable ventilation systems. *Journal of the Air and Waste Management Association*, 58:1474-1482

The objective of Trial E is to assess concentrations of PCBs in air within rooms that contain portable air cleaners equipped with activated charcoal filters, each operating at 400 cfm. Two such air cleaners will be operated in Room 3 and Room 5. Unit ventilators will operate as normal.

### H4: Ventilation Rates are Modified by Interactions Between the Duty Schedule of the Boiler and Thermostat Set Points.

At least two conditions exist during the heating season when outdoor air dampers of unit ventilators will close fully, and therefore minimize flow of outdoor air into the building.

Both conditions occur when the room temperature is more than 2 °F below the set point of the room air thermostat (between 69 to 72 °F in most rooms of the school). When the boiler is on the damper may close intermittently throughout the day based on occupant manipulation of thermostat. When the boiler is off the damper will remain closed until the room temperature exceeds the room set point temperature. The second condition can occur when the boiler is turned off during the middle of a school day causing the room temperature to remain below the thermostat set point temperature.

The *boiler/ventilation hypothesis* was tested on October 14, 2010, and demonstrated to be correct.

EH&E made a recommendation to Lexington Facilities to maintain the heating season boiler pressure set point 24 hours a day, 7 days a week. This operation plan will minimize the frequency of outdoor air dampers closing fully. Continuous availability of the boiler in this manner began on October 15, 2010. EH&E will continue to work with Facilities to identify ways of maintaining ventilation during occupied periods while minimizing fuel consumption.

**Attachment 2** Description of the Trials and Hypothesis Tested in Room 1 – 6

<table>
<tr><th>Trial</th><th>Hypothesis</th><th>Room</th><th>Conditions</th><th>Sampling Parameters</th></tr>
<tr><td>A:<br>Evaluate flux of polychlorinated biphenyls (PCBs) from window wall assembly in a heated and unheated zone</td><td rowspan="2">H1:<br>Release of PCBs from curtain walls</td><td>2</td><td>• Isolate west-facing wall, leaving unit ventilator exposed<br>• Isolate south-facing window wall and fin tube radiator<br>• Operate Ultraviolet (UV at same outdoor air flow as Round 6<br>• Room Thermostat at 70 degrees Fahrenheit (°F), Boiler on.<br>• Door Closed.</td><td>• Evaluate air exchange within each isolated space using tracer gas.<br>• Log temperature in each enclosed space.<br>• Air samples in the occupied space, at the UV discharge air stream, and within the wall enclosures.</td></tr>
<tr><td>B:<br>Evaluate practical way to control remaining emissions of PCBs from window wall</td><td>6</td><td>• Foam insulation within frame, within 1 foot of convective heaters.<br>• Foam insulation within frame, within 1 foot of drop ceiling.<br>• Seal I-beam chases.<br>• Seal cove base, top and bottom edges.<br>• Encapsulate caulk at junction of vertical and horizontal frames.<br>• Fill void behind convective heaters with insulation.<br>• Measure outdoor air flow rate.<br>• Room Thermostat at 70 °F, boiler on.<br>• Door Closed.</td><td>• Log temperature in room.<br>• Air samples in the occupied space.</td></tr>
<tr><td>C:<br>Evaluate UV with an old motor, transformer and capacitor</td><td rowspan="2">H2:<br>Release of PCBs from UV</td><td>1</td><td>• UV isolated from room, steam pressure, and outdoor air.<br>• Isolate I-beam.<br>• Provide supplemental ventilation of 300 cubic feet per minute (cfm).<br>• Space heaters to warm the room to 70 °F.<br>• Room Thermostat at 70 °F, boiler on.<br>• Door Closed.</td><td>• Log temperature in room and UV.<br>• Air samples in the occupied space, within the UV enclosure, and within the I-beam enclosure.</td></tr>
<tr><td>D:<br>Evaluate UV with new motor, transformer and capacitor</td><td>4</td><td>• UV isolated from room, steam pressure, and outdoor air.<br>• Provide supplemental ventilation of 300 cfm.<br>• Room Thermostat at 70 °F, boiler on.<br>• Door Closed.</td><td>• Log temperature in room.<br>• Air samples in the occupied space, and within the UV enclosure.</td></tr>
<tr><td>E:<br>Assess effect of portable air cleaners with activated charcoal filters</td><td rowspan="2">H3:<br>In-room filtration units can decrease PCBs</td><td>5</td><td>• Two portable air cleaners, each operating at high fan speed (400 cfm) and located adjacent to UV.<br>• Operate UV at same outdoor air flow as Round 6.<br>• Room Thermostat at 70 °F, boiler on.<br>• Door closed.</td><td>• Log temperature in room.<br>• Air samples in the occupied space, and at the UV discharge air stream.</td></tr>
<tr><td>F:<br>Assess combined effect of air cleaner and curtain wall encapsulation</td><td>3</td><td>• Foam insulation within frame, within 1 foot of convective heaters.<br>• Foam insulation within frame, within 1 foot of drop ceiling.<br>• Isolate I-beam.<br>• Seal cove base, top and bottom edges.<br>• Encapsulate caulk at junction of vertical and horizontal frames.<br>• Two portable air cleaners, each operating at high fan speed (400 cfm) and located adjacent to UV.<br>• Operate UV at same outdoor air flow as Round 6.<br>• Room Thermostat at 70 °F, boiler on.<br>• Door closed.</td><td>• Log temperature in room.<br>• Air samples in the occupied space, at the UV discharge air stream, and within the I-beam enclosure.</td></tr>
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**Attachment 3** Number of Air Samples and Locations in Room 1 – 6

| Trial | Hypothesis | Room | Occupied Space | UV Discharge Air | UV Enclosure | I-beam Enclosure | Window Wall Enclosure | No. Samples per Room |
|---|---|---|---|---|---|---|---|---|
| A:<br>Evaluate flux of PCBs from window wall assembly in a heated and unheated zone | H1:<br>Release of PCBs from Curtain Walls | 2 | 1 | 1 | | | 2 | 4 |
| B:<br>Evaluate practical way to control remaining emissions of PCBs from window wall | | 6 | 1 | | | | | 1 |
| C:<br>Evaluate UV with an old motor, transformer and capacitor | H2:<br>Release of PCBs from UV | 1 | 1 | | 1 | 1 | | 3 |
| D:<br>Evaluate UV with new motor, transformer and capacitor | | 4 | 1 | | 1 | | | 2 |
| E:<br>Assess effect of portable air cleaners with activated charcoal filters | H3:<br>In-room filtration units can decrease PCBs | 5 | 1 | 1 | | | | 2 |
| F:<br>Assess combined effect of air cleaner and curtain wall encapsulation | | 3 | 1 | 1 | | 1 | | 3 |
| No. Samples per Space | | | 6 | 3 | 2 | 2 | 2 | 15 |

UV Ultraviolet
PCB polychlorinated biphenyl