

## **Appendix D: Work Plan/QAPP with Pre-Study Broken CFL Cleanup Guidance**

Title: Study Plan, Mercury exposure minimization during cleanup of broken compact fluorescent lamps

### **Project Personnel:**

Maine DEP: Heather Jackson, Stacy Ladner, Deb Stahler

Maine CDC: Erik Frohberg, Dr. Deb Rice, Dr. Andrew Smith

### **Project Organization: MDEP, BRWM**

This study has been developed by the Hazardous/ Universal Waste Unit within the Bureau of Remediation and Waste Management of the Department of Environmental Protection. Stacy Ladner is the project manager for the study. Stacy Ladner, Deb Stahler and Heather Jackson will be performing cleanup scenarios as listed in the Sampling/ Analysis section of this study plan. Deb Stahler, project Chemist, will provide guidance regarding mercury analyzer operation and data analysis. Eric Frohberg, DHHS toxicologist, provided review comments for study plan and Maine CDC will provide review and evaluation of the study results. All have direct contact with each other and are responsible to know and follow this work plan. The final report will be the responsibility of Heather Jackson in collaboration with the project team.

### **Introduction:**

#### **Goals:**

The goal of this study is to collect data to support mercury cleanup guidance when a single compact fluorescent lamp is broken.

We will collect data to support guidance for the following questions:

1. Will breaking one compact fluorescent light bulb cause the air in a small-moderate sized room to have mercury concentrations above the Maine Ambient Air Guidelines (AAG) of 300 ng/m<sup>3</sup> in the breathing zone for both adults and crawling infants?
2. How long do you need to vent the room before concentrations remain below the AAG even when the room is no longer vented?
3. How does the type of floor surface affect cleanup efficiency, and if the surface is a rug, does it need to be removed?
4. How does vacuuming affect the air mercury concentrations?
5. Do vacuum cleaners become irreversibly contaminated with mercury if they are used to clean up broken lamps, or are there any simple steps to decontaminate them?

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### **End Use of Data:**

Regulators and public health officials may use data to create guidance for the general public. Data will be available to public.

### **Background:**

Compact fluorescent lamps (CFL) are an energy efficient source of light. However, these lamps contain mercury and may need special handling if broken. Recently the issue of what guidance to give when someone breaks a lamp in a home with children has been highlighted in several news stories. Differences in the guidance given by state agencies has been confusing and worrisome to the public.

The Bureau of Remediation and Waste Management at the Department of Environmental Protection (DEP) has been tasked with writing a guidance document that can be used by state agencies. While there are some limited data about release of mercury from fluorescent lamps, more data are needed to support this guidance. The Department currently has a cleanup guidance which may be revised based upon the results of this study.

### **Study Design:**

The basic plan includes measuring mercury air concentrations continuously over time up to one week for six scenarios where one CFL is broken on different surfaces and cleaned up with and without venting, and with and without vacuuming. Three Lumex RA 915+ mercury analyzers, with a quantitation limit of 20 ng/M3, will be used to measure mercury concentrations as described in the attached standard operating procedures. Two analyzers will be connected to lap-top computers using RA-915+ software version 3.17.4 to continuously monitor mercury concentrations during the initial lamp break and periods of time throughout the experiment. The third analyzer will be used to measure mercury concentrations near vacuum surfaces initially, during and right after vacuum operations, and later after decontamination both when the vacuum is turned off, and after 10 minutes of operation when the vacuum is warm. Discrete mercury concentrations will also be measured 1" from vacuum surfaces before and after vacuuming broken lamp residuals, and after simple decontamination procedures. Lumex mercury analyzer data are considered screening level data. Lumex data are being employed in this study to collect high volume continuous data, and because the Lumex mercury analyzers are what DEP uses to screen mercury air concentration data in homes where mercury thermometers and fluorescent lamps are broken.

All scenarios will be carried out in a room with dimensions 11'4" x 12'1" with 10' ceilings. A window opening to the outside of the building with dimensions, 30" x 38" will be closed during the non-vented trial, and will be opened for discrete lengths of time as determined to be effective in the vented trials. Heat is delivered to the room via ceiling duct during the heating season. Heat is not expected to be operating during the time frame of the experimental trials. There is no room air conditioning or air-out vent, the only air exchange is through doors and windows. Inside and outside temperature will be recorded at 8AM, noon and 4PM of each day. Each scenario will be repeated three times and the combined mercury concentration data will be evaluated in the study report. New CFL, with known amounts of liquid mercury dosing will be used in this study since it is generally understood that the amount of

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elemental/ liquid mercury will be highest in new, rather than spent lamps. We plan to use one model from one manufacturer, and if at all possible, one lot number to eliminate variability in the amount of mercury spilled in each trial. Manufacturer information will be documented for the selected CFL.

Table A, below, describes the six different experimental scenarios.

<b>Floor Treatment</b>	<b>Cleanup</b>	<b>Hg Measurements</b>
<u>Scenario 1:</u> Wood	No lamp cleanup/ no ventilation	Measure air concentrations continuously until highest concentration is reached
<u>Scenario 2:</u> Wood	Ventilate room and clean up glass over $\frac{3}{8}$ " (hardware cloth), clean remainder according to current guidance*	Measure continuously
<u>Scenario 3:</u> Short pile rug	Ventilate room and clean up glass over $\frac{3}{8}$ " (hardware cloth), clean remainder according to current guidance	Measure continuously
<u>Scenario 4:</u> Long pile "shag" rug	Ventilate room and clean up glass over $\frac{3}{8}$ " (hardware cloth), clean remainder according to current guidance	Measure continuously
<u>Scenario 5:</u> Short pile rug	Ventilate room and clean up glass over $\frac{3}{8}$ " (hardware cloth), vacuum	Measure continuously/ take discrete measurements at vacuum locations
<u>Scenario 6:</u> Long pile "shag" rug	Ventilate room and clean up glass over $\frac{3}{8}$ " (hardware cloth), vacuum	Measure continuously/ take discrete measurements at vacuum locations

\* Current cleanup guidance is specified in Attachment 2 of this work plan.

In addition, two different types of vacuum cleaners will be used, one will have an internal vacuum bag, and the other will be a motorized sweeper with no internal bag. Both vacuum cleaners will be emptied after the lamp cleanup, outside surfaces wiped with a wet-wipe and stored for a period of time to determine whether or not the vacuum remains a mercury "source" for a period of time up to two weeks after use.

### Lumex RA 915+ mercury analyzer serial numbers:

1. Augusta Lumex: Serial Number 329
2. Bangor Lumex: Serial Number 254
3. Portland Lumex: Serial Number 215

### Vacuum Cleaner Model information:

1. Kenmore Canister Model 116, Serial D81401163 using vacuum bag <sup>20</sup> 5033
2. Dirt Devil Power Sweep, purchased new June 4, 2007

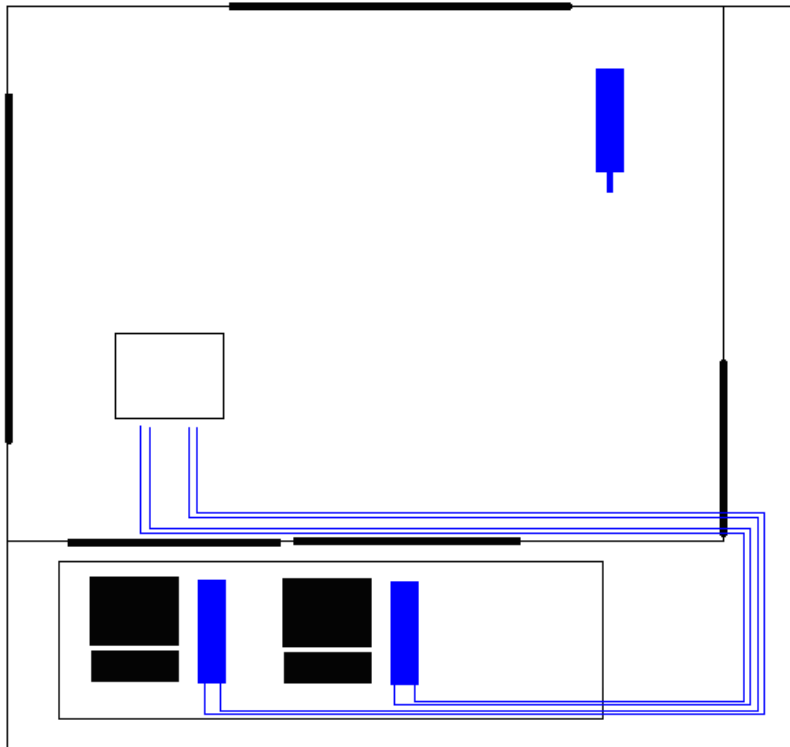
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Both vacuum cleaners were tested for mercury emission before cleanup scenarios, and results for all testing was < 20 ng/M3 emissions.

Compact Fluorescent Lamps: Philips Soft White Energy Saver 60; 800 Lumens light output, 14 watts, 8000 hours life.

### Sampling/ Analysis Plan:

Room set up is given in Figure 1, below:



Room dimensions: 12'1" X 11'4" with 10' ceilings.

Lamp will be broken inside cardboard box with dimensions: 14½" x 23" x 3½" height lined with vinyl plastic and equipped with scenario floor covering. A painted hardware cloth with ¼" square grid for easy glass cleanup will be placed on top of floor surface.

Opening window on east side of building (top of drawing] with dimensions 30" x 38" opens to the outside of building and will be used for ventilation.

Door in lower right will only be opened to allow access on a limited basis, and access will be documented.

Sampling lines and instrument exhaust lines run under the door, which is not sealed. There is a ⅝" space under the door.

Air mercury concentrations will be measured at two heights, 1' from floor and 5' from floor and placed adjacent to the lamp breakage location. Fixed sampling lines are ½" ID lines with a 12' lineal run for a total volume of approximately 1 Liter. Since the Lumex pump operates at 15 L/ min, there is less than 5 seconds delay between mercury air concentrations entering the sampling tube, and concentrations measured by the analyzer. Discrete mercury concentrations will be measured outside room under door and in breathing zone outside room door.

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### **Scenario 1: Procedure for non-vented trial on hardwood with no cleanup:**

1. Set up room with cardboard box and Lumex analyzers positioned as in Figure 1.
2. Windows and door should be closed. Record room temperature on the Project Daily Temperature Record each day.
3. Line cardboard box with vinyl plastic and place first hardwood flooring, then painted hardware cloth in bottom.
4. Place CFL on hardware cloth and cover with vinyl plastic coverlet.
5. Follow Lumex SOP (Attachment 1 of this QAPP) for initial start-up, and begin recording mercury air concentrations.
6. Don appropriate PPE.
7. Break CFL by striking plastic covered CFL with hammer & move cover plastic to one side of box.
8. Exit room and allow Lumex analyzers to record up to 24 hours after breakage.
9. Review Lumex analyzer data. Continue monitoring until all results stabilize under 300 ng/M3.
10. Repeat step 9 until room mercury levels stabilize.
11. Measure and record mercury vapor concentrations outside door during study to confirm that levels do not exceed ambient air guidelines (300 ng/M3).
12. Vent room, don appropriate PPE and clean up broken lamp.
13. Bag and properly dispose of all broken lamp debris and decontaminate room by venting overnight. Other decontamination procedures will be employed if room mercury concentrations do not stabilize under 50 ng/M3.

### **Scenario 2: Procedure for vented trial on hardwood with current guidance cleanup:**

1. Set up room with cardboard box and Lumex analyzers positioned as in Figure 1.
2. Windows and door should be closed. Record room temperature on the Project Daily Temperature Record each day.
3. Line cardboard box with vinyl plastic and place first hardwood flooring, then painted hardware cloth in bottom.
4. Place CFL on hardware cloth and cover with vinyl plastic coverlet.
5. Follow Lumex SOP (Attachment 1 of this QAPP) for initial start-up, and begin recording mercury air concentrations.
6. Don protective clothing and respirator as described in PPE.
7. Break CFL by striking plastic covered CFL with hammer & move cover plastic to one side of box.
8. Vent room.
9. Clean up lamp using current DEP cleanup guidance as described in Attachment 2.
10. Record mercury concentrations until measurements stabilize under 20 ng/M3.
11. Close outside window and let mercury concentrations equilibrate to check for rebound.
12. Measure and record mercury vapor concentrations outside door during study to confirm that levels do not exceed ambient air guidelines.
13. Bag and properly dispose of any remaining mercury contaminated materials and decontaminate room by venting overnight. Other decontamination procedures will be employed if room mercury concentrations do not stabilize under 50 ng/M3.

### **Scenario 3: Procedure for vented trial with short pile rug/ current guidance cleanup:**

1. Set up room with cardboard box and Lumex analyzers positioned as in Figure 1.

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2. Windows and door should be closed. Record room temperature on the Project Daily Temperature Record each day.
3. Line cardboard box with vinyl plastic, place short pile rug on top of plastic, and place painted hardware cloth on top of rug.
4. Place CFL on hardware cloth and cover with vinyl plastic coverlet.
5. Follow Lumex SOP (Attachment 1 of this QAPP) for initial start-up, and begin recording mercury air concentrations.
6. Don protective clothing and respirator as described in PPE.
7. Break CFL by striking plastic covered CFL with hammer & move cover plastic to one side of box.
8. Vent room.
9. Clean up lamp using current DEP cleanup guidance as described in Attachment 2.
10. Record mercury concentrations until measurements stabilize under 20 ng/M3.
11. Close outside window and let mercury concentrations equilibrate to check for rebound.
12. Measure and record mercury vapor concentrations outside door during study to confirm that levels do not exceed ambient air guidelines.
13. Bag and properly dispose of any remaining mercury contaminated materials and decontaminate room by venting overnight. Other decontamination procedures will be employed if room mercury concentrations do not stabilize under 50 ng/M3.

### **Scenario 4: Procedure for vented trial with long pile rug/ current guidance cleanup:**

1. Set up room with cardboard box and Lumex analyzers positioned as in Figure 1.
2. Windows and door should be closed. Record room temperature on the Project Daily Temperature Record each day.
3. Line cardboard box with vinyl plastic, place long pile rug on top of plastic, and place painted hardware cloth on top of rug.
4. Place CFL on hardware cloth and cover with vinyl plastic coverlet.
5. Follow Lumex SOP for initial start-up, and begin recording mercury air concentrations.
6. Don protective clothing and respirator as described in PPE.
7. Break CFL by striking plastic covered CFL with hammer & move cover plastic to one side of box.
8. Vent room.
9. Clean up lamp using current DEP cleanup guidance as described in Attachment 2.
10. Record mercury concentrations until measurements stabilize under 20 ng/M3.
11. Close outside window and let mercury concentrations equilibrate to check for rebound.
12. Measure and record mercury vapor concentrations outside door during study to confirm that levels do not exceed ambient air guidelines.
13. Bag and properly dispose of any remaining mercury contaminated materials and decontaminate room by venting overnight. Other decontamination procedures will be employed if room mercury concentrations do not stabilize under 50 ng/M3.

### **Scenario 5: Procedure for vented trial with short pile rug/ vacuum cleanup:**

1. Set up room with cardboard box and Lumex analyzers positioned as in Figure 1.
2. Windows and door should be closed. Record room temperature on the Project Daily Temperature Record each day.
3. Line cardboard box with vinyl plastic, place short pile rug on top of plastic, and place painted hardware cloth on top of rug.

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4. Place CFL on hardware cloth and cover with vinyl plastic coverlet.
5. Follow Lumex SOP (Attachment 1 of this QAPP) for initial start-up, and begin recording mercury air concentrations.
6. Don protective clothing and respirator as described in PPE.
7. Break CFL by striking plastic covered CFL with hammer & move cover plastic to one side of box.
8. Clean up lamp:
  - Open outside window,
  - Pick up cover plastic and place inside plastic trash bag.
  - Carefully pick up hardware cloth, dump contents into trash bag and
  - vacuum small pieces of glass and powder residue with canister vacuum.
  - Carefully remove vacuum bag and place it in the lamp trash bag.
  - Wipe outside contact surfaces of vacuum with wet wipe and place used wipes in trash bag.
  - Close lamp trash bag.
  - Scan the vacuum with Lumex analyzer to determine areas of highest measurement (keep Lumex sampling tube 1" from vacuum surfaces).
  - Record 10 second average measurements at all areas of the vacuum where levels exceed 300 ng/M3.
  - Exit room and place lamp trash bag in hazardous waste container.
9. After one hour, record 10 second average measurements at all areas of the vacuum where levels exceed 300 ng/M3.
10. Turn on vacuum, allow to run continuously for 10 minutes and repeat step 9.
11. After three hours repeat step 9 & 10.
12. Repeat steps 9 & 10 periodically until all readings on the vacuum are below 300 ng/M3.
13. Record room air mercury concentrations until room air measurements stabilize under 20 ng/M3.
14. Close outside window and let mercury concentrations equilibrate to check for rebound.
15. Measure and record mercury vapor concentrations outside door during study to confirm that levels do not exceed ambient air guidelines.
16. Bag and properly dispose of carpet and decontaminate room by venting overnight. Other decontamination procedures will be employed if room mercury concentrations do not stabilize under 50 ng/M3.

### **Scenario 6: Procedure for vented trial with long pile rug/ vacuum cleanup:**

1. Set up room with cardboard box and Lumex analyzers positioned as in Figure 1.
2. Windows and door should be closed. Record room temperature on the Project Daily Temperature Record each day.
3. Line cardboard box with vinyl plastic, place long pile rug on top of plastic, and place painted hardware cloth on top of rug.
4. Place CFL on hardware cloth and cover with vinyl plastic coverlet.
5. Follow Lumex SOP (Attachment 1 of this QAPP) for initial start-up, and begin recording mercury air concentrations.
6. Don protective clothing and respirator as described in PPE.
7. Break CFL by striking plastic covered CFL with hammer & move cover plastic to one side of box.
8. Clean up lamp:

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- Open outside window,
  - pick up cover plastic and place inside plastic trash bag.
  - Carefully pick up hardware cloth, dump contents into trash bag and
  - vacuum small pieces of glass and powder residue with motorized sweeper.
  - Wipe contact surfaces of vacuum with wet wipe and place used wipes in trash bag.
  - Close lamp trash bag.
  - Scan the vacuum with Lumex analyzer to determine areas of highest measurement (keep Lumex sampling tube 1" from vacuum surfaces).
  - Record 10 second average measurements at all areas of the vacuum where levels exceed 300 ng/M3.
  - Exit room and place lamp trash bag into hazardous waste container.
8. After one hour, record 10 second average measurements at all areas of the vacuum where levels exceed 300 ng/M3.
  9. Turn on vacuum, allow to run continuously for 10 minutes and repeat step 9.
  10. After three hours repeat step 9 & 10.
  11. Repeat steps 9 & 10 periodically until all readings on the vacuum are below 300 ng/M3.
  12. Record room air mercury concentrations until room air measurements stabilize under 20 ng/M3.
  13. Close outside window and let mercury concentrations equilibrate to check for rebound.
  14. Measure and record mercury vapor concentrations outside door during study to confirm that levels do not exceed ambient air guidelines.
  15. Bag and properly dispose of carpet and decontaminate room by venting overnight. Other decontamination procedures will be employed if room mercury concentrations do not stabilize under 50 ng/M3.

### Safety:

#### Hazard Analysis:

Mercury exposure: Mercury air concentrations within the test room are expected to exceed the Maine ambient air guideline for periods of time, and will be monitored. Only personnel with 40 hour safety training who are in the DEP respirator program will be allowed inside the test room during the test period. In addition to air concentrations, mercury and other heavy metals may be present on plastic, wood or rug surfaces. PVC plastic will be worn during experimental operations. PVC plastic gloves, along with any other contaminated media will be bagged and placed in a drum labeled for hazardous waste disposal. Mercury air concentrations will be monitored during all experimental trials.

Broken glass: Lamps will be broken during experimental trials, and glass fragments will be handled during cleanup. A piece of painted hardware cloth will be placed directly under the CFL prior to breakage to collect glass fragments over 3/8" in width to minimize cuts and punctures. Cut resistant gloves in conjunction with PVC plastic will be worn during cleanup operations.



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### PPE:

1. Gloves:
  - Ansell HyFlex coated cut-resistant
  - Disposable PVC plastic
2. Tyvek coverall
3. Full face respirator with dust and mercury cartridges attached

### Quality Assurance/ Quality Control:

#### Sampling/ Analysis:

1. One manufacturer, make/ model CFL were purchased for this study on the same date, May 16, 2007 from the same store. All lamps are Philips Soft White, 800 lumens, 14 watts, 120 volts, 0.2 amps; stamped 815790 on each package; and inventory item 15274.
2. Calibration verification and background air/ blank contamination will be determined for each mercury analyzer for each day of use.
3. All procedures contained in this work plan, including attached standard operating procedures must be followed unless a modification is approved by the project team and documented.
4. All scenarios will be repeated three times, and precision evaluated.

#### Data Evaluation:

All data will be reviewed by the project chemist and state toxicologist and discussed in the study report.

### Reporting:

A report of data collected during this study will include:

- manufacturer, make/ model and lot number for CFL used in this study,
- recorded temperatures,
- tables of Lumex results generated by Lumex RA 915+ software,
- discrete Lumex measurements taken from vacuum cleaner locations,
- copies of any notes generated during the study,
- documentation of any changes to standard protocols,
- documentation of Lumex calibration verification,
- any data evaluation procedures and
- discussion of results/ revised cleanup guidance.

## Pre-Study Cleanup Guidance

### What if I break a fluorescent bulb in my home?



The most important thing to remember is to **never use a vacuum**. A standard vacuum will spread mercury-containing dust throughout the area as well as potentially contaminating the vacuum. What you should do is:

- Keep people and pets away from the breakage area so that the mercury in the powder inside the bulb is not accidentally tracked into other areas.
- Ventilate the area by opening windows.
- If possible, reduce the temperature.
- Wear appropriate personal protective equipment, such as rubber gloves, safety glasses, old clothing or coveralls, and a dust mask (if you have one) to keep bulb dust and glass from being inhaled.
- Carefully remove the larger pieces and place them in a secure closed container or airtight plastic bag.
- Next, begin collecting the smaller pieces and dust. You can do this using a disposable broom and dustpan or two stiff pieces of paper to scoop up the pieces.
- Put all material into the container or airtight plastic bag. Pat the area with the sticky side of duct, packing or masking tape. Wipe the area with a damp cloth or paper towels to pick up fine particles.
- Put all waste and materials used to clean up the bulb in the secure closed container or airtight plastic bag and label it "Universal Waste - broken lamp".
- Take the container for recycling as universal waste. To determine where your town has made arrangements for recycling of this type of waste, call your town office or check out the Maine Department of Environmental Protection website at <http://www.maine.gov/dep/rwm/hazardouswaste/uwmuniciplemaster.xls>

The next time you replace a bulb, consider putting a drop cloth on the floor so that any accidental breakage can be easily cleaned up.