PROTOCOL FOR COLLECTING AND ANALYZING MERCURY VAPOR IN AIR WITH A LUMEX RA-915+ MERCURY ANALYZER

Maine Department of Environmental Protection
Bureau of Remediation and Waste Management

Standard Operating Procedure: **BRWMHg01**
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1.0 APPLICABILITY

This standard operating procedure (SOP) is designed to be a guideline for operating the Lumex RA-915 for mercury vapor analysis. The Lumex RA-915 is applicable for ambient air testing of mercury vapor in the range of 20 ng/M^3 to 50,000 ng/M^3. (50,000ng/M^3 = .05 mg/M^3) For areas of higher concentration, a Jerome meter should be used. Do not directly expose the RA-915 to elemental mercury as this may permanently contaminate the instrument.

The ambient air guideline for mercury is 300 ng/M^3.

2.0 PURPOSE

The purpose of this document is to describe the Maine Department of Environmental Protection, Bureau of Remediation and Waste Management (MDEP/BRWM) procedure for collecting and analyzing air samples for mercury vapor analysis.

3.0 RESPONSIBILITIES

All Bureau Staff must follow this procedure when using the Lumex RA-915 for mercury vapor analysis. All managers and supervisors within MDEP/BRWM are responsible for ensuring that their staff is familiar with and adhere to this procedure. This instrument is not intrinsically safe and must not be used in confined spaces without proper training, monitoring, and permits required in the Department's Confined Space Policy. Any mercury reading above 300 ng/ M^3 (the ambient air guideline) will require pregnant or potentially pregnant staff to leave the area or use appropriate respiratory protection. MDEP/BRWM staff should not work for extended periods of time (over 30 minutes) where mercury reading are above 12,500 ng/M^3 (1/2 of the ACGIH TLV of 25,000 ng/M^3) without appropriate respiratory protection. Mercury reading above 25,000 ng/M^3 require MDEP/BRWM staff to leave the area or use appropriate respiratory protection. Any exposures over 25,000 ng/M^3 should be reported on a safety exposure report form.

4.0 DEFINITIONS:

4.1 MDEP: Maine Department of Environmental Protection
4.2 BRWM: Bureau of Remediation and Waste Management
4.3 Hg: Mercury
4.4 SOP: Standard Operating Procedure
4.5 ACGIH: American Conference of Industrial Hygienists
4.6 TLV: Threshold Limit Value

5.0 PROCEDURES

5.1 Starting the instrument:

- The instrument can be powered by either 120-v AC line current (with adapter cord), a battery pack in the instrument, or vehicle cigarette lighter adapter. The battery pack is intended for a maximum of 4 hours continuous use, and should be recharged using the included cord plugged into120 v AC line current. The instrument may be used with batteries if the battery indicator is flashing red. A steady red indicates the battery needs to be charged and AC power must be used

to run the instrument. A supplemental battery pack is stored in the side pocket and can be plugged into the AC adapter cord port. The supplemental battery will provide an additional 2 hours use.

- Pre-operational procedures:
  1. Before operating the RA-915, conduct a visual inspection of the analyzer's component parts. The instrument may be used while in the carrying case.
  2. Place the RA-915 in a horizontal position with the Palm monitor (controls and display screen) on top. The power switch will be the front end. (see photo 1)
  3. Set the test cell control handle (on the side of instrument) to the **OFF** position. This can be accessed inside the side pocket of the carrying case.
  4. Check to make sure Palm monitor is securely connected to the base unit.
  5. The handle for optical bridge switch at the back and opposite the power switch should be pre-set to position III.
- Turn on the power switch on front of the instrument. The Palm monitor will then show the Lumex version screen (see photo 2).
- Press the "Ent" button on the Palm monitor. The MAIN MENU display will appear. There will be an * next to the words MAIN MENU.
- Press (3-5 sec) and release the Lamp Ignition button on front of the machine. When the lamp lights the * next to the words MAIN MENU will disappear. Repeat this step as necessary to light the lamp.
- Allow the instrument to warm up for 5 minutes prior to testing.

5.2 Menu Screens:

The MAIN MENU will have the following options:

- Parameter ⇒ Used to change parameter settings (see below).
- On Stream ⇒ Used to analyze background and environmental samples.
- On Time ⇒ Not used for air analysis.
- Test ⇒ Used to verify instrument calibration.
- Settings ⇒ Used to save new parameter settings or restore factory settings. This should not normally be used.

To select an option, highlight the option and push the ***Ent*** button.
To return to the main menu, push the ***Esc*** button.

Parameter settings for air analysis should generally follow preset values. The following settings have been stored:

Parameter	Value	Units
Average time	1	sec
Baseline Cor time	20	sec
Frame time	10	sec
Integr. time	120	sec
Low limit	20	ng/M^3
High limit	300	ng/M^3

5.3 Background air analysis:

- Prior to taking the instrument to a potentially contaminated site, a background air sample should be analyzed to demonstrate that the instrument reading is below the reporting limit for this instrument, 20 ng/M^3.
- A background sample must be taken at the beginning and end of each analysis day. All results must be below 20 ng/M^3. Do not proceed until this condition has been met.

- For this analysis the Lumex RA-915 should be operated in the ON STREAM mode as described below:

Operation in ON STREAM (AIR ANALYSIS) mode

1. The optical bridge handle should already be in the III position as described in the starting instructions above (section 4.1).
2. Use the arrow buttons, on the Palm monitor indication unit to select the ON STREAM mode and press the Ent button. This will switch the compressor on, and the zero signal will be measured. The following will occur on the display (see photo 3):
   - The current S value which corresponds to the mercury concentration in the pumped air in ng/M^3 is displayed in the upper right of the palm monitor
   - The Si level is also displ ayed below the S value. This result (Si) corresponds to the value S averaged over a given time range.
   - The bottom right displays a countdown (in seconds) of the time over which S values were averaged. The current setting is for values to be averaged over 10 seconds.
   - An **Alarm!!** Message is displayed across the top of the screen if the mercury concentration exceeds the ambient air guideline. Any mercury reading above the ambient air guideline (300 ng/ M^3) will require pregnant or potentially pregnant staff to leave the area or use appropriate respiratory protection.
3. If the ***Ent*** button is pressed a second time, the following changes occur on the display
   - Three Si readings and S_c (the average of these three Si readings) are displayed. In this mode three 10 second average readings are repeated, averaged, and displayed with the corresponding relative deviation (R) in the measurements.
   - The average, S_c = (S1+S2+S3)/3.
   - The relative deviation of three measured concentrations is displayed as R
     R = 100*(max(S1,S2,S3) - min(S1,S2,S3))/S_{ave}, %.
   - If S_c is less than the parameter "Low limit" (20 ng/M^3), "< 20" is displayed.
4. Record the three Si readings, S_c and R for the background sample in a field notebook and any analysis record developed for the current sampling event.
5. If the background reading does not fall below 20 ng/M^3, remove the intake hose and repeat the procedure to determine whether the intake hose is contaminated.
6. To quit the On Stream mode, press the ***ESC*** button, which causes the air pump to switch off. The device switches over to the standby mode waiting for the next command. The message MAIN MENU appears on the Palm display.

5.4 Calibration verification:

- The instrument calibration must be verified on each analysis day prior to analyzing samples, and again at the end of the day.
- The calibration is considered verified if the relative deviation (designated with R on the instrument) is below 20%.
- Calibration verification is measured in the TEST mode as described below:

Operation in the TEST mode (serviceability check)

1. Use arrow buttons, on the indication unit to select the (TEST) mode and press the ***Ent*** button. After the instrument measures the zero signal the display will show the message *Enter Test Cell*.
2. Set the test cell handle on the side of the instrument to the ON position, and wait for 20 seconds before pressing the ***Ent*** button. The following will be displayed:

- The current S value which represents the measured mercury concentration in the test cell in ng/M^3;
- the Sk value, which represents the mercury concentration which should be measured based on the test cell temperature; (see table on page 21 of the RA-915+ Operation Manual for reference)
- the average measured mercury concentration (Si);
- the relative deviation (R) of the measured value average (Si) from the theoretical value is automatically calculated by: R= 100*|(Si- Sk)/Sk|; and
- a countdown (in seconds) of the time over which Si values were averaged. The current setting is for values to be averaged over 10 seconds.
- The message "*Temperature*" is displayed across the top, if the temperature of the test cell is beyond the admissible temperature range for proper operation of the analyzer.

3. Record the Si, Sk, and R values associated with the calibration check in a field notebook and any analysis record developed for the current sampling event.
4. If the relative deviation (R) of the measured values Si from its table value is below 20%, the RA-915+ analyzer is ready for operating, otherwise see "Maintenance" in the Operation Manual.
5. To quit the TEST mode, press the ESC button whereupon the analyzer switches over to the standby mode for the removal of the test cell. The display will show the message Remove Test Cell. Remove test cells and press the ESC button again and the analyzer switches over to the standby mode waiting for the next command. The message appearing on the display reads MAIN MENU.

5.5 Analysis:

- Allow the Lumex RA-915 to equilibrate to site temperature.
- Sample locations should be selected according to a site plan designed for the specific site. It is important to note that environments with high levels of mercury are not suitable for the Lumex RA-915. Several precautions should be taken at possibly contaminated sites:
  1. Use a Jerome meter to delineate areas possibly contaminated above 0.05 mg/M^3.
  2. If a Jerome meter is not available, start the investigation outside the possibly contaminated areas and work toward the contaminated areas stopping when the mercury readings exceed the calibration range of the instrument (0.05 mg/M^3).
  3. Do not place the instrument on any potentially contaminated area, including floors or surfaces where mercury has been spilled.
  4. Do not place the inlet sample tube on any potentially contaminated surface.
- Air temperature should also be measured and recorded concurrently with the mercury sample results. A digital thermometer is included in the travel case with the mercury analyzer for this use.
- For this analysis the Lumex RA-915 should be operated in the ON STREAM mode as described in section 4.3, making sure to record the three Si values, Sc, and R in a field notebook and any analysis record developed for the current sampling event.
- Check a (low) background sample and calibration verification at the end of the sampling day.
- To turn the instrument off press the Esc key to go to the main menu. Then turn the power toggle switch off. If the instrument was operated on battery power, the battery

must be recharged prior to storing the instrument. Storing the instrument with an uncharged battery may cause damage to the battery.

5.6 Instrument Maintenance and Storage:

- The instrument should be stored in a low mercury (<20 ng/M^3) atmosphere at temperatures between 40°F and 100°F with relative humidity less than 80%. If it is inadvertently stored below 32°F, it should be taken to and kept at a temperature of 60°F or higher for up to 24 hours (temperature dependent) prior to use.
- When the analyzer is used with battery power, the battery must be recharged before returning the instrument to storage. Storage of a discharged battery for 3 days may permanently damage the battery.
- Maintenance procedures for the analyzer include:
  1. daily (when in use) visual inspection;
  2. periodic preventive maintenance;
- All the maintenance operations should be duly recorded in the analyzer log.
- Daily (when in use) inspection is performed in the work place and involves visual inspection of the analyzer and serviceability check. The serviceability check consists of a background air check for contamination and a calibration verification check.
- Periodic prevention maintenance is performed in the work place and involves:
  1. Quarterly:
     - checking the fastening of the body covers;
     - checking the connectors for cleanness;
     - checking the state of the cables;
  2. Checking the dust filter: A small dust filter is located inside the intake hose attachment port. This filter should be checked on a quarterly basis (sooner if used in high dust areas) and replaced if the dust filter has turned color from white to brown & appears to be clogged. To remove the filter for inspection/ replacement, use a pair of tweezers.
  3. The built-in absorption filter (located in the left-hand inlet on the front wall of the base unit) should be replaced as needed. Typically this will be once or twice per year. If the instrument is used often, or in a mercury environment above 10,000ng/M^3 for a period of time the filter should be replaced more often.
- Annual preventive maintenance is recommended. It is performed by OhioLumex and involves recalibration and checking the RA-915+ for conformity to the technical specifications.
- For further information refer to the Operation Manual and Lumex RA-915+ Mercury Analyzer Maintenance Schedule and Procedure OL-110.

5.7 Documentation

All sampling activities must be documented according to a site-specific plan, either in a field notebook or on pre-printed sampling worksheets. At a minimum the following items must be documented:

- Project name
- Date and time of sample
- Background air results
- Calibration verification results

- Sample location
- Name of person(s) performing air sampling/ analysis
- Temperature
- Mercury result
- Any special considerations or sampling conditions

5.8 Quality Assurance/Quality Control

5.8.1 QA Sample Collection: Collection and analysis of the following QA samples is mandatory:

- Background sample: A background air sample should be taken outside of the site and in a location where there is no (low) mercury contamination. Results must be below 20 ng/ M^3. This sample is taken to ensure that the instrument is free of contamination. At a minimum, background samples should be taken at the beginning an end of each sampling day. If the instrument is taken into an environment where mercury vapor concentrations exceed the calibration range of the instrument (50,000 ng/ M^3) a background sample must be re-analyzed before continuing with the sampling event.
- Calibration verification: The instrument calibration must be verified at the beginning and end of each sampling day. The calibration is considered verified if the relative deviation (designated with R on the instrument) is below 20%. The instrument must be returned to the factory for calibration yearly, and when calibration falls outside the designated range.
- Duplicate samples: Each time a sample is analyzed the instrument automatically takes three 10 second average readings (Si) and averages the three readings to arrive at a result (Sc). A relative deviation (displayed as R) is also calculated by the instrument by the following formula:

  $R = 100*(\max(S1,S2,S3) - \min(S1,S2,S3))/S_{ave}$
  $S_{ave} = (\max(S1,S2,S3) + \min(S1,S2,S3))/2$

5.8.2 Deviations from SOPs: All deviations from the procedures outlined in this or in any other SOP must be documented in field notes.

6.0 REFERENCES:

1. **Multifunctional Mercury Analyzer RA-915+ Operation Manual**, OhioLumex Co, Inc. Analytical Equipment, Cleveland, Ohio, 2001.
2. **Quality Assurance Plan** for Maine Department of Environmental Protection's Division of Site Remediation, Revision 2, April 30, 1999
3. **Standard Operating Procedure Development, Format, Approval and Distribution,** Maine Department of Environmental Protection SOP OC-PR-0001, 6/15/01.

Lap-top Computer Connection for Continuous Mercury Vapor Concentrations Monitoring

Follow manufacturer directions below to use the Lumex in continuous monitoring mode. This will generate a data file that can be evaluated in Lumex computer software and can be imported into an Excel file.

RA 915+ Mercury Analyzer Monitoring Software

1. Turn POWER on RA 915 to ON. Connect to computer.
2. Turn LAMP to ON, warm up the instrument for 20 minutes.
3. Click on RA 915 icon on the computer and click on AIR in main menu. **Click on MONITORING icon in the PROGRAM bar** (The MONITORING window will appear. Minimize screen).
4. On the bar GRAPH click on PARAMETERS.
5. Click on COMMON tab and type name (name of the site) in FILE NAME field. Should you forget to name file the default untitled.dat will be set for you by the software. You may rename it later.
6. Axis X is a timeframe for auto zero in seconds. Set it four times shorter as your total monitoring time (set in minutes), (i.e. for 10 minutes run duration set X for 150 seconds). In this case ZERO will be taken automatically, at the beginning, at the end and in between totaling six auto ZERO measurements. This setting is a must.
7. If you are planning to visually monitor measurement line on the screen set Axis Y per the concentration range you expect to find. The preliminary data will be known to you by direct measurement with the Lumex. This setting will not affect the print out graph at the end (Print out graph will be auto scaled).

8. Set INTERVAL in GRAPH to the resolution you need. This is frequency of sample data logging. Maximum interval is 5 seconds, minimum is 1 second. One second is recommended for maximum accuracy
9. Click on Tab LIQUID. In window BASELINE set T zero aver. = 30 sec.
10. Ref. Points =1, and disregard all other settings in this Tab window.
11 Click on Tab Monitor. In window Measure, set DURATION to the time in minutes for how long you would like to monitor this particular site.
12. Set DELAY to 20 seconds (must not exceed T zero aver.). This is time after auto ZERO measurements are taken needed to fill measurement cell. Analytical signal line will change color from red (baseline color) to dark red (Hg concentration color).
13. Click on SAVE (floppy disc in the middle) and APPLY (checkmark). Restore MONITORING window on the screen and type the description of your test site, etc.
In Window GRAPH click on RUN and MONITORING window becomes active with File name in the File name box, pump will start automatically

and a 30 second Zero test will be performed. You could do Zero baseline test any time manually during the run by clicking on BLANK in MONITORING window (however, the instrument will do this automatically as set in 6.).
You may terminate the run manually by clicking on TERMINATION button.
When run is completed or terminated, instrument will perform the last ZERO check and will report the AVEREGED concentration throughout the run. ZERO points measured during the run will not affect averaging the concentration result. After that the instrument will shut off the pump and will remain on stand by with LAMP ON.

If your printer is connected (recommended) you may print this as an original file by clicking on PRINT at FILE bar.
To acquire new data click on NEW in GRAPH bar and change FILE NAME in PARAMETER, SAVE and APPLY.
You may save this file to floppy disc or open the file in Excel by starting the Excel program and look for the file in Program Files, Lumex, RA915, All files, open.