Source Test Procedure **ST-10**

**MERCURY**

Adopted (January 20, 1982)

**REF: Regulation 11-5-301**

1. **APPLICABILITY**

   1.1 This method is used to quantify emissions of gaseous and particulate mercury. It determines compliance with Regulation 11-5-301.

2. **PRINCIPLE**

   2.1 The sample stream is drawn through a solution of iodine monochloride which collects the mercury in the gas stream. The mercury compounds in the iodine monochloride (ICl) are reduced to elemental mercury and analyzed according to Analytical Procedure Lab 6. If high concentrations of particulate are expected, use particulate filters as prescribed in ST-15.

3. **RANGE**

   3.1 The minimum measurable emission of mercury is \(2 \times 10^{-5}\) grains/SDCF.

   3.2 Elevated concentrations of mercury may be determined by increasing the concentration of iodine monochloride in the absorbing reagent. The concentration of reagent to be used may be determined by stoichiometry, allowing a 50% excess.

4. **INTERFERENCES**

   None Known.

5. **APPARATUS**

   5.1 Probe Nozzle. The probe nozzle shall be equivalent to the nozzle shown in Figure 10-1. The probe nozzle shall be constructed of borosilicate glass, quartz, or stainless steel.

   5.2 Filter Holder. Use filter tubes equivalent to the one shown in Figure 10-1 and constructed of borosilicate glass or quartz.

   5.3 Filter Tube Holder. Use a filter tube holder which will contain three filter tubes and the probe nozzle in a leak-free manner. Figure 10-2 shows an acceptable filter tube holder configuration.

   5.4 Filter Medium. Use borosilicate glass wool, or equivalent. Corning Glass Works, Catalogue #3950 is acceptable.

   5.5 Connections. The connection between the filters and the first impinger must be able to withstand stack temperatures. Vinyl tubing is acceptable in making all other connections.
5.6 Pitot Tube. Use a Stauscheibe (Type-S), or equivalent, with a known coefficient which is constant within ± 5% over the entire working range. The pitot type coefficient is determined by placing both the S-type and the standard pitot tube in a gas stream and measuring the pressure head with both over the entire Type-S pitot tube as follows:

$$C_{ps} = C_{pstd} \left[ \frac{\Delta P_{std}}{\Delta P_s} \right]^2$$

where:

- $C_{ps}$ = Type-S pitot tube coefficient
- $\Delta P_s$ = Pressure head, Type-S pitot tube
- $\Delta P_{std}$ = Pressure head, standard pitot tube
- $C_{pstd}$ = Standard pitot tube coefficient

5.7 Temperature Measuring Device. Use a Chromel-Alumel thermocouple accurate to ± 15°F, connected to a temperature compensated null type potentiometer, or equivalent, to measure stack temperatures.

5.8 Encasement Tube. Assemble the items in 5.3, 5.6 and 5.7 in a pipe as shown in Figure 10-2 to facilitate handling. To prevent the pitot tube from interfering with the gas flow or stream-lines approaching the sample nozzle, position the pitot tube and sample nozzle not closer together than 0.75 inches.

5.9 Absorber. Use four Greenberg-Smith impingers. The fourth impinger shall be modified by removing the impaction plate and attaching a thermometer to the inlet stem.

5.10 Cooling System. Use an ice bath to contain the impingers.

5.11 Sample Pump. Use a leak-free vacuum pump capable of maintaining a 1.0 CFM flow rate at 15 inches of mercury. The pump must have a sample rate control valve and a vacuum gauge attached to the inlet.
5.12 Silica Gel Tube. Use approximately 500cc of silica gel, followed by a Drierite indicator, to insure that the gas entering the dry test meter is free of H₂O.

5.13 Dry Test Meter. Use a 175 CFH dry test meter accurate within ± 2% of the true volume and equipped with a thermometer to measure the outlet temperature. The working pressure across the meter shall not exceed one inch water column.

5.14 Rotameter. Use a calibrated rotameter to measure the sampling rate.

5.15 Pressure Gauge. Use a Magnehelic differential pressure gauge, or equivalent, in the same range as the velocity and static pressures being measured in the stack.

5.16 Analytical Balance. An analytical balance capable of measuring condensate weights to the nearest 0.1 gram is acceptable.

5.17 Barometer. Use a barometer that is accurate to within ± 0.2 inches of mercury.

Figure 10-2

Filter Tube Assembly

6. REAGENTS

6.1 0.1M Iodine Monochloride. Refer to Analytical Procedure Lab 6.
7. PRE-TEST PROCEDURES

7.1 Impinger Preparation. 100 ml of the 0.1 M ICl shall be placed in the first three impingers which shall then be weighed. Record the data on the data sheet shown in Form 10-1.

7.2 Nozzle Size Determination. Do the preliminary test outlined below to determine the correct nozzle size to aid in isokinetic sampling.

7.2.1 Determine the number and location of the stack traverse points in accordance with ST-18.

7.2.2 Conduct a velocity traverse in accordance with ST-17 and measure the stack gas temperature.

7.2.3 Determine the moisture content of the stack gases in accordance with ST-23.

7.2.4 Nozzle Diameter:

\[ D_n = 13.7 \left( \frac{T_s}{V_s(100 - \%H_2O)} \right)^{\frac{1}{2}} \]

Where:

- \( D_n \) = Nozzle Diameter, mm
- \( T_s \) = Stack Gas Temperature, °R
- \( H_2O \) = Stack Gas Moisture Concentration, %
- 13.7 = A constant based on an assumed meter rate of 0.5 CFM, meter temperature of 70°F, and a molecular weight of 28.8
- \( V_s \) = Stack Gas Velocity fps as calculated in Section 8.2 of ST-17

7.3 Assemble the sampling train as shown in Figure 10-3.

7.4 The entire sampling train must be leak-checked before each test run. Plug the sampling probe, start the pump, and adjust the pump vacuum to 380 mm Hg (15” Hg). A leak rate through the meter which exceeds 0.57 1pm (0.02 CFM) is unacceptable.

8. SAMPLING

8.1 Each test run shall be of 50 minute duration when testing emissions from continuous operations. Each test run at batch process operations shall be for 90% of the batch time or 50 minutes, whichever is less.

8.2 Sample at the traverse points determined in accordance with ST-18.

8.3 The sampling rate at each traverse point must be isokinetic. Measure the stack velocity and stack temperature at each sample point and adjust the meter flow rate according to the following equation:

\[ Q_m = \frac{2.638 \times 10^{-3} (100 - \%H_2O) D_n^2 V_s}{T_s} \]

Where:
8.4 When inserting the probe into the stack rotate the nozzle so it points downstream to avoid particulate collection prior to sampling. Immediately before sampling rotate the probe so that the nozzle points upstream.

**Figure 10-3**

**Mercury Sampling Train**

8.5 Record the following information at five-minute intervals or whenever changing sampling locations on a field data form as shown in Form 10-2.

- Stack Velocity Head
- Sample Time
- Sample Rate
- Cumulative Sample volume
- Impinger Saturation Temperature
- Stack Gas Temperature
- Impinger Vacuum
- Dry Test Meter Temperature
8.6 Add ice as necessary to maintain impinger temperature at 7 °C (45°F) or less.

8.7 At the conclusion of each run, stop the pump, remove the probe from the stack, record the final meter reading. Point the probe upward and purge the sample train with ambient air.

8.8 Take three consecutive samples.

9. POST-TEST PROCEDURES
9.1 Stopper the impingers to minimize sample losses.
9.2 Weigh each impinger to the nearest 0.1 g.

10. AUXILIARY TESTS
10.1 Determine the CO₂, O₂, and CO concentrations simultaneously with each particulate run in accordance with ST-5, ST-14, and ST-6. An Orsat analysis (ST-24) is also acceptable.

11. CALCULATIONS
11.1 Standard Dry Sample Volume

\[ V_o = \frac{17.71 V_m P_b}{T_m} \]

where:

\( V_o \) = Standard dry sample volume, SDCF @ 70 °F and 29.92 inches Hg.

\( V_m \) = Actual Metered Volume, ft³

\( P_b \) = Barometric Pressure, inches Hg.

\( T_m \) = Average Meter Temperature, °R

17.71 = Constant correcting to 70 °F and 29.92 inches Hg.

11.2 Water Vapor Content

\[ H_2O = \frac{(0.0474 W_C) + \frac{V_o P_{sat}}{P_b - P_i - P_{sat}}}{V_o + (0.0474 W_C) + \frac{V_o P_{sat}}{P_b - P_i - P_{sat}} \times 100} \]

Where:

\( W_C \) = Total condensate weight, all impingers, grams

\( P_{sat} \) = Water saturation pressure, inches Hg

\( P_b \) = Barometric pressure, inches Hg

\( P_i \) = Pump inlet vacuum, inches Hg

\( H_2O \) = Percent water vapor

0.0474 = Cubic feet of vapor resulting from 1 cubic centimeter of liquid H₂O.
11.3 Stack Gas Molecular Weight

\[ MW = 0.44 \times (\%CO_2) + 0.32 \times (\%O_2) + 0.28 \times (\%N_2 + \%CO) + 0.18 \times (\%H_2O) \]

Where:
- \( MW \) = Molecular Weight
- \( \%CO_2 \) = Percent Carbon Dioxide by volume (dry basis)
- \( \%O_2 \) = Percent Oxygen by volume (dry basis)
- \( \%CO \) = Percent Carbon Monoxide by volume (dry basis)
- \( \%H_2O \) = Percent Moisture by volume
- \( \%N_2 \) = Percent Nitrogen by volume (dry basis - determine by difference)

11.4 Stack Gas Flow Rate - Determine in accordance with ST-17.

11.5 Total mercury emissions. The emission rate of mercury shall be calculated as:

\[ M = \frac{W \times 10^6 \times Q_o \times 60 \times T}{V_o} \]

Where:
- \( M \) = Mass emission rate, g/day
- \( W \) = Total weight of Mercury collected, µg (micrograms)
- \( Q_o \) = Stack gas flowrate, SDCFM
- \( V_o \) = Sample Volume, SDCF
- \( T \) = Plant operation, hr/day
- 60 = minutes/hour

11.6 Isokinetic Ratio. Calculate for each traverse point as:

\[ R_i = \frac{T_{si} \times Q_{mi}}{60(100 - H_2O) \times A \times V_{si} \times T_{mi}} \times 100\% \]

Where:
- \( R_i \) = Isokinetic ratio at given point, i
- \( t_i \) = Time, at point i, minutes
- \( A \) = Nozzle area, ft\(^2\)
- \( V_{si} \) = Stack velocity, point i, FPS
- \( T_{mi} \) = Meter temperature, point i, °R
- \( T_{si} \) = Stack temperature, point i, °R
- \( Q_{mi} \) = Metered volume, point i
- 60 = Minutes/hr.

Overall isokinetic ratio for each run:

\[ R = \frac{Q_{mi}}{60(100 - H_2O) \times A \times V_{si} \times t_i \times T_{si}} \times 100\% \]
12. REPORTING

12.1 The data and information indicated in Form 10-3 shall be reported.
# Impinger Weightings

<table>
<thead>
<tr>
<th>Impinger I. D. #</th>
<th>(A) Tare Weight (g)</th>
<th>(B) Filled Weight (g)</th>
<th>(C) Final Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impinger I. D. #</th>
<th>(C-A) Sample Weight (g)</th>
<th>(C-B) Condensate Wt. (g)</th>
<th>Condensate Weight / Run (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Run A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Run B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Run C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Run D</td>
</tr>
</tbody>
</table>
### Bay Area Air Quality Management District
939 Ellis Street, San Francisco, CA 94109

**Form 10-2**
Source Test Data Sheet

<table>
<thead>
<tr>
<th>Nozzle Diameter</th>
<th>Pitot Tube I.D., Cp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas System</td>
<td>Pbar, Barometer</td>
</tr>
<tr>
<td>Leak Test Rate</td>
<td>Time @ Point</td>
</tr>
<tr>
<td># of Points</td>
<td>Time/Run (Min.)</td>
</tr>
</tbody>
</table>

**Sampling Train:**
- Probe #
- Filter #
- Imp. #
- Imp. #
- Pump/Box #

<table>
<thead>
<tr>
<th>Initial Traverse Data</th>
<th>Sampling Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trav. Point I.D.</td>
<td>Source Test Team</td>
</tr>
<tr>
<td>Dist. from Wall</td>
<td></td>
</tr>
<tr>
<td>Duct Temp. °F</td>
<td></td>
</tr>
<tr>
<td>ΔP °H₂O</td>
<td></td>
</tr>
<tr>
<td>Angle of Flow</td>
<td></td>
</tr>
<tr>
<td>Traverse Point I.D.</td>
<td></td>
</tr>
<tr>
<td>ΔP °H₂O</td>
<td></td>
</tr>
<tr>
<td>Duct Temp. °F</td>
<td></td>
</tr>
<tr>
<td>Vs FPS</td>
<td></td>
</tr>
<tr>
<td>Time (minutes)</td>
<td></td>
</tr>
<tr>
<td>Meter Rate CFH</td>
<td></td>
</tr>
<tr>
<td>Meter Temp. °F</td>
<td></td>
</tr>
<tr>
<td>Meter Volume Ft³</td>
<td></td>
</tr>
<tr>
<td>Train Vacuum °Hg</td>
<td></td>
</tr>
<tr>
<td>Sat’d Gas Temp. °F</td>
<td></td>
</tr>
</tbody>
</table>

Post Run Impinger Catch (ml) =
Assumed O₂ =
Assumed CO₂ =
Post Run Calculated %H₂O =

ST-10-10
Summary of Source Test Results

**Source Information**

<table>
<thead>
<tr>
<th>Firm Name and Address</th>
<th>Firm Representative and Title</th>
<th>Source Test Engineers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Permit Conditions:</th>
<th>Source:</th>
<th>Permit Services Division/Enforcement Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant No.</td>
<td>Permit No.</td>
<td>Test Requested By:</td>
</tr>
<tr>
<td>Operates</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Operating Parameters:**

**Applicable Regulations:**

**Source Test Results and Comments:**

<table>
<thead>
<tr>
<th>METHOD</th>
<th>TEST</th>
<th>RUN A</th>
<th>RUN B</th>
<th>RUN C</th>
<th>AVERAGE</th>
<th>LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST-17</td>
<td>Stack Volume Flowrate, SDCFM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stack Gas Temperature, °F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST-23</td>
<td>Water Content, Volume %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST-14</td>
<td>Oxygen, Volume %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST-5</td>
<td>Carbon Dioxide, Volume %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST-6</td>
<td>Carbon Monoxide, ppmv</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carbon Monoxide, lb/hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST-10</td>
<td>Mercury Emissions, g/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Isokinetic Ratio, act./theo.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Air Quality Engineer II | Date | Supervising Air Quality Engineer | Date | Approved by Air Quality Engineering Manager

ST-10-11