

## Source Test Method **ST-35**

### **TOTAL AND HEXAVALENT CHROME**

(Adopted January 18, 1989)

**REF: Regulations 11-8-301, 310, 330**

#### **1. APPLICABILITY**

- 1.1 This method is used to quantify total and hexavalent chromium emissions. It is applicable to the determination of compliance with Regulation 11-8-301, 310, and 330.

#### **2. PRINCIPLE**

- 2.1 Sample Collection. Chromium emissions are sampled isokinetically from the emission point and collected on Teflon coated disc filters. The materials collected on the filters are then analyzed for total and hexavalent chromium according to Analytical Procedure, Lab-34. If the source is known to emit only hexavalent chromium then only an analysis for total chromium is necessary.

#### **3. RANGE**

- 3.1 Detection Limit. The minimum measurable concentrations of total chromium and hexavalent chromium, by this method, are 8.8 and 7.0 micrograms per cubic meter, respectively.

#### **4. INTERFERENCES**

- 4.1 There are no known interferences for those sources covered by Regulation 11, Rule 8. However, the samples must be extracted, stabilized and analyzed within the time frames specified in Analytical Procedure, Lab-34.

#### **5. APPARATUS**

- 5.1 Probe Nozzle. The probe nozzle shall be constructed of borosilicate glass, or quartz with a sharp, tapered leading edge. The angle of the taper shall be 30 degrees and the taper shall be on the outside to preserve a constant internal diameter. The probe nozzle shall be of the button-hook or elbow design. Nozzle diameters shall be sized to allow for isokinetic sampling.
- 5.2 Filter Medium. Use Pallflex Type T60A20 Teflon disc filter or equivalent.
- 5.3 Connections. The connection between the filter and the first impinger must be able to withstand stack temperatures. All connections leading up to the filter should be constructed of Teflon and/or borosilicate glass and/or quartz. 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  $\pm 5\%$  over the entire working range. The

pitot tube coefficient is determined by placing both the Type-S and the standard pitot tube in a gas stream and measuring the pressure head with both over the entire velocity range of interest. Calculate the coefficient of the Type-S pitot tube as given by Equation 35-1.

$$C p_s = C p_{std} \left[ \frac{\Delta P_{std}}{\Delta P_s} \right]^{\frac{1}{2}} \quad \text{[Equation 35-1]}$$

where:

$C p_s$  = Type-S pitot tube coefficient, (dimensionless)

$C p_{std}$  = Standard pitot tube coefficient, (dimensionless)

$\Delta P_s$  = Pressure head, Type-S pitot tube, (inches H<sub>2</sub>O)

$\Delta P_{std}$  = Pressure head, standard pitot tube, (inches H<sub>2</sub>O)

- 5.5 Temperature Measuring Device. Use a Chromel-Alumel thermocouple accurate to  $\pm 15^{\circ}\text{F}$ , connected to a temperature compensated null type potentiometer, or equivalent, to measure stack temperatures.
- 5.6 Condensers. Use three Greenberg-Smith impingers. The third impinger shall be modified by removing the impaction plate and attaching a thermometer to the inlet stem.
- 5.7 Cooling System. Use an ice bath to contain the impingers.
- 5.8 Sample Pump. Use a leak-free vacuum pump capable of maintaining a 28.7 lpm (1.0 CFM) flow rate at 380 mm Hg (15 inches of mercury). The pump must have a sample rate control valve and a vacuum gauge attached to the inlet.
- 5.9 Silica Gel Tube. Use approximately 500 cc of silica gel followed by a Drierite indicator, to insure that the gas entering the dry test meter is free of water.
- 5.10 Dry Test Meter. Use a 175 CFH dry test meter accurate within  $\pm 2\%$  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 of water column.
- 5.11 Rotameter. Use a calibrated rotameter to measure the sampling rate.
- 5.12 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.
- 5.13 Analytical Balance. An analytical balance capable of measuring condensate weights to the nearest 0.1 gram is acceptable.
- 5.14 Barometer. Use a barometer that is accurate to within  $\pm 0.2$  inches of mercury.

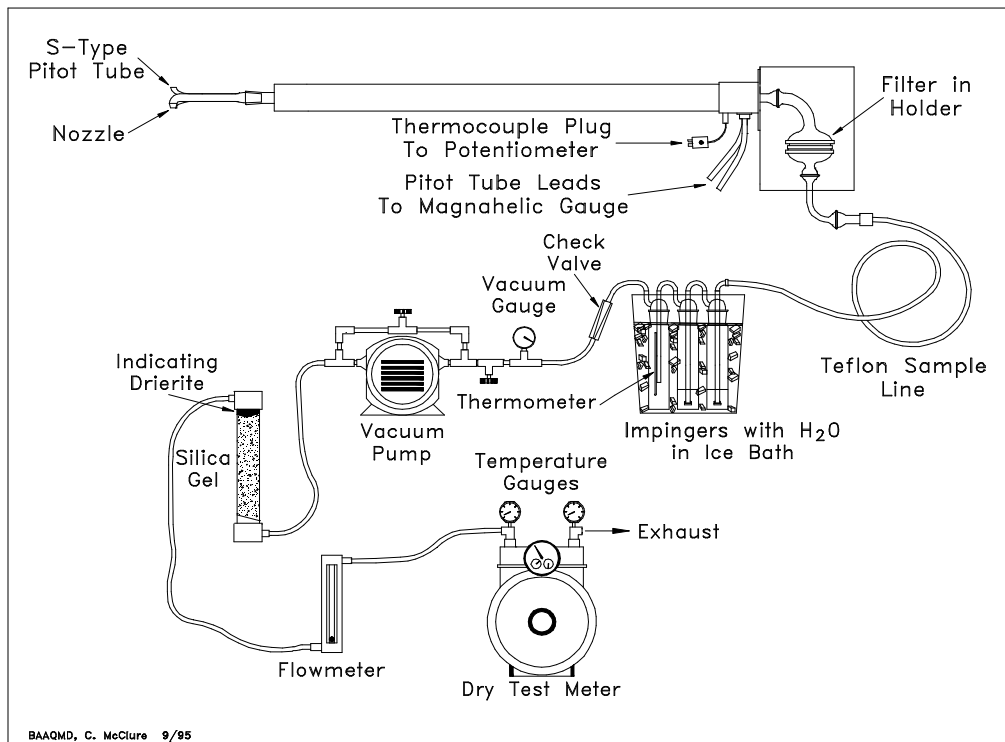
- 5.15 Filter Heating System. Use a heating system capable of maintaining a constant temperature around the filter holder, during sampling, of  $120 \pm 14$  °C ( $248 \pm 25$  °F). A temperature gauge accurate to within 3 °C (5.4 °F) shall be installed such that the temperature around the filter holder can be monitored during sampling.

## 6. PRE-TEST PROCEDURES

- 6.1 Impinger Preparation. Fill the first two Greenberg-Smith impingers with approximately 100 ml of distilled water. Weigh and record the weights on the data sheet as shown in Form 35-1.
- 6.3 Nozzle Size Determination. The nozzle size is determined by the same method described in Section 6.3 of ST-15.
- 6.3 Assembly. Assemble the sampling train as illustrated in Figure 35-1.
- 6.4 Leak Check. 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 inches Hg). A leak rate through the meter which exceeds 0.57 lpm (0.02 CFM) is unacceptable.

Figure 35-1

### Chromium Sampling Train



## 7. SAMPLING

- 7.1 Test Length. Each test run shall be a minimum of 50 minutes 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.

- 7.2 Start-up. When inserting the probe into the stack, rotate the nozzle so that it points down stream to avoid particulate collection prior to sampling. Immediately before sampling, rotate the probe so that the nozzle points upstream.
- 7.3 Sample Location. Sample at the traverse points determined in accordance with ST-18.
- 7.4 Data Record. Record the following information at 5 minute intervals or whenever changing sampling locations on a field data sheet as shown in Form 35-2.

Stack Velocity Head  
Sample time  
Isokinetic Sample Rate  
Cumulative Sample Volume  
Impinger Saturation Temperature  
Stack Gas Temperature  
Impinger Vacuum  
Dry Test Meter Temperature

- 7.6 Saturation Impinger. Add ice as necessary to maintain impinger temperatures at 7°C (45°F) or less.
- 7.7 Shut Down. At the conclusion of each run, stop the pump, remove the probe from the stack and record the final meter reading.
- 7.8 Sample Recovery. Leak-check the sample train as detailed in Section 6.4 of this method. Wash the sample probe, nozzle, filter cap and all tubing leading up to the filter with a maximum of 25 ml of acetone. Save this probe and nozzle wash in chemically inert storage containers for chromium analysis. Remove the filter from the filter holder and place in a clean Petri dish for subsequent chromium analysis.
- 7.9 Repeatability. Three consecutive test runs shall be performed whenever possible. The sample shall be extracted isokinetically ( $\pm 10\%$ ) if the stack gas velocity exceeds 6 ft/sec.

## 8. POST-TEST PROCEDURES

- 8.1 Analysis. Analyze the filters and any material in the nozzle for chromium according to Analytical Procedure, Lab 34.

## 9. AUXILIARY TESTS

- 9.1 Amp-hour Usage Determinations. If the bath is equipped with a DC ammeter, read and record amperage directly. Otherwise, record power usage into the electroplating rectifier. Record the voltage level supplied to the plating bath. Record the AC to DC efficiency factor through the rectifier.

If no efficiency factor has been determined, then assume a 75% efficiency in power conversion through the rectifier. Calculate the amperage using Equation 35-2.

$$I = \frac{1000 \times e \times P}{E} \quad \text{[Equation 35-2]}$$

Where:

- e = Power conversion efficiency across the rectifier, (dimensionless)
- E = Voltage to plating bath, (volts)
- I = Amperage through plating bath, (Amps)
- P = Power consumption by rectifier, (Kw)

## 10. CALCULATIONS

10.1 Standard Dry Sample Volume. Calculate the standard dry sample volume according to Equation 35-3.

$$V_o = \frac{530 \times V_m \times P_b}{29.92 \times T_m} \quad \text{[Equation 35-3]}$$

where:

- P<sub>b</sub> = Barometric Pressure, (inches Hg)
- T<sub>m</sub> = Average Meter Temperature, (°R)
- V<sub>m</sub> = Actual Metered Volume, ft<sup>3</sup>
- V<sub>o</sub> = Standard dry meter volume (dry ft<sup>3</sup> or SDCF)
- 29.92 = Standard barometric pressure, (inches Hg)
- 530 = Standard temperature, (°R)

10.2 Water Vapor Content. Calculate the water content using Equation 35-4.

$$W_f = \frac{(0.0474 \times W_c) + \frac{V_o P_{sat}}{(P_b - P_i - P_{sat})}}{(0.0474 \times W_c) + V_o + \frac{V_o P_{sat}}{(P_b - P_i - P_{sat})}} \quad \text{[Equation 35-4]}$$

where:

- P<sub>b</sub> = Barometric pressure, inches Hg
- P<sub>i</sub> = Pump inlet vacuum, inches Hg
- P<sub>sat</sub> = Water saturation pressure in the impingers, inches Hg.
- V<sub>o</sub> = Standard dry sample volume, (ft<sup>3</sup>)
- W<sub>c</sub> = Total condensate weight, all impingers, (grams)
- W<sub>f</sub> = Water fraction, (dimensionless)

0.0474 = Cubic feet of vapor resulting from 1 cc of liquid water (ft<sup>3</sup>/gram)

- 10.3 Isokinetic Ratio. Isokinetic ratio for sample collection at each traverse point shall be calculated according to Equation 35-5.

$$R_i = \frac{(T_{si})(V_{mi})}{60 \times (1 - Wf) \times A_n \times V_{si} \times t_i \times T_{mi}} \quad [\text{Equation 35-5}]$$

where:

- $R_i$  = Isokinetic ratio at traverse point i
- $T_{si}$  = Stack temperature at traverse point i, °R
- $V_{mi}$  = Metered volume at traverse point i, ft<sup>3</sup>
- $V_{si}$  = Stack gas velocity at traverse point i, FPS
- $t_i$  = Time at traverse point i, minutes
- $T_{mi}$  = Meter temperature at traverse point i, °R
- $A_n$  = Cross-sectional area of nozzle, Ft<sup>2</sup>
- $Wf$  = Water fraction, (dimensionless)
- 60 = Conversion from seconds to minutes

- 10.4 Hexavalent Chromium concentration. The hexavalent chromium concentration from each test run shall be calculated according to Equation 35-6.

$$C = \frac{35.31 \times W}{1000 \times V_o} \quad [\text{Equation 35-6}]$$

where:

- $C$  = Hexavalent chromium concentration, (mg/m<sup>3</sup>)
- $V_o$  = Standard dry sample volume, (SDCF)
- $W$  = Weight of hexavalent chromium per filter plus probe and nozzle wash, (µg)
- 35.31 = Conversion factor, (ft<sup>3</sup>/m<sup>3</sup>)
- 1000 = Conversion factor, (µg/mg)

- 10.5 Hexavalent Chromium emission rate. The hexavalent chromium emission rate shall be calculated according to Equation 35-7.

$$M = \frac{60 \times (1 \times 10^{-6}) \times W \times Q_{std}}{V_o} \quad [\text{Equation 35-7}]$$

where:

- $M$  = Hexavalent chromium emission rate, (g/hr)

- $Q_{std}$  = Standard dry volumetric flow rate exhausting from the stack, (SDCFM)  
 $V_o$  = Standard dry sample volume, (SDCF)  
 $W$  = Weight of hexavalent chromium per filter plus probe and nozzle wash, ( $\mu\text{g}$ )  
 $60$  = Conversion factor, (min/hr)  
 $1 \times 10^{-6}$  = Conversion factor, (g/ $\mu\text{g}$ )

- 10.6 Hexavalent Chromium plating emission factor. Hexavalent chromium emissions per amp-hour shall be calculated according to Equation 35-8.

$$M_a = \frac{1000 \times M}{I} \quad \text{[Equation 35-8]}$$

where:

- $M_a$  = Hexavalent chromium plating emission factor, (mg/amp-hr)  
 $I$  = Amperage determined in section 9.1 of this source test procedure  
 $M$  = Hexavalent chromium emission rate, (g/hr)  
 $1000$  = Conversion factor, (mg/g)

## 11. REPORTING

- 11.1 The data and information indicated in Form 35-3 shall be reported.

# Bay Area Air Quality Management District

## Form 35-1

### Source Test Laboratory Data Sheet

#### Impinger Weightings

Plant Name: _____	Plant Number: _____
Source Operation: _____	Test Date: _____
Source Test #: _____	Page: 1 of _____
Impinger Solution: _____	Initial: _____

Impinger I. D. #	( A ) Tare Weight (g)	( B ) Filled Weight (g)	( C ) Final Weight (g)

Impinger I. D. #	( C-A ) Sample Weight (g)	( C-B ) Condensate Wt. (g)	Condensate Weight / Run (g)
			Run A
			Run B
			Run C
			Run D



# Bay Area Air Quality Management District

939 Ellis Street, San Francisco, CA 94109

## Form 35-2 Source Test Data Sheet

Plant # \_\_\_\_\_  
 Source I.D. \_\_\_\_\_  
 Sample Type \_\_\_\_\_  
 Process Cycle \_\_\_\_\_  
 Duct Size \_\_\_\_\_  
 Duct Shape \_\_\_\_\_  
 Duct Pressure \_\_\_\_\_  
 Assumed %H<sub>2</sub>O \_\_\_\_\_

Run # \_\_\_\_\_  
 Temp Meter # \_\_\_\_\_  
 Mag. Gauge # \_\_\_\_\_

Date: \_\_\_\_\_  
 Box ΔH@ \_\_\_\_\_  
 Meter (Y) \_\_\_\_\_

Nozzle Diameter \_\_\_\_\_  
 Pitot Tube I.D., Cp \_\_\_\_\_  
 Gas System \_\_\_\_\_  
 Pbar, Barometer \_\_\_\_\_  
 Leak Test Rate \_\_\_\_\_  
 Time @ Point \_\_\_\_\_  
 # of Points \_\_\_\_\_  
 Time/Run (Min.) \_\_\_\_\_

Sampling Train: Probe # \_\_\_\_\_ Filter # \_\_\_\_\_ Imp. # \_\_\_\_\_ Imp. # \_\_\_\_\_ Pump/Box # \_\_\_\_\_

Initial Traverse Data					Sampling Data									
Trav. Point I.D.	Dist. from Wall	Duct Temp. °F	ΔP "H <sub>2</sub> O	Angle of Flow	Traverse Point I.D.	ΔP "H <sub>2</sub> O	Duct Temp. °F	Vs FPS	Time (minutes)	Meter Rate CFH	Meter Temp. °F	Meter Volume Ft <sup>3</sup>	Train Vacuum "Hg	Sat'd Gas Temp. °F

Post Run Impinger Catch (ml) = \_\_\_\_\_  
 Assumed O<sub>2</sub> = \_\_\_\_\_  
 Assumed CO<sub>2</sub> = \_\_\_\_\_  
 Post Run Calculated %H<sub>2</sub>O = \_\_\_\_\_

Source Test Team

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Comments: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Form 35-3**

<b>Distribution:</b>  Firm Permit Services Enforcement Services Technical Services Planning Requester DAPCO	<b>BAY AREA                  AIR QUALITY MANAGEMENT DISTRICT</b>  <i>939 Ellis Street                  San Francisco, California 94109                  (415) 771-6000</i>  <b>Summary of                  Source Test Results</b>	Report No.: _____ Test Date: _____ <b>Test Times:</b> Run A: _____ Run B: _____ Run C: _____
<b>Source Information</b>		<b>BAAQMD Representatives</b>
Firm Name and Address	Firm Representative and Title  Phone No. (      )	Source Test Engineers
Permit Conditions:	Source:	Permit Services Division/Enforcement Division
	Plant No.                      Permit No. Operates	Test Requested By:
Operating Parameters:		
<b>Applicable Regulations:</b>		<b>VN Recommended:</b>

**Source Test Results and Comments:**

<u>METHOD</u>	<u>TEST</u>	<u>RUN A</u>	<u>RUN B</u>	<u>RUN C</u>	<u>AVERAGE</u>	<u>LIMIT</u>
ST-17	Stack Volume Flowrate, SDCFM					
	Stack Gas Temperature, °F					
ST-23	Water Content, Volume %					
ST-35	Total DC Amps					
	Hexavalent Chromium, mg/amp-hr					
	Hexavalent Chromium, g/hr					
	Hexavalent Chromium, mg/m <sup>3</sup>					
	Isokinetic Ratio, (act/theo)					

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