Source Test Procedure **ST-9**

LEAD

Adopted (January 20, 1982)

REF: Regulation, 11-1-301

1. APPLICABILITY

1.1 This procedure is used to quantify emissions of Lead. It determines compliance with Regulation 11-1-301.

2. PRINCIPLE

2.1 The stack gases are withdrawn isokinetically and passed through a glass fiber filter and impingers containing iodine monochloride (ICl). The filter and impinger catches are then measured for lead content according to Analytical Procedure Lab 4b.

3. RANGE

3.1 The minimum measurable emission of particulate lead is 7 x 10^{-5} grain/SDCF and gaseous lead is 2 x 10^{-5} gr/SDCF.

4. INTERFERENCES.

None Known.

5. APPARATUS

5.1 Probe Nozzle. The sampling train and its components are shown in Figure 9-1. The probe nozzle shall be constructed of borosilicate glass, quartz, or stainless steel.

5.2 Filter Medium. Use a Gelman, Type "A" glass fiber disc type filter or equivalent.

5.3 Connection. The connection between the filter and the first impinger must be able to withstand stack temperatures.

5.4 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 tube 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 velocity range of interest. Calculate the coefficient of the Type-S pitot tube as follows:

$$Cp_s = Cp_{std}\left[\frac{\Delta P_{std}}{\Delta P_s}\right]^{\frac{1}{2}}$$

where: Cp_s = Type-S pitot tube coefficient

ΔP_s = Pressure head, Type-S pitot tube

ΔP_{std} = Pressure head, standard pitot tube

Cp_{std} = Standard pitot tube coefficient

5.5 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.

5.6 Absorbers. 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 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.

5.9 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 H_2O.

5.10 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 a one inch 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 ± 0.2 inches of mercury.

6. REAGENTS

6.1 0.1 m Iodine Monochloride - Refer to Analytical Procedure Lab-6.

7. PRE-TEST PROCEDURES

7.1 Impinger Preparation. Fill each of two unmodified Greenberg-Smith impingers with approximately 100 ml of iodine monochloride. Weigh and record the weights on the data as shown in Form 9-1.

7.2 Nozzle Size Determination. Do the preliminary tests 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.

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

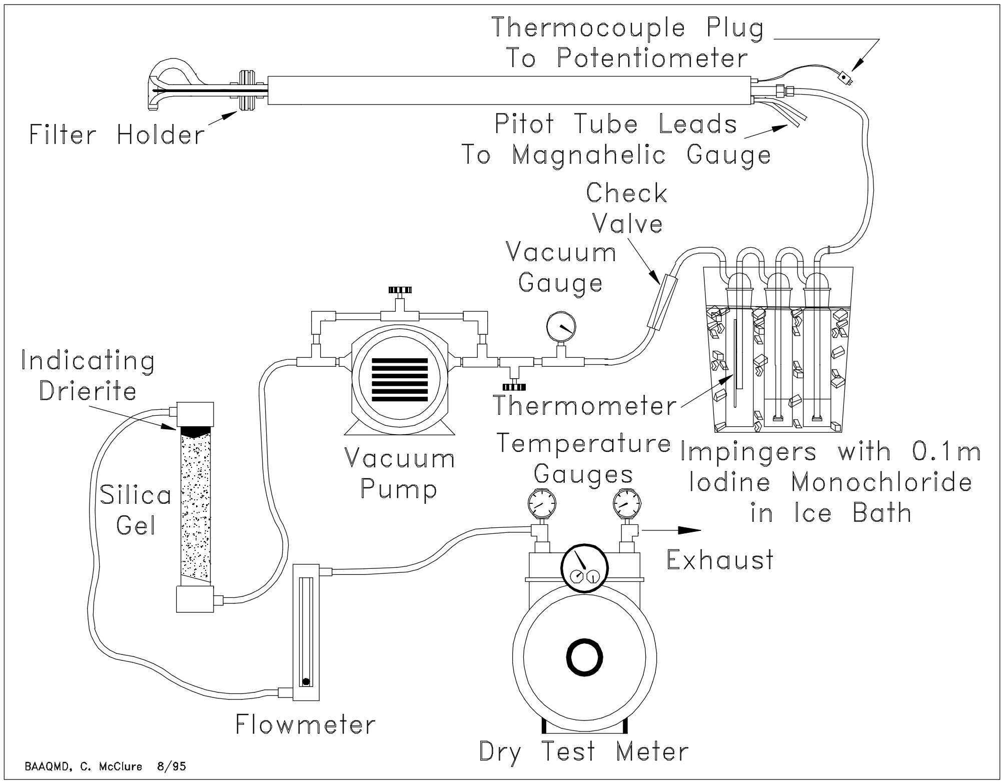
where:

D_n	=	Nozzle diameter, mm
T_s	=	Stack Gas Temperature
H_2O	=	Stack Gas Moisture Concentration, %
13.7	=	A constant based on an assumed meter rate of 0.5 CFM, meter temperature of 70^oF, and a molecular weight of 28.8
V_s	=	Stack Gas Velocity, fps, as calculated in ST-17.

7.3 Assemble the sampling train as shown in Figure 9-1.

Figure 9-1

Lead Sampling Train



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 lpm (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:

Q_m	=	Isokinetic Sampling Rate, ACFM
T_s	=	Meter Temperature, ^oR
H_2O	=	Stack Gas Moisture content (from 6.3.3)
2.638×10^{-3}	=	Constant derived from 60 sec/min, 70 ^oF, 29.92 inches Hg and molecular weight

8.4 When inserting the probe into the stack rotate the nozzle so it points down stream to avoid particulate collection prior to sampling. Immediately before sampling rotate the probe so the nozzle points upstream.

8.5 Record the following information at five minute intervals or whenever changing sampling locations on a field data sheet as shown in Form 9-2.

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 temperatures at 7 ^oC (45^oF) or less.

8.7 At the conclusion of each run, stop the pump, remove the probe from the stack and 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 Rinse the nozzles with approximately 50 ml of 6 normal nitric acid.

9.2 Analyze the filter, any material in the nozzle and the ICl solutions for lead according to Analytical Procedure Lab 4b.

10. AUXILIARY TESTS

10.1 Determine the CO_2, O_2, 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:

Vo	=	Standard dry sample volume, SDCF @ 70 ^oF and 29.92 inches Hg
Vm	=	Actual Metered Volume, ft^3
Pb	=	Barometric Pressure, inches Hg
Tm	=	Average Meter Temperature, ^oR
17.71	=	Constant correcting to 70 ^oF 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 H_2O.

11.3 Stack Gas Molecular Weight

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

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 Mass Emission Rate

$$M = \frac{W \times Q_o \times 60 \times T}{\left(454 x 10^{-6}\right) \times V_o}$$

Where:

M	=	Mass emission rate, lbs/day
W	=	Total weight of Lead collected in filter and impingers, µg (micrograms)
Q_O	=	Stack gas flowrate, SDCFM
V_O	=	Sample Volume, SDCF
T	=	Plant operation, hr/day
60	=	minutes/hour
454	=	grams/pound
10^{-6}	=	grams/microgram

11.6 Isokinetic Ratio. Calculate for each traverse point as:

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

Where:

R_i	=	Isokinetic ratio at given point
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, ^oR
T_{si}	=	Stack temperature, point i, ^oR
Q_{mi}	=	Metered volume, point i
60	=	Minutes/hr.

Overall isokinetic ratio for each run:

$$R = \frac{Q_{mi}}{60(100 - H_2O) A\, T_m\, V_{si}\ t_i T_{si}} \times 100\%$$

12. REPORTING

12.1 The data and information indicated in Form 9-3 shall be reported.

Bay Area Air Quality Management District

Form 9-1

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 9-2

Source Test Data Sheet

Plant # ____________
Source I.D. ____________
Sample Type ____________
Process Cycle ____________
Duct Size ____________
Duct Shape ____________
Duct Pressure ____________
Assumed %H_20 ____________

Run # ____________ Date: ____________
Temp Meter # ____________ Box ΔH@ ____________
Mag. Gauge # ____________ 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. ^{0}F	ΔP "H_20	Angle of Flow	Traverse Point I.D.	ΔP "H_20	Duct Temp. ^{0}F	Vs FPS	Time (minutes)	Meter Rate CFH	Meter Temp. ^{0}F	Meter Volume Ft^3	Train Vacuum "Hg	Sat'd Gas Temp. ^{0}F

Post Run Impinger Catch (ml) = ________
Assumed O_2 = ________
Assumed CO_2 = ________
Post Run Calculated %H_2O = ________

Source Test Team
____
____
____

Comments: ____________________
____
____
____

Form 9-3

Distribution: Firm Permit Services Enforcement Services Technical Services Planning Requester DAPCO	**BAY AREA** **AIR QUALITY MANAGEMENT DISTRICT** *939 Ellis Street* *San Francisco, California 94109* *(415) 771-6000* **Summary of Source Test Results**	**Report No.:** ________ **Test Date:** ________ **Test Times:** **Run A:** ________ **Run B:** ________ **Run C:** ________

Source Information		**BAAQMD Representatives**
Firm Name and Address	Firm Representative and Title Phone No. ( )	Source Test Engineers
Permit Conditions:	Source: Plant No. Permit No. Operates Hr/Day & Day/Yr.	Permit Services Division/Enforcement Division Test Requested By:
Operating Parameters		
Applicable Regulations:		VN Recommended:

Source Test Results and Comments:

METHOD	TEST	RUN A	RUN B	RUN C	AVERAGE	LIMIT
ST-17	Stack Volume Flowrate, SDCFM					
	Stack Gas Temperature, ^{0}F					
ST-23	Water Content, Volume %					
ST-14	Oxygen, Volume %					
ST-5	Carbon Dioxide, Volume %					
ST-6	Carbon Monoxide, ppmv					
	Carbon Monoxide, lb/hr					
ST-9	Lead (Pb) Emissions, lb/day					
	Isokinetic Ratio, act./theo.					

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