Source Test Procedure **ST-17**

STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE

(Adopted January 20, 1982)

1. APPLICABILITY

1.1 This procedure is used to determine stack gas velocity and to quantify volumetric flow rate. It is applicable for use in determining compliance with any regulation of the BAAQMD wherein stack gas velocity or flow rate is required.

2. PRINCIPLE

2.1 The stack gas velocity is determined by using a pitot tube to measure the velocity heads at pre-determined traverse points (ST-18) across the stack. The stack gas temperature, static pressure, molecular weight and moisture content are also measured. The volumetric flow rate can then be determined from knowledge of the duct geometry. Velocity measurements should be made from a Type "A" sampling point whenever possible. If sampling facilities permit, velocity traverses are conducted from two ports which are in radii of 90^0.

3. RANGE AND REPEATABILITY

3.1 The minimum measurable stack gas velocity is 8 feet per second. The maximum measurable velocity is limited only by available equipment.

3.2 The repeatability of the stack gas velocity method is ± 7%.

4. INTERFERENCES

4.1 Not Applicable.

5. APPARATUS

5.1 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 a standard pitot tube in a gas stream and measuring the pressure head with both over the entire velocity range of interest. The coefficient of the type S pitot tube shall be calculated as:

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

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

5.2 Differential Pressure Gauge. Use a Magnehelic differential pressure gauge, or equivalent, capable of measuring the velocity head with ± 5% accuracy.

5.3 Temperature Gauge. Use a Chromel-alumel thermocouple to measure stack temperature within ± 15^0 of the stack absolute temperature (^{0}F).

5.4 Barometer. Use a mercury, aneroid, or other calibrated barometer capable of measuring atmospheric pressure to within ± 0.2 inches of mercury.

5.5 Connections. All flexible tubing connections must be leak free.

6. PRE-TEST PROCEDURES

6.1 Set up the apparatus.

6.2 The pitot tube shall be pressurized so as to create a reading on the differential pressure gauge and then blocked at both ports. The pressure should remain constant.

6.3 Determine the location of the traverse points according to ST-18.

6.4 Calculate the molecular weight of the gas stream. The following stack gas concentrations shall be measured by the procedures indicated. An orsat analysis as outlined in ST-24 may be substituted for ST-5, ST-6 and ST-14.

% Carbon Dioxide, dry basis (ST-5)

% Carbon Monoxide, dry basis (ST-6)

% Oxygen, dry basis (ST-14)

% Water Vapor (ST-23)

Record the stack gas composition on the test data sheet, Form 17-1.

7. TEST PROCEDURES

7.1 The velocity head and the temperature at each traverse point is measured and recorded along with the point location on the source test data sheet.

7.2 Measure the static pressure in the stack and record on the data sheet.

8. CALCULATIONS

8.1 Average Molecular Weight

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

Where:

MW = Average Molecular Weight

0.44	=	Molecular weight of CO_2 divided by 100
$\%CO_2$	=	Percent Carbon Dioxide by volume (dry basis)
0.32	=	Molecular weight of O_2 divided by 100
$\%O_2$	=	Percent Oxygen by volume (dry basis)
0.28	=	Molecular weight of N_2 or CO divided by 100
%CO	=	Percent Carbon Monoxide by volume (dry basis)
$\%N_2$	=	Percent Nitrogen by volume (dry basis - determined by difference)

8.2 Stack Gas Velocity

$$V_s = 85.49\left(Cp_s\right)\left[(\Delta P)^{\frac{1}{2}}{}_{avg}\right]\left[\frac{T_s}{(P_b + P_d)MW}\right]^{\frac{1}{2}}$$

Where:

V_s	=	Average stack velocity, FPS
Cp_s	=	Pitot tube coefficient
T_s	=	Stack gas temperature, ^0R
P_b	=	Barometric pressure, inches Hg (absolute)
P_d	=	Stack gas static pressure, inches Hg
85.49	=	A constant derived from molecular weight, standard conditions, and Bernoulli's equation
$\left[(\Delta P)^{\frac{1}{2}}{}_{avg}\right]$	=	Arithmetic average of square roots of the veloci ty heads in inches of water

8.3 Stack Gas Flowrate

$$Q_o = \frac{(10.6)\left(V_s\right)\left(A\right)(P_b + P_d)(100 - \%H_2O)}{T_s}$$

Where:

Q_o	=	Volumetric flowrate, SDCFM
A	=	Stack cross-sectional area, ft^2
$\%H_2O$	=	% water vapor
10.6	=	A constant derived from correction to 530 ^OR, 29.92 in Hg, and 60 sec/min.

9. REPORTING

9.1 These values are determined as auxiliary data for other procedures and shall be reported with those test results.

Bay Area Air Quality Management District

939 Ellis Street, San Francisco, CA 94109

Form 17-1

Source Test Data Sheet

Plant #			Nozzle Diameter
Source I.D.			Pitot Tube I.D., Cp
Sample Type			Gas System
Process Cycle			Pbar, Barometer
Duct Size			Leak Test Rate
Duct Shape			Time @ Point
Duct Pressure			# of Points
Assumed %H_20			Time/Run (Min.)

Run # ______ Date: ______

Temp Meter # ______ Box $\Delta H@$ ______

Mag. Gauge # ______ Meter (Υ) ______

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

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Comments: ______

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