FIELD PROCEDURE 1
Sample and Velocity Traverses

Note: *The data sheet (FDS) serves as a summary sheet; hence, there is no Summary Sheet.*

A. Measurement Site

1. Select a site located ≥2 equivalent diameters (D_e's) downstream and ≥0.5 D_e upstream from any flow disturbance such as a bend, expansion, or contraction in the stack, or from a visible flame.
2. If criteria above cannot be met, consider the alternative procedure for determining the acceptability of a measurement location in FP 1a.

B. Number of Traverse Points

1. Refer to Figure F1-1 (see FDS1-2. *right side* for particulate traverses and *left side* for velocity, non-particulate traverses) and select the number of traverse points that corresponds to the number of D_e's upstream and downstream.
2. Select the higher of the two numbers of traverse points, or a greater value, such that the number is:
   a. For circular stacks, a multiple of 4.
   b. Rectangular stacks, one of those shown in Table F1-1.

C. Cross-sectional Layout and Location of Traverse Points for Circular Stacks

1. Locate the traverse points on two perpendicular diameters according to Table F1-2 and Figure F1-2.
2. For particulate traverses, locate one diameter in a plane containing the greatest expected concentration variation, e.g., after bends, in the plane of the bend.
3. Stacks with D_e >24 Inches
   a. If any traverse points fall within 1.00 in. of the stack wall, relocate them away from the wall by either 1.00 in. or a distance equal to the nozzle ID, whichever is larger. These relocated traverse points (on each end of a diameter) are the "adjusted" traverse points.
   b. Whenever two successive traverse points are combined to form a single adjusted traverse point, treat the adjusted point as two separate traverse points, both in the sampling (or velocity measurement) procedure, and in recording the data.
4. Stacks with D_e's ≤24 Inches

   Follow the procedure in step C3, except use 0.50 in. instead of 1.00 in.

D. Cross-sectional Layout and Location of Traverse Points for Rectangular Stacks

1. Determine the grid configuration from Table F1-1, and locate the traverse point at the centroid of each elemental area (see example in Figure F1-3).
2. If more than the minimum number of traverse points is used, expand the "minimum number of traverse points" matrix (see Table F1-1) by adding the extra traverse points along one or the other or both legs of the matrix; the final matrix need not be balanced. For example, if a 4 x 3 "minimum number of points" matrix were expanded to 36 points, the final matrix could be 9 x 4 or 12 x 3, and would not necessarily have to be 6 x 6.

Traverse Point	Distance % of diameter
1	4.4
2	14.7
3	29.5
4	70.5
5	85.3
6	95.6

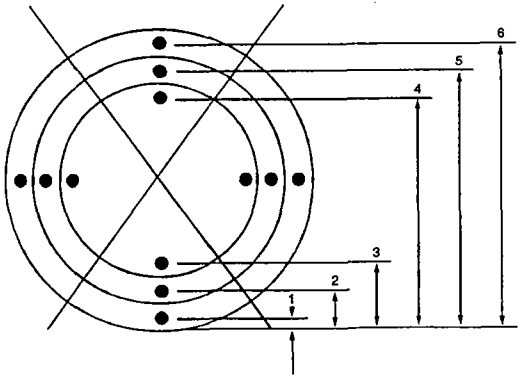


Figure F1-2. Circular stack cross-section layout.

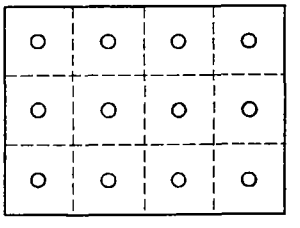


Figure F1-3. Rectangular stack cross-section layout.

FIELD DATA SHEET 1
Sampling and Velocity Traverse Points

Client/Plant Name _____ Job # _____

City/State _____ Date/Time _____

Test Location _____ Personnel _____

Port I.D.			
Distance from Far Wall to Outside of Port			
Nipple Length and/or Wall Thickness			
Stack/Duct (✓) Blue Print ( ) Measured ( )			
Depth/Diameter *(> 12 in. ?)*			
Width (if rectangular)			
Equiv. Diameter (if rect.) $D_e = 2\,D\,W/(D + W)$			
Area (A) *(> 113 in.^{2} ?)* $A = \pi D_2/4$ or $D\,W$			
	Distance	D_e	No. Pts*
Upstream *(≥ 2 D_e?)*			
Downstream *(≥ 0.5 D_e?)*			
Rectangular Matrix			

* ***Circle larger of two.***

Pt.	% Duct Depth	Dist. from Inside Wall*	Dist. from Outside of Port
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

* Do not place closer to stack walls than:
1.0 in. for stack dia. >24 in.
0.5 in. for stack dia. 12 to ≤24 in.

Sketch of Location: In the space above, sketch a flow diagram of the test location; show the distance from the ports to flow disturbances before and after. Sketch the cross-sectional area; show sampling port locations. In horizontal ducts, check for dust buildups and measure or estimate the depth.

QA/QC Check
Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: _____ _____
Personnel (Signature/Date) Team Leader (Signature/Date)

CONSIDERATIONS

1. If test location is after a cyclone or inertial demister following venturi scrubbers or if the stack has tangential inlets or other configurations that tend to induce swirling, ***verify that cyclonic flow does not exist. See FP 1a (Check here ___ if verification is made a..J attach FDS 1a.*** If cyclonic flow exists, modify source by using straightening vanes or use another location.
2. If D <12 inches for circular stack or duct, or if A <113 in.^{2} for rectangular, ***do not use this method; rather use FP 1A (Check here __ and attach FDS 1A).***
3. If the test location <2 D_e downstream or <0.5 D_e upstream ***from*** a flow disturbance, e.g., bend, expansion, or contraction in the stack, or from a visible flame, ***do not use this method. Alternatively, conduct the procedure in Section 2.5 of Method 1 to determine whether the location is acceptable. Check here __ if this option is used and attach FDS 1b.***
4. For rectangular stacks, a balanced matrix layout must be used, i.e., one of the matrices shown in Table F1-1. Once the minimum sample point matrix requirement is met, an unbalanced matrix may be used. For example, if you need a 3 x 3 matrix, but have ten ports, you may use a 3 x 10 or a 4 x 10 matrix. A 2 x 5 or 2 x 10 matrix is not acceptable.
5. For particulate traverses, one of the diameters must be in the plane containing the greatest expected concentration variation, e.g., after bends, in the plane of the bend.
6. If any of the specifications are not met, check with enforcement agency to determine whether the agency will accept the location. Attach a statement of the agency's decision to this data sheet and obtain signature.

TABLE F1-1

No. Pts	Matrix	No. Pts	Matrix
9	3 x 3	30	6 x 5
12	4 x 3	36	6 x 6
16	4 x 4	42	7 x 6
20	5 x 4	49	7 x 7
25	5 x 5		

Figure F1-1

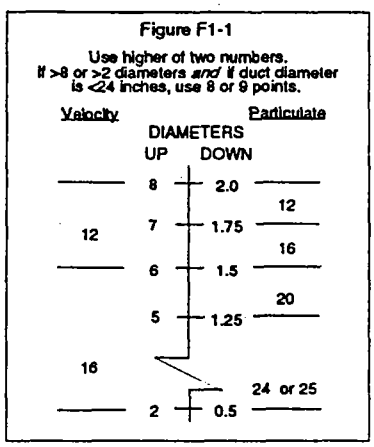


TABLE F1-2

LOCATION OF POINTS IN CIRCULAR STACKS OR DUCTS

	4	6	8	10	12	14	16	18	20	22	24
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7			89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8			96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9				91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10				97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11					93.3	85.4	78.0	70.4	61.2	39.3	32.3
12					97.9	90.1	83.1	76.4	69.4	60.7	39.8
13						94.3	87.5	81.2	75.0	68.5	60.2
14						98.2	91.5	85.4	79.6	73.8	67.7
15							95.1	89.1	83.5	78.2	72.8
16							98.4	92.5	87.1	82.0	77.0
17								95.6	90.3	85.4	80.6
18								98.6	93.3	88.4	83.9
19									96.1	91.3	86.8
20									98.7	94.0	89.5
21										96.5	92.1
22										98.9	94.5
23											96.8
24											98.9

LOCATION OF POINTS IN RECTANGULAR STACK OR DUCTS

	2	3	4	5	6	7	8	9	10	11	12
1	25.0	16.7	12.5	10.0	6.3	7.1	6.3	5.6	5.0	4.5	4.2
2	75.0	50.0	37.5	30.0	25.0	21.4	16.8	16.7	15.0	13.6	12.5
3		83.3	62.5	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.6
4			87.5	70.0	58.3	50.0	43.8	38.9	35.0	31.8	29.2
5				90.0	75.0	64.3	56.3	50.0	45.0	40.9	37.5
6					91.7	78.6	68.7	61.1	55.0	50.0	45.8
7						92.9	81.3	72.2	65.0	59.1	54.2
8							93.8	83.3	75.0	68.2	62.5
9								94.4	85.0	77.3	70.8
10									95.0	86.4	79.2
11										95.5	87.5
12											95.8

FIELD PROCEDURE 1a
Flow Verification or Alternative Measurement Site

Note: *Use section A after such devices as cyclones and inertial demisters following venturi scrubbers, or in stacks having tangential inlets or other duct configurations that tend to induce swirling to check for the presence or absence of cyclonic flow.*

A. Flow Verification

1. Set up the apparatus (see FP 2). Level and zero the manometer. Position the Type S pitot tube at each traverse point, in succession. The "0° reference" is when the planes of the face openings of the pitot tube are perpendicular to the stack cross-sectional plane.
2. Rotate the pitot tube (up to ±90° yaw angle) until a null reading is obtained. Carefully determine and record the value of the rotation angle (α) to the nearest degree (see FDS 1a).

B. Alternative Measurement Site

This alternative applies to sources $< 2\ D_e$ downstream or $< 0.5\ D_e$ upstream, and is limited to ducts > 24 in.

1. Use 40 traverse points for circular ducts and 42 points for rectangular ducts.
2. Prepare the directional probe and differential pressure gauges as recommended by the manufacturer.
3. ***Optional:*** Leak-check the system (see FP 2a).
4. Level and zero the manometers. Periodically check the level and zero during the traverse.
5. Obtain the readings shown in FDS 1b at each traverse point, and determine the yaw and pitch angles.
6. ***Mandatory:*** Leak-check the system (see FP 2a). Failing the leak-check invalidates the test run.

FIELD DATA SHEET 1a
Flow Verification

Test Point	Yaw Angle (deg)
No. of Pts:	Sum:
	Avg:

Test Location _____

Job # _____ Date/Time _____

Pitot ID # _____ Personnel _____

Note: *To combine this information with the preliminary traverse for Method 5 sampling, use the data sheet under Method 5.*

CONSIDERATIONS

____ Are the face openings of the Type S pitot tube parallel to each other and perpendicular to the axis passing through both?

____ When the face of the pitot tube is parallel to the axis of the stack or duct, does the yaw angle indicator read zero?

____ Average yaw angle $\leq 20°$? If not, ***do not use this location.*** Alternatively, modify the source by using straightening vanes or use another location that satisfies Method 1 criteria.

No. of Pts = includes points with 0° yaw.

Sum = sum of absolute values

Avg = Sum/(No. of Pts)

QA/QC Check
Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: _____ _____
Personnel (Signature/Date) Team Leader (Signature/Date)

FIELD DATA SHEET 1b
Alternative Measurement Site

Test Location _____ Job # _____

Date/Time _____ No. of Test Pts (✓): ___ 42 (Rectangular) ___ 40 (Circular,

Duct Size _____ *>24 in. (?)* 3-D Pitot _____ Personnel _____

Note: *This alternative procedure is limited to ducts >24 inches in diameter where blockage and wall effects are minimal; the procedure generally applies to sites <2 D_e downstream and <0.5 D_e upstream from flow disturbances.*

Test Pt	Yaw	$P_4 - P_5$	$P_1 - P_2$	Pitch	R_i	Test Pt	Yaw	$P_4 - P_5$	$P_1 - P_2$	Pitch	R_i

$$R_{avg} = \frac{\sum_{i=1}^{n} R_i}{n} \qquad S_d = \sqrt{\frac{\sum_{i=1}^{n} (R_i - R_{avg})}{(n-1)}}$$

Avg (abs) _____ _____ _____

___ Post-test Leak Check (***Stable for >15 seconds at 3 in. H_2O?)***

___ $R_i \leq 20°$ and SD $\leq 10°$? If so, use at ≥24 or 25 traverse points for particulate sampling and ≥16 for velocity measurements.

QA/QC Check
Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: _____ _____
Personnel (Signature/Date) Team Leader (Signature/Date)

FIELD PROCEDURE 1A
Sample and Velocity Traverses in Small Stacks or Ducts

Note: This procedure is the same as that in FP 1, except for the special provisions that apply to small stacks or ducts, i.e., 4 in. ≤ D < 12 in. or 12.57 in.^{2} ≤ A < 113 in.^{2}.

A. Selection of Measurement Site

1. Particulate Measurements - Steady or Unsteady Flow

   Select a site as shown in Figure F1A-1 (see FDS 1A).

2. Particulate (Steady Flow) or Velocity (Steady or Unsteady Flow) Measurements

   a. If the average total volumetric flow rate in a duct is constant with respect to time or if only velocity measurements are required, select one location and use the same criterion as in FP 1.

   b. Conduct velocity traverses before and after particulate sampling to demonstrate steady state conditions, i.e., $v_f/v_i \leq 1.10$.

B. Number of Traverse Points

Particulate Measurements (Steady or Unsteady Flow)

1. Use FP 1 except consider the distance between the velocity and sampling sites in addition to the upstream and downstream distances.

2. Choose the highest of the three numbers of traverse points as in FP 1.

FIELD DATA SHEET 1A
Sampling and Velocity Traverse Point Determination
(Small Stacks or Ducts)

Test Location _____ Job # _____

Date/Time _____ Personnel _____

Applicability
Method 1A applies only when 4 in. ≤ D <12 in. (circular) and 12.57 in.^{2} ≤ A <113 in.^{2} (rectangular). A standard type pitot tube must be used for the velocity measurements and must ***NOT*** be attached to the sampling probe.

Use FDS 1 and attach this sheet to it. The following are pertinent to FP 1A:

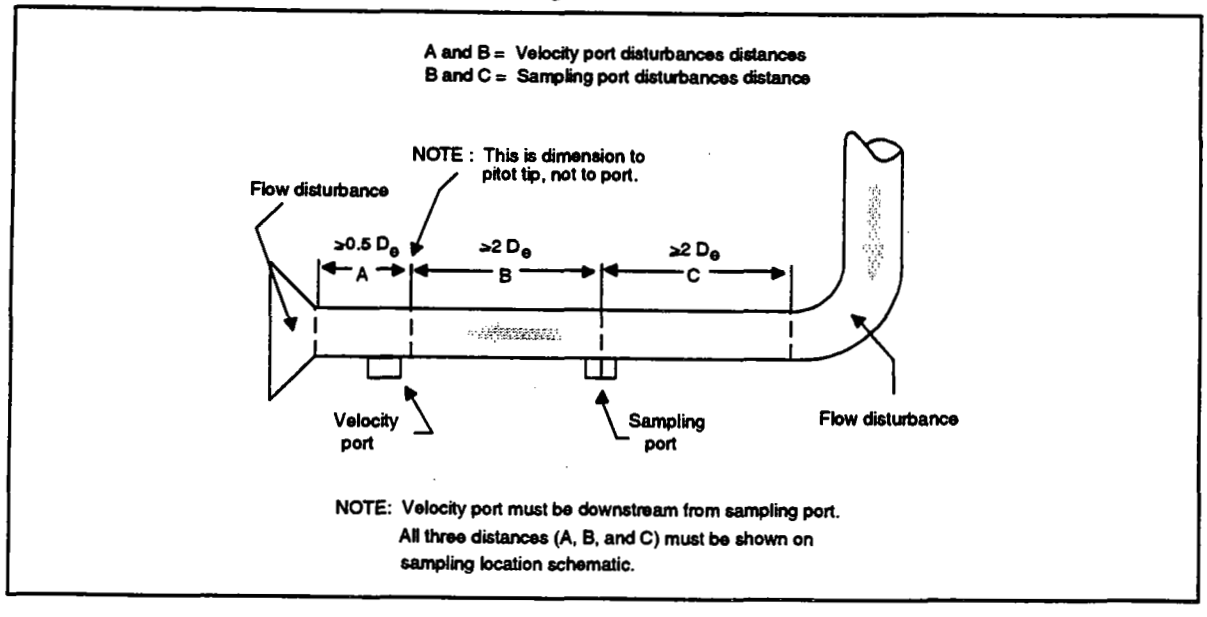
Distance from Ports to Flow Disturbances (see figure below)

	Std Pitot Tip Plane			**Sampling Port**		
	Distance	D_e	No. Pts	Distance	D_e	No. Pts
Upstream	B _____	_____	_____	C _____	_____	_____
Downstream	A _____	_____	_____	B _____	_____	_____

Use the upstream/downstream distances as in FP 1 to determine the minimum number of traverse points; use the highest of the four numbers of traverse points.

If the source operates under steady flow conditions and one test location is used for both velocity and particulate matter measurements, the average velocity after the particulate sampling run must agree within ±10% of that before the test run. Attach appropriate FDSs.

Figure F1A-1.



QA/QC Check
Completeness _____ Legibility _____ Accuracy _____ Specifications _____ Reasonableness _____

Checked by: _____ _____
Personnel (Signature/Date) Team Leader (Signature/Date)