SUMMARY SHEET 14
Total Fluoride

			Run #1	Run #2	Run #3	Avg
Client/Plant Name		FDS 5/14				
Job No.		FDS 5/14				
Sampling Location		FDS 5				
Run ID #		FDS 5/14				
Test Date		FDS 5/14				
Run Start Time		FDS 5				
Run Finish Time		FDS 5				
Net Traverse Points		FDS 1				
Traverse Matrix (Rectangular)		FDS 1				
Net Run Time, min	θ	FDS 5				
Nozzle Diameter, in.	D_n	FDS 5				
Dry Gas Meter Calibration Factor	Y	CDS 5				
Average ΔH (orifice meter), in. H_2O	ΔH	FDS 5				
Barometric Pressure, in. Hg	P_b	FDS 5				
Stack Static Pressure, in. H_2O	P_g	FDS 5				
Abs Stack Pressure (P_b + P_g/13.6), in. Hg	P_s	SS 5				
Average Duct Temperature, °F	t_s	FDS 5				
Avg Abs Duct Temperature, (t_s + 460)	T_s	SS 5				
Carbon Dioxide, % dry	$\%CO_2$	FDS 3				
Oxygen, % dry	$\%O_2$	FDS 3				
Carbon Monoxide + Nitrogen, % dry	$\%(CO+N_2)$	FDS 3				
Dry Molecular Weight, lb/lb-mole	M_d	FDS 3				
Average DGM Temperature, °F	t_m	FDS 5				
Volume of Metered Gas Sample, dcf	V_m	FDS 5				
Volume of Metered Gas Sample, dscf	$V_{m(std)}$	SS 5				
Volume Water Condensed, mL	V_{lc}	FDS 5				
Volume of Water Vapor, scf	$V_{w(std)}$	SS 5				
Moisture Content, fraction	B_{ws}	SS 5				
Pitot Tube Coefficient	C_p	CDS 2a				
Average Velocity Pressure, in. H_2O	Δp	FDS 5				
Average $[(t_{si} + 460)\ \Delta p]^{1/2}$	$[T_{si}\ \Delta p]^{1/2}$	FDS 5				
Average Duct Velocity, ft/sec	v_s	SS 5				
Isokinetic Sampling Rate, %	%I	SS 5				
Manifold Duct Diameter at Sampling Pt, in.	D	FDS 5				
Manifold D (D x 0.3048), m	D_d	SS 14				
Manifold Barometric Pressure, mm Hg	P_{bm}	FDS 14				
Manifold Nozzle Diameter, m	D_{dn}	FDS 14a				
Average Roof Monitor Temperature, °C	t_r	FDS 14				
Avg Abs Roof Monitor Temp, (273 + t_r), K	T_r	SS 14				

			Run #1	Run #2	Run #3	Avg
Avg Manifold Anemometer Velocity, m/min	v_m	FDS 14				
Desired Duct Velocity, m/sec	v_d	SS 14				
Manifold Isokinetic Ratio, %	$\%I_m$	SS 14				
Isokinetic Correction Factor	F	SS 14				
Overall Roof Monitor Velocity, m/min	v_{mt}	FDS 14				
Roof Monitor Open Area, m^2	A	FDS 14				
Roof Monitor Volumetric Flow, scmm	Q_{sd}	SS 14				
Total Fluoride in Sample, mg	F_t	LDS 13A/B				
Concentration of Fluoride, mg/ft^3	C_s	LDS 13A/B				
Post-test Calibration Checks						
Temperature and Barometer		CDS 2d				
Differential Pressure Gauge		CDS 2d				
Metering System		CDS 5				

$$v_d = \frac{8\ D_{dn}^2\ v_m}{60\ D_d^2}$$

$$\%I_m = \frac{0.3048\ v_s}{v_d}(100)$$

$$F = 1 + \frac{\%I_m - 120}{200}$$

Multiply emission rate by F, only if $\%I_m > 120\%$.

$$Q_{sd} = 0.3855\ \frac{v_{mt}\ (1 - B_{ws})\ P_{bm}\ A}{T_r}$$

FIELD PROCEDURE 14
Fluoride Emissions from Potroom Roof Monitors for Primary Aluminum Plants

Note: FP 14 describes the measurements of flow rates and fluoride concentrations from potroom roof monitors in primary aluminum plants.

A. Roof Monitor Velocity

1. A day (24 hr) before the test run, turn on the exhaust fan and adjust flow rate to an estimated isokinetic condition (i.e., average velocity at the manifold nozzles equal to the average velocity at the roof monitor) to condition the ductwork.

2. Estimate the average velocity at the roof monitor before each run using the anemometer (the one in the section containing the sampling manifold) readings from 24 hr before or from any other information. If velocities are anticipated to be significantly different because of different potroom operations, the test run may be divided into two or more "sub-runs," and an average velocity for each sub-run may be estimated.

3. Adjust the fan to isokinetic conditions (see Equation F14-1). Perform a pitot tube traverse of the sample duct (using either a standard or Type S pitot tube) according to FP 2 to verify isokinetic conditions. Once a run or sub-run has begun, do not make any isokinetic rate adjustments.

$$v_d = \frac{8\ D_n^2\ v_m}{60\ D_d^2} \qquad \text{Eq. F14-1}$$

where:

v_d = Desired velocity in duct at measurement location, m/sec.

D_n = Diameter of a manifold nozzle, m.

D_d = Diameter of duct at measurement location, m.

v_m = Average velocity in the roof monitor, m/min.

B. Fluoride Sampling/Velocity Determination

1. Each test run shall be ≥8 hr (times for all runs shall be about within ±10% of the average); during each run, the operation of all pots shall be representative of normal operating conditions underneath the sampling manifold. For more recently-constructed plants, 24 hr or more may be required to be representative of all potroom operations.

2. Sample the duct and recover and analyze the sample using Method 13A or 13B. Use a single train for the entire sampling run or for each sub-run. If a separate train is used for each sub-run, sampling nozzles must have areas within ±2% of the average. For each sub-run, perform a complete traverse of the duct.

3. During the test run, record the velocity or volumetric flowrate readings of each propeller anemometer at least every 15 min at equal time intervals (or continuously).

4. Record the temperature of the roof monitor every 2 hr during the test run.

FIELD DATA SHEET 14
Potroom Roof Monitors of Primary Aluminum Plants

Client/Plant Name ____________________ Date ____________ Job # ____________

City/State ____________________ Personnel ____________________

Run # ____________ Roof Monitor Open Area, A ________ m^2 Bar. Press., P_b ________ mm Hg

Start Time ____________ End Time ____________ *Note: Mark with asterisk (*) the manifold anemometer.*

Clock time (hr/min)	Anemometers (m/min)				Temp. t_r (°C)	Clock time (hr/min)	Anemometers (m/min)				Temp, t_r (°C)
	1	2	3	4			1	2	3	4	
0:15						6:15					
0:30						6:30					
0:45						6:45					
1:00						7:00					
1:15						7:15					
1:30						7:30					
1:45						7:45					
2:00						8:00					
2:15						8:15					
2:30						8:30					
2:45						8:45					
3:00						9:00					
3:15						9:15					
3:30						9:30					
3:45						9:45					
4:00						10:00					
4:15						10:15					
4:30						10:30					
4:45						10:45					
5:00						11:00					
5:15						11:15					
5:30						11:30					
5:45						11:45					
6:00						12:00					
Average, v_m											
Overall Average, v_{mt}											

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness __

Checked by: ____________________ ____________________

Personnel (Signature/Date) Team Leader (Signature/Date)

FIELD PROCEDURE 14a
Manifold/Anemometer System

A. Manifold System Construction

Construct the manifold system using the general configuration and dimensions shown in Figures F14a-1 and F14a-2; dimensions may be slightly altered to fit a particular roof monitor. Details are:

1. Eight nozzles, 0.40 to 0.50 m ID, each leg with a flow regulator, e.g., blast gate or valve.
2. Length of the manifold system from the first nozzle to the eighth: 35 m or 8% of the length of the potroom (or potroom segment) roof monitor, whichever is greater.
3. Round ductwork from the roof monitor manifold, 0.30 to 0.40 m ID.
4. Stainless steel, aluminum, or other construction material for all sample-exposed surfaces. ***Note:*** Aluminum construction requires 6 weeks of conditioning with fluoride-laden roof monitor air before initial test. Other materials of construction require comparative testing to demonstrate no loss of fluorides in the system.
5. Leak-free connections in the ductwork.
6. Two sample ports in a vertical section of the duct between the roof monitor and exhaust fan, $\geq 10\ D_e$ downstream and $\geq 3\ D_e$ upstream from flow disturbances, 90° apart, and one traverse line in the plane of the nearest upstream duct bend.

B. Roof Monitor Air Sampling System Installation

1. Balance the flow rates in the eight individual nozzles to approximate the average effluent velocity in the roof monitor. Measure the velocity at the center of each manifold leg duct; use a standard pitot tube (not a Type S) into a ≤ 2.5 cm diameter hole (see Figure F14a-2) in the manifold. Ensure that there is no leakage around the pitot tube. Use the blast gate (or valve) to adjust the flow. Fasten each blast gate (or valve) so that it will remain in position, and close the pitot port holes. Perform this calibration when the manifold system is installed or, if preassembled on the ground, before being installed.
2. Install anemometers as follows:
   a. Single, Isolated Potroom. Divide roof monitor length by 85 m, round off to nearest whole number. For a roof monitor 130 m long, round off to two. Divide the monitor cross-section into as many equal areas as this number.
   b. Two or More (Potrooms). Follow the procedure in step B2a for each potroom (or segment) that contains a sampling manifold.
   c. Install an anemometer at the centroid of each equal area, except for those within the manifold section. Install these at the midpoint of the width of the roof monitor or at a point of average velocity (based on a velocity traverse made during normal operations) and install at least one anemometer within 10 m of the center of the manifold.
3. Install at least one manifold system for each potroom group (as defined in Subpart S, Section 60.191) near the midsection of the potroom (or potroom segment), or above pots that are representative of normal operating conditions, and close to one of the propeller anemometers. Avoid the ends. Center the sample nozzles in the throat of the roof monitor (see Figure F14a-1).
4. Install a thermocouple in the roof monitor near the sample duct.

C. Notes

1. The roof monitor shown in Figure F14a-1 is a general type. If the general guidelines cannot be met, consult with the Administrator.
2. Sufficient velocities should be maintained in the system to prevent F deposition.

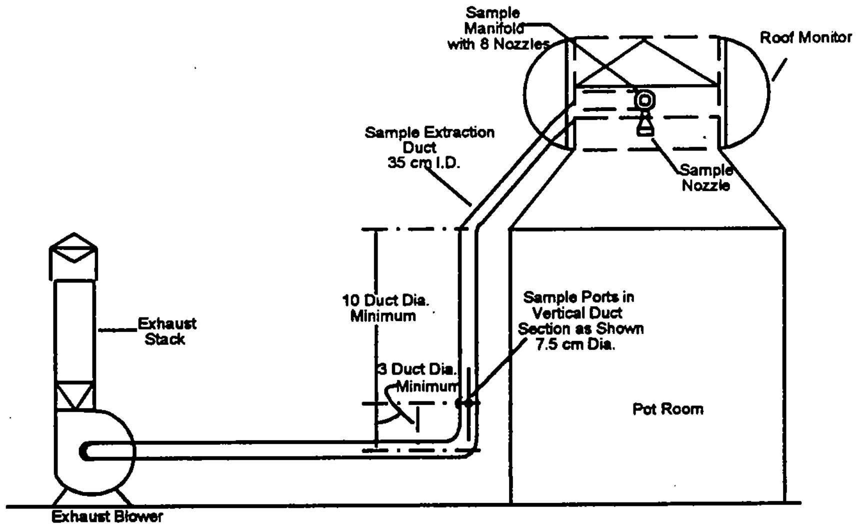

Figure F14a-1. Roof Monitor Sampling System.

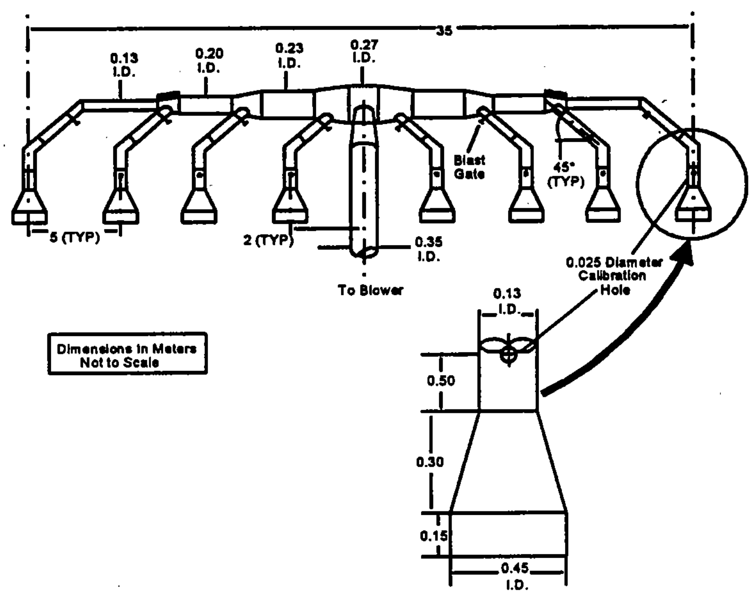

Figure F14a-2. Sampling Manifold and Nozzles.

FIELD DATA SHEET 14a
Manifold/Anemometer System

Client/Plant Name ____________________ Date ____________ Job # ____________

City/State ____________________ Personnel ____________________

Check (✓): Single, Isolated Potroom ___ Two or More Potrooms ___

Potroom Length, L_p = ________ m 0.08 L_p = ________ m

Manifold Length, L_m = ________ m (≥higher of 35 m or 0.08 L_p)

No. of Anemometers, L_p/85 = _____ (round off to nearest whole number)

Sample Extraction Location: Diameter, D_e = _______ m (0.30 to 0.40 m ?)

Upstream, U ________ m U/D_e = ________ (≥10 ?)

Downstream, D ________ m D/D_e = ________ (≥3 ?)

Manifold Nozzle Diameter, D_n = __________ m (0.40 to 0.50 m ?)

Construction Material (✓): Stainless Steel ___ Aluminum ___ Other ___

___ Sample extraction two ports 90° apart?

___ General configuration and dimensions similar to Figures F14a-1 and F14a-2?

___ Connection leak-free? (By visual inspection)

___ Thermocouple installed near sample duct in roof monitor?

___ Anemometer at centroid of each equal area?

___ Manifold anemometer within 10 m of manifold center?

___ Manifold anemometer at midpoint of width? If not, show velocity traverse:

Velocity Traverse of Width

Pt ___ ___ ___ ___ ___

Δp ___ ___ ___ ___ ___

Sketch location of manifold in relation to roof monitor (give dimensions):

Pitot Tube ID# ____________ Coefficient _______ Δp readings should be ≤ ±20% of average for a balanced system.

Run No.	1	2	3	4	5
Nozzle No.	Δp in. H_2O	Δp in. H_2O	Δp in. H_2O	Δp in. H_2O	Δp in. H_2O
1					
2					
3					
4					
5					
6					
7					
8					
Average					

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: ______________________________ ______________________________

Personnel (Signature/Date) Team Leader (Signature/Date)

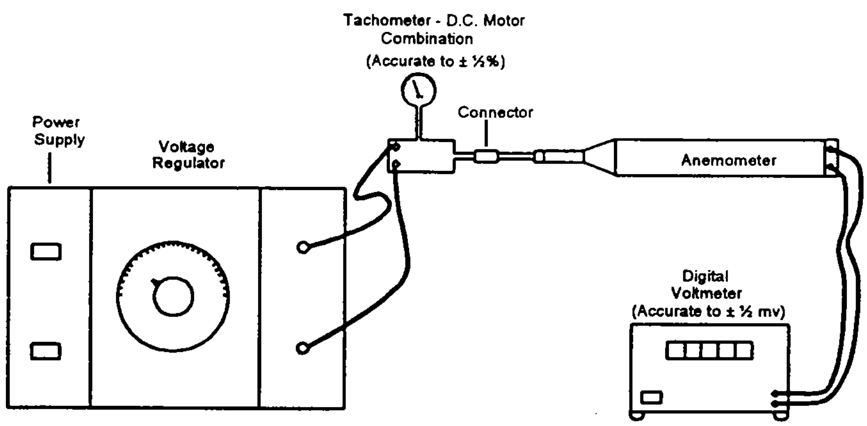

Figure C14-1. Typical RPM Generator.

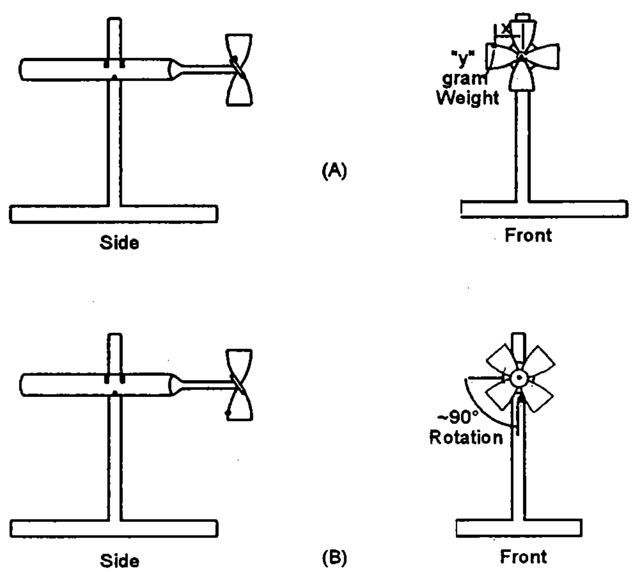

Figure C14-2. Check of Anemometer Starting Torque. A "y" Gram Weight Placed "x" Centimeters from Center of Propeller Shaft Procedures a Torque of "xy" g-cm. The Minimum Torque Which Produces a 90° (approximately) Rotation of the Propeller is the "Starting Torque."

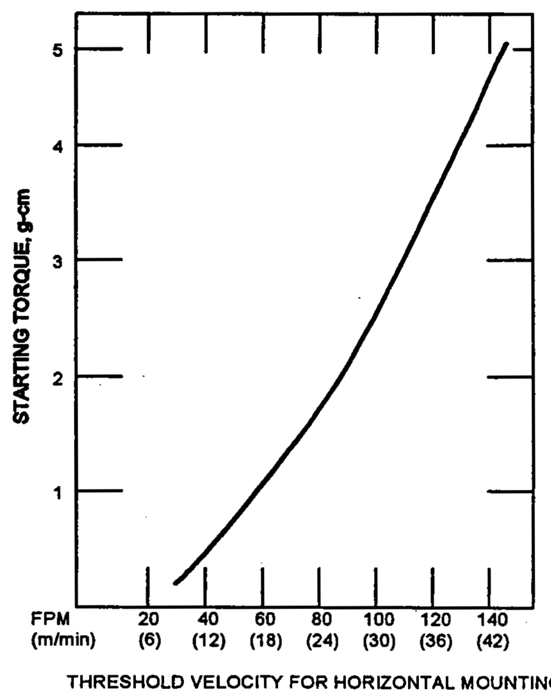

Figure C14-3. Typical Curve of Starting Torque vs. Horizontal Threshold Velocity for Propeller Anemometers. Based on Data Obtained by R.M. Young, Company, May, 1977.

CALIBRATION PROCEDURE 14
Propeller Anemometers

A. *Calibration*

1. Obtain a "reference" performance curve relating anemometer signal output to air velocity (covering the velocity range of interest) from the manufacturer. A "reference" performance curve is one that has been derived from primary standard calibration data, with the anemometer mounted vertically. "Primary standard" data are obtainable by:
   a. Direct calibration of one or more of the anemometers by the National Institute of Standards and Technology (NIST).
   b. NIST-traceable calibration.
   c. Calibration by direct measurement of fundamental parameters such as length and time (e.g., by moving the anemometers through still air at measured rates of speed, and recording the output signals).
2. Check the signal output of the anemometer by using an accurate rpm generator (see Figure C14-1) or synchronous motors to spin the propeller shaft at a minimum of three evenly spaced rpm settings, e.g., 60 ± 15, 900 ± 100, and 1800 ± 100 rpm and measuring the output signal at each setting. Output signal readings must be ≤ ±5% of manufacturer's value at each setting.
3. Inspect the propeller for any significant damage or warpage and replace damaged or deformed propellers.
4. Check the anemometer threshold velocity as follows:
   a. Mount the anemometer as shown in Figure C14-2(A).
   b. Fasten a known weight (a straight-pin will suffice) to the anemometer propeller at a fixed distance from the center of the propeller shaft to generate a known torque; e.g., a 0.1-g weight, placed 10 cm from the center of the shaft, will generate a torque of 1.0 g-cm. Try different combinations of weight and distance to estimate the starting torque, and determine the threshold velocity of the anemometer (for horizontal mounting) using a graph such as Figure C14-3 (obtained from the manufacturer). Horizontal threshold velocity must be ≤50 fpm.
5. Compare temperature readings from the thermocouple-potentiometer system against reference thermometers at 0, 100, and 150°C. Measured temperatures must be within ±5°C at each of the reference temperatures.
6. Check the calibration of each recorder and counter at a minimum of three points, approximately spanning the expected range of velocities. Use the calibration procedures recommended by the manufacturer, or other suitable procedures. Difference for the three calibration points must be ≤ ±5%.

B. *Periodic Performance Checks*

1. Check the calibration of the propeller anemometers, thermocouple-potentiometer system and the recorders and counters within 60 days before the first performance test and, thereafter, at 12-month intervals.
2. If any of the above systems fail the performance checks or if any repairs or replacements are made during the 12 months, conduct the periodic performance checks at 3-month intervals, until sufficient information (consult with the Administrator) is obtained to establish a modified performance check schedule and calculation procedure. **Note:** Failure of the first annual performance checks does not require recalculating the data for the past year.

CALIBRATION DATA SHEET 14
Propeller Anemometers

Client/Plant Name ______________________ Date ____________ Job # ____________

City/State ______________________ Personnel ______________________

Attach "reference" performance curve of anemometer output to velocity; starting torque vs. velocity; recorder/counter calibration curve.

Anemometer ID#						
RPM	Rdg	Ref	Rdg/Ref ≤ ±5% ?	Rdg	Ref	Rdg/Ref ≤ ±5% ?
60 ± 15						
900 ± 100						
1800 ± 100						
Threshold Velocity	≤ 50 fpm ?			≤50 fpm ?		
Weight (g)						
Distance (cm)						
Velocity						
Recorder/Counter	Rdg	Ref	Rdg/Ref ≤ ±5% ?	Rdg	Ref	Rdg/Ref ≤ ±5% ?
Pt 1						
Pt 2						
Pt 3						
Thermocouple	Rdg	Ref	Diff ≤ ±5°C ?	Rdg	Ref	Diff ≤ ±5°C ?
0°C						
100°C						
150°C						
Damaged/Warped ?						

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: ______________________ ______________________

Personnel (Signature/Date) Team Leader (Signature/Date)