

FIELD PROCEDURE 3
Dry Molecular Weight

Note: This procedure includes three different types of sampling techniques. Select the appropriate procedure for the test. Use FDS 3.

A. Single-point, Grab Sampling and Analysis

1. Set up the equipment as shown in Figure F3-1. Ensure all connections ahead of the analyzer are tight.
2. *Optional:* If an Orsat analyzer is used, leak-check the analyzer (*see FP 3a*).
3. Place tip of probe at the centroid of the stack cross section or at a point no closer to the walls than 3.3 ft.
4. Purge the sampling line long enough to allow at least five exchanges.
5. Draw a sample into the analyzer, and immediately analyze it for %CO₂ and %O₂.
6. Calculate the dry molecular weight.
7. Repeat the sampling, analysis, and calculation procedures until the dry molecular weights of any three grab samples differ from their mean by no more than 0.3 lb/lb-mole.
8. Report average of these three molecular weights to the nearest 0.1 lb/lb-mole.

B. Single-point, Integrated Sampling and Analysis

1. *Optional:* Leak-check the flexible bag. (*see FP 3b*).
2. Set up the equipment as shown in Figure F3-2.
3. *Optional:* Leak-check the train (*see FP 3c*).
4. Evacuate the flexible bag, and connect the probe.
5. Place tip of probe at the centroid of the stack cross section or at a point no closer to the walls than 3.3 ft. Purge the sampling line, connect the bag, and ensure that all connections are tight.
6. Sample at a constant rate, simultaneously with, and for the same total length of time as, the pollutant emission rate determination until 30 L of sample gas or desired volume has been collected.

7. Obtain one integrated flue gas sample during each pollutant emission rate determination.
8. *Optional:* If an Orsat analyzer is used, leak-check the Orsat analyzer (*see FP 3a*) before the determination.
9. Within 8 hr after the sample is taken, analyze it for %CO₂ and %O₂.
10. Calculate the dry molecular weight.
11. Repeat the analysis and calculation procedures until the individual dry molecular weights for any three analyses differ from their mean by no more than 0.3 lb/lb-mole.
12. Report the average these three molecular weights to the nearest 0.1 lb/lb-mole.

C. Multi-point, Integrated Sampling and Analysis

1. For equivalent stack diameter (D_e) < 24 in., use ≥ 8 traverse points for circular stacks and ≥ 9 for rectangular stacks, and ≥ 12 traverse points for all other cases.
2. Locate the traverse points according to Method 1.
3. Follow the procedures outlined in Section B, except for the following: Traverse all sampling points, and sample at each point for an equal length of time. Record sampling data as shown in FDS 3. See also FDS 5 if sampling is conducted with particulate sampling.

D. Alternatives and Modifications

1. Rather than using an integrated sample, an Orsat may be used to analyze individual grab samples obtained at each point.
2. If either CO₂ or O₂ is measured, stoichiometric calculations may be used to determine M_d .
3. An $M_d = 30.0$ for processes burning natural gas, coal, or oil may be used.

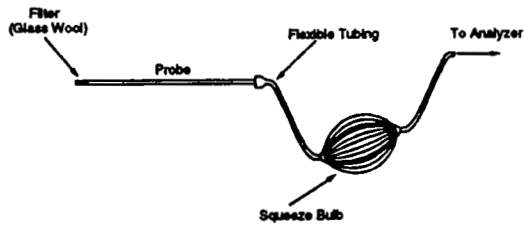


Figure F3-1. Grab-Sampling Train.

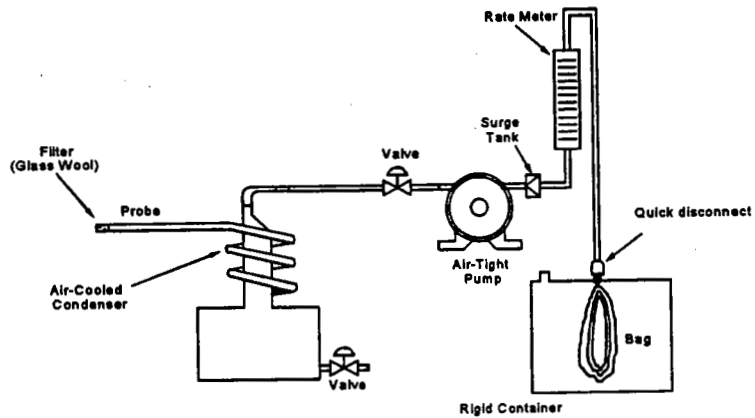


Figure F3-2. Integrated Gas-Sampling Train.

**FIELD DATA SHEET 3
Dry Molecular Weight**

Client/Plant Name _____ Job # _____
 City/State _____ Date _____
 Test Location/Run # _____ Personnel _____

Orsat/Fyrite (Single-point, Grab or Integrated, Sampling and Analysis)						
Orsat ID:		Fyrite ID:		Analyzer Leak-Check OK?: _____		
Time of Sample Collection	Time of Analysis	%CO ₂ Rdg (A)	%O ₂ Rdg (B)	%O ₂ (B-A)	%(CO + N ₂) (100-B)	M _d lb/lb-mole
M _d = 0.440 %CO ₂ + 0.320 %O ₂ + 0.280 %(CO + N ₂)					Average	
Bag ID: _____			Each M _d ≤ 0.3 lb/lb-mole from average? _____			
Bag Leak-Check OK? _____			Train Leak-Check OK? _____			

Note: The equation for M_d does not consider argon in air (about 0.9%, M = 39.9) and introduces a negative error of about 0.4%.

Multi-point, Integrated Sampling			
Time	Traverse Pt.	Flow Rate, Q	% Deviation
Average			< ± 10%?

$$\% \text{ Dev.} = (Q - Q_{\text{avg}}) / Q_{\text{avg}} \times 100, < \pm 10\%$$

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

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

FIELD PROCEDURE 3a
Leak-Check of Orsat Analyzer

1. Bring the liquid level in each pipette up to the reference mark on the capillary tubing, and then close the pipette stopcock.
2. Raise the leveling bulb sufficiently to bring the confining liquid meniscus onto the graduated portion of the burette, and then close the manifold stopcock.
3. Record the meniscus position. Wait ≥ 4 min.
 - a. Each pipette liquid level must not fall below the bottom of the capillary tubing.
 - b. Burette meniscus must not change >0.2 mL.

FIELD PROCEDURE 3b
Leak-Check of Flexible Bags

Note: There are several variations of this leak-check procedure. Select the appropriate procedure.

A. Procedure A

1. Connect bag to a water manometer.
2. Pressurize the bag to 2 to 4 in. H₂O.
3. Allow the bag to stand for 10 min.
4. Any displacement in the water manometer indicates a leak.

B. Procedure B

This Procedure is a variation of Procedure A.

1. Follow steps A1 and A2.
2. Allow the bag to stand overnight.
3. A deflated bag indicates a leak.

FIELD PROCEDURE 3c
Leak-Check of Non-isokinetic Sampling Trains .

Note: There are several variations of this leak-check procedure. Select the one specified.

A. Procedure A

1. Place a vacuum gauge at the condenser inlet (or other specified point), pull a vacuum ≥ 10 in. Hg, plug the outlet at the quick disconnect, and then turn off the pump.
2. The vacuum must remain stable for ≥ 30 sec.

B. Procedure B

1. Temporarily insert a vacuum gauge at or near the probe inlet.
2. Plug the probe inlet (or other specified point), and pull a vacuum ≥ 10 in. Hg.
3. Note the time rate of change of the dry gas meter dial (must be $\leq 2\%$ of average sampling rate).
4. Carefully release the probe inlet plug before turning off the pump.

C. Procedure C

1. Temporarily insert a vacuum gauge at or near the probe inlet, and temporarily attach a rotameter (0 to 40 cc/min) or a 50-cc soap bubble meter to the dry gas meter outlet.
2. Plug the probe inlet (or other specified point), and pull a vacuum ≥ 10 in. Hg.
3. Note the reading (must be $\leq 2\%$ of average sampling rate).
4. Carefully release the probe inlet plug before turning off the pump.

D. Procedure D (Pump Leak-check)

It is suggested (not mandatory) that the pump be leak-checked separately, either before or after the sampling run. If done before, do it before the train leak-check; if done after, do it after the train leak-check. To leak-check the pump, proceed as follows:

1. Disconnect the drying tube from the probe-impinger assembly.
2. Place a vacuum gauge at the inlet to the pump.
3. Pull a vacuum of ≥ 10 in. Hg, plug or pinch off the outlet of the flow meter, and then turn off the pump (must remain stable for ≥ 30 sec).

E. Procedure E

1. For components after the pump, apply a slight positive pressure.
2. Apply a liquid (e.g., detergent in water) at each joint, and check for gas bubbles.

**SUMMARY SHEET 3A
Oxygen and Carbon Dioxide**

		Run #1	Run #2	Run #3	Avg
Client/Plant Name		FDS 6C			
Job No.		FDS 6C			
Sampling Location		FDS 6C			
Run ID #		FDS 6C			
Test Date		FDS 6C			
Run Start Time		FDS 6C			
Run Finish Time		FDS 6C			
<u>Oxygen</u>					
Average Gas Concentration, dry basis, ppm	\bar{C}	FDS 6C			
Avg System Cal Bias Check Responses for Zero Gas, ppm	C_o	FDS 6C			
Avg System Cal Bias Check Responses for Upscale Cal Gas, ppm	C_m	FDS 6C			
Actual Conc of Upscale Cal Gas, ppm	C_{ma}	FDS 6C			
Effluent gas concentration, dry basis, ppm	C_{gas}	SS 3A			
<u>Carbon Dioxide</u>					
Average Gas Concentration, dry basis, ppm	\bar{C}	FDS 6C			
Avg System Cal Bias Check Responses for Zero Gas, ppm	C_o	FDS 6C			
Avg System Cal Bias Check Responses for Upscale Cal Gas, ppm	C_m	FDS 6C			
Actual Conc of Upscale Cal Gas, ppm	C_{ma}	FDS 6C			
Effluent gas concentration, dry basis, ppm	C_{gas}	SS 3A			

$$C_{gas} = (\bar{C} - C_o) \frac{C_{ma}}{C_m - C_o}$$

**FIELD PROCEDURE 3A
Oxygen and Carbon Dioxide
(Instrumental Analyzer Procedure)**

Note: The procedure for FP 3A is essentially the same as that for FP 6C, except for the obvious changes due to the gases being analyzed. Follow FP 6C (use FDS 6C), except for the following:

A. Variations from FP 6C

1. Obtain calibration gases (CO₂ in N₂ or CO₂ in air or gas mixtures of CO₂/SO₂, O₂/SO₂, or O₂/CO₂/SO₂ in N₂).
2. For O₂ monitors that cannot analyze zero gas, use a calibration gas concentration equivalent to <10% of span for the zero gas.
3. For non-Protocol 1 calibration gases, Method 3 is the reference method and the acceptance criteria is ±5% or 0.2% O₂ or CO₂, whichever is greater (see CDS 6Ca).
4. Initially and whenever changes are made in the instrumentation that could alter the interference response (e.g., changes in the type of gas detector), conduct an interference response test according to FP 20, step B3.
5. Select a measurement site and sampling points using the same criteria that are applicable to tests performed using Method 3B.
6. Run for the same sampling time per run as that used for Method 3B plus twice the stable response time for the instrument.

B. Quality Control Procedures

- The following quality control procedures are recommended when the results of this method are used for an emission rate correction factor, or excess air determination. The tester should select one of the following options for validating measurement results (see FDS 3B):*
1. If both O₂ and CO₂ are measured, use the procedures in Method 3B.
 2. If only O₂ is measured, use an Orsat or Fyrite analyzer to measure the CO₂ concentration at the sample by-pass vent discharge. Run duplicates concurrent with at least one run, and average the results for each run. Then use the procedures in Method 3B.
 3. If only CO₂ is measured, follow the procedure in step B2, except measure O₂. Investigate differences between FP 3A and the duplicate Fyrite analyses of >0.5%.

FIELD PROCEDURE 3B
Emission Rate Correction Factor or Excess Air

Note: This procedure is the same as that in Method 3 except for what follows here and below: Do not use a Fyrite-type gas analyzer without prior approval from the Administrator. Use an Orsat analyzer only in this method. For 4.0% CO₂ or > 15% O₂, the measuring burette of the Orsat must have at least 0.1% subdivisions. It is suggested that both CO₂ and O₂ be measured to validate results.

A. Single-point, Grab Sampling and Analysis

1. **Mandatory:** Leak-check the Orsat analyzer (see FP 3a). Do not proceed without passing this leak-check.
2. In analyzing the sample, make repeated passes through each absorbing solution until two consecutive readings are the same, with three to four passes between readings. (If constant readings cannot be obtained after three consecutive readings, replace the absorbing solution.)
3. **Mandatory:** After the analysis is completed, leak-check the Orsat analyzer.

B. Single-point, Integrated Sampling and Analysis

1. **Mandatory:** The optional leak-checks in FP 3, steps B1 (flexible bag) and B3 (sampling train) are mandatory.
2. **Mandatory:** Leak-check the Orsat analyzer (see FP 3a).
3. Analyze the sample within **4 hr** after the sample is taken.
4. Analyze the sample as in step A2 of the procedure.
5. Repeat the analysis until any three analyses meet the criteria in FDS 3B.
6. Average three acceptable values and report to the nearest 0.1% for CO₂, O₂, or CO.
7. **Mandatory:** After the analysis is completed, leak-check the Orsat analyzer.

C. Multi-point, Integrated Sampling and Analysis

Follow section C of FP 3 and section B of this procedure.

D. Quality Control Procedures

When both CO₂ and O₂ are measured, calculate F_o and compare values against those in FDS 3B-1.

E. Notes

1. Section D does not apply to processes that:
 - a. Remove CO₂ or O₂.
 - b. Add O₂ (e.g., oxygen enrichment) and N₂ in proportions different from that of air.
 - c. Add CO₂ (e.g., cement or lime kilns).
 - d. Have no fuel factor, F_o, values obtainable (e.g., extremely variable waste mixtures).
2. Section D does not detect sample dilution resulting from leaks during or after sample collection.
3. Section D applies to samples collected downstream of most lime or limestone flue-gas desulfurization units as the CO₂ added or removed from the gas stream is not significant in relation to the total %CO₂. The %CO₂ from other types of scrubbers using only water or basic slurry can be significantly affected and would render the F_o check minimally useful.

FIELD DATA SHEET 3B
Emission Rate Correction and Excess Air

Client/Plant Name _____ Job # _____

City/State _____ Date _____

Test Location/Run # _____ Personnel _____

Orsat (Single Point, Grab or Integrated, Sampling and Analysis)							
Orsat ID:		Leak-Check Before OK? _____		Leak-Check After OK? _____			
Time of Sample Collection	Time of Analysis	%CO ₂ Rdg (A)	%O ₂ Rdg (B)	%O ₂ (B-A)	%CO Rdg (C)	%CO (C-B)	%N ₂ (100-C)
Average (report to ±0.1% abs):							
Bag ID:		Triplicates differ by: ≤0.2% for ≤4.0% CO ₂ ? _____ ≤0.2% for ≥15% O ₂ ? _____ ≤0.3% for >4.0% CO ₂ ? _____ ≤0.3% for <3% O ₂ and CO? _____					
Bag Leak-Check OK? Before _____			After _____		Train Leak-Check OK? Before _____		After _____

Note: The Orsat must pass the leak-checks before and after analysis for results to be valid, as well as all mandatory ones.

Multi-point, Integrated Sampling			
Time	Traverse Pt.	Flow Rate, Q	% Deviation
Average			< ± 10%?

% Dev. = $(Q - Q_{avg}) / Q_{avg} \times 100, < \pm 10\%$

% Excess Air = $\frac{\% O_2 - 0.5 \% CO}{0.264 \% N_2 - (\% O_2 - 0.5 \% CO)}$

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

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

DATA VALIDATION

Fuel Type	F _o Range
Coal:	
Anthracite and lignite	1.016 - 1.130
Bituminous	1.083 - 1.230
Oil:	
Distillate	1.260 - 1.413
Residual	1.210 - 1.370
Gas:	
Natural	1.600 - 1.836
Propane	1.434 - 1.586
Butane	1.405 - 1.553
Wood	1.000 - 1.120
Wood bark	1.003 - 1.130

If calculated F_o values are beyond the acceptable ranges shown in this table, investigate the following before accepting the test results:

- Strength of the solutions in Orsat.
- Analyzing technique against air or other known concentration.
- Fuel factor.
- Level of the emission rate relative to the compliance level, i.e.; if the measured emissions are much lower or much greater than the compliance limit, repetition of the test would not significantly change the compliance status of the source and would be unnecessarily time consuming and costly.

An acceptability range of ±12% is appropriate for the F_o factor of mixed fuels with variable fuel ratios.

$$F_o = \frac{20.9 - O_2}{\%CO_2}$$

%CO₂, %O₂, and %CO are on a dry basis. If CO is present in measurable quantities by this method, adjust the O₂ and CO₂ values before calculating F_o as follows:

$$\%CO_{2(ad)} = \%CO_2 + \%CO$$

$$\%O_{2(ad)} = \%O_2 - 0.5 \%CO$$

