SUMMARY SHEET 20
Nitrogen Oxides

			Run #1	Run #2	Run #3	Avg
Client/Plant Name		FDS 20c				
Job No.		FDS 20c				
Sampling Location		FDS 20c				
Run ID #		FDS 20c				
Test Date		FDS 20c				
Run Start Time		FDS 20c				
Run Finish Time		FDS 20c				
Moisture Content, fraction	B_{ws}	FDS 4				
Low-load						
Avg NO_x Concentration, ppm at 15% O_2	C_{adj}	FDS 20c				
Mid-load						
Avg NO_x Concentration, ppm at 15% O_2	C_{adj}	FDS 20c				
Peak-load						
Avg NO_x Concentration, ppm at 15% O_2	C_{adj}	FDS 20c				
Avg O_2 Concentration, %	$\%O_2$	FDS 20c				
Avg SO_2 Concentration, ppm	C_{SO2}	FDS 6				
Avg SO_2 Concentration, ppm at 15% O_2	C_{adj}	SS 20				

$$C_{adj} = C_{SO_2} \frac{5.9}{20.9 - \%O_2}$$

***Note:** If CO_2 is the diluent gas measured, see FDS 20c for determining C_{adj} for SO_2.*

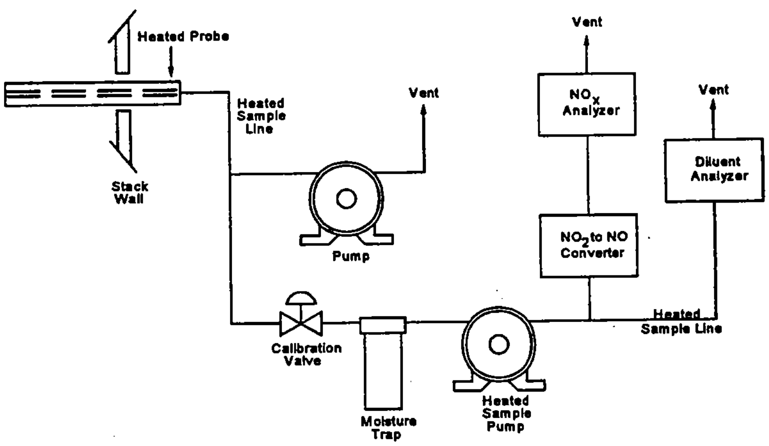

Figure F20-1. Measurement System Design.

FIELD PROCEDURE 20
Nitrogen Oxides and Oxygen
(Gas Turbines)

Note: This procedure is preliminary to the measurement of the stack gases. For measurement of the stack gases, see FP 20a.

A. Calibration Gases

1. Obtain NO_X calibration gases (NO in N_2) as follows:
   a. High-level. 80% to 90% of span value.
   b. Mid-level. 45% to 55% of span value.
   c. Low-level. 20% to 30% of span value.
   d. Zero. <0.25% of span value. Ambient air may be used for the NO_x zero gas.
2. Obtain diluent calibration gases as follows:
   a. High-level. Purified air at 20.9% O_2 or 8% - 12% CO_2 in air.
   b. Mid-level. 11% to 15% O_2 in N_2 or 2% - 5% CO_2 in air.
   c. Zero. Purified N_2 or purified air (<100 ppm CO_2)
3. Use Protocol 1 gases or analyze the cylinder gases within one month of the emission test (see FP 6C, steps A4 and A5 and CDS 20), using Methods 7 and 3 as the reference methods for NO_X and O_2 or CO_2 respectively. Acceptance criteria for each triplicate result must be (from the average) ±10% or ±10 ppm, whichever is greater, for NO_X and ±0.5% O_2 for O_2. For the use of manufacturer's tag values, the triplicate average of the reference methods must be ±5% for NO_X and 0.5% O_2 for O_2. If these criteria are not met, conduct an additional set of three reference test runs until all six runs agree (from the average) within ±10% or ±10 ppm, whichever is greater, for NO_X and ±0.5% O_2 for O_2. Use the average of these six runs as the cylinder gas value.

B. Preliminary Procedures

1. Prepare the system and set up the measurement system. An example of an acceptable system is shown in Figure F20-1.
2. <u>Calibration Error Check</u>. Before each test program, conduct the ***calibration checks*** for both the NO_X and the diluent analyzers as follows:
   a. First, introduce zero gases and the mid-level calibration gases, and set the analyzer output responses to the appropriate levels.
   b. Then, introduce each of the remainder of the calibration gases, one at a time, to the measurement system. Record the responses on FDS 20.
   c. NO_x monitor only: For a valid calibration check the linear curve determined by the zero and mid-level gases must predict the low-level and high-level gas values ±2% of the span value.
3. <u>Interference Response Test</u>. Conduct an ***interference response test*** on each analyzer once before its initial use in the field and after changes are made in the instrumentation that could alter the interference response, e.g., changes in the type of gas detector. Data from interference response tests conducted by the instrument vendor are acceptable.
   a. Introduce the following gases into the measurement system separately, or as gas mixtures.
      - CO: 500 ± 50 ppm
      - SO_2: 200 ± 20 ppm
      - CO_2: 10 ± 1%
      - O_2: 20.9 ± 1%
   b. Record the response of the system to these components in concentration units; record the values on LDS 20.
4. <u>Response Time Test</u>. Conduct the ***response time test*** before each test program and whenever changes are made to the measurement system. Perform three runs, and record the data as shown in FDS 20. A stable value is equivalent to a change of <1% of span value for 30 sec or <5% of the measured average concentration for 2 min.
   a. Introduce zero gas into the system at the calibration valve until all readings are stable; then, switch to monitor the stack effluent until a stable reading is obtained. Record the upscale response time.
   b. Introduce high-level calibration gas into the system. Once the system has stabilized at the high-level calibration concentration, switch to monitor the stack effluent and wait until a stable value is reached. Record the downscale response time.
5. <u>Conversion Efficiency</u>. Determine the ***NO_2 to NO conversion efficiency*** (if applicable, e.g., NO_2 ≥5% of total NO_X) before each test program. A converter is not necessary if the NO_2 portion of the exhaust gas is less than 5% of the total NO_x concentration or if

the gas turbine is operated at 90% or more of peak load capacity.. (The NO_2 to NO converter check described in title 40, Part 86: Certification and Test Procedures for Heavy-duty Engines for 1979 and Later Model Years, may be used. Attach appropriate FDS.)

a. Add gas from the mid-level NO in N_2 calibration gas cylinder to a clean, evacuated, leak-tight Tedlar bag. Dilute this gas approximately 1:1 with 20.9% O_2, purified air.

b. Immediately attach the bag outlet to the calibration valve assembly and begin operation of the sampling system. Operate the sampling system, recording the NO_x response for at least 30 min. **See FDS 20.**

FIELD DATA SHEET 20
Analyzer Zero, Calibration, Response Time, Conversion Efficiency

Client/Plant Name ______________________ Job # __________

City/State ______________________ Date __________

Test Location ______________________ Personnel ______________________

NO_X Analyzer ID# ______________ Span value ______________ ppm

Diluent Analyzer ID# ______________ Span value ______________ % (O_2 or CO_2)

Determine Calibration Error prior to the first test run:

		Calibration Gas		Analyzer	Cal Error Result
		Cylinder ID #	Gas Value (ppm or %)	Response (ppm or %)	(% of span)
NO_x Analyzer	Zero				
	Low-level				
	Mid-level				
	High-level				
Diluent Analyzer	Zero				
	Mid-level				
	High-level				

____ NO_x ≤2% of span?

____ Diluent ≤2% of span?

$$\% \text{ Cal Error} = \frac{\text{Analyzer Response} - \text{Gas Value}}{\text{Span Value}} \times 100$$

Determine Response Time:

	NO_X Analyzer		Diluent Analyzer (O_2 or CO_2)	
Run No.	Upscale (sec.)	Downscale (sec.)	Upscale (sec.)	Downscale (sec.)
1				
2				
3				
Average				
Slower Time				

The slower time is the system response time.

____ Stable Response = <1% span value for 30 sec or <5% of 2-min average?

NO_2-NO Converter Efficiency

Peak response recorded during test ________

Response recorded at end of 30 minutes ________ (Attach strip chart or recorder readout)

% Decrease from peak response ________ (≤2%?)

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: ______________________ ______________________

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

FIELD DATA SHEET 20 (Continued)
Zero and Calibration Drift

Client/Plant Name ______________________ Job # __________

City/State ______________________ Date __________

Test Location ______________________ Personnel __________

Determine %Drift after every test run:

Run #	Condition	Cylinder Value	Analyzer Response		Difference	% Drift
			Initial	Final	(Initial - Final)	
1	NO_x Analyzer					
	Zero					
	Mid-level					
	Diluent Analyzer					
	Zero					
	Mid-level					
2	NO_x Analyzer					
	Zero					
	Mid-level					
	Diluent Analyzer					
	Zero					
	Mid-level					
3	NO_x Analyzer					
	Zero					
	Mid-level					
	Diluent Analyzer					
	Zero					
	Mid-level					

$$\% \text{ Drift} = \frac{|\text{Difference}|}{\text{Span Value}} \times 100$$

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

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

LABORATORY DATA SHEET 20
Interference Response

Date ______________________ Personnel ______________________

Analyzer Type ______________________ Analyzer ID# ______________________

Test Gas	Nominal Concentration	Actual Concentration	Analyzer Response	% of Span
Method 20			***Span Value:***	
CO	500 ± 50 ppm			
SO_2	200 ± 20 ppm			
CO_2	10 ± 1 %			
O_2	20.9 ± 1%			
Method:			***Span Value:***	

$$\% \text{ of Span} = \frac{\text{Analyzer Response}}{\text{Instrument Span}} \times 100$$

_____ Sum of the interference responses to the test gas for either the NO_x or diluent analyzer <2% of span value?

QA/QC Check

Completeness _____ Legibility _____ Accuracy _____ Specifications _____ Reasonableness _____

Checked by: ______________________ ______________________

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

CALIBRATION DATA SHEET 20
Analysis of Calibration Gases

Date ______________________ *(Must be within 1 month before the test)* NO_X Span ____________________

Cylinder ID#: Zero: ______________ Low: ______________ Mid: ______________ High: ______________

Reference Method for NO_X ______ *(Attach appropriate data sheets)* Personnel ______________________

NO_x			
Run No.	Low-Level	Mid-Level	High-Level
1			
2			
3			
4			
5			
6			
Average	*(20%-30% of span value?)*	*(45%-55% of span value?)*	*(80%-90% of span value?)*
Max % Dev			
Tag Value, ppm			

____ Max %Dev ≤ ±10% or ±10 ppm from average?

____ Average ppm ≤ ±5% of tag value? *If not, use the average of the six runs as the cylinder value.*

Cylinder ID#: Zero: ____________________ Mid: ____________________ High: ____________________

Reference Method used ______ *(Attach appropriate data sheets)* Personnel ______________________

Diluent (O_2 or CO_2)		
Run No.	Mid-Level	High-Level
1		
2		
3		
4		
5		
6		
Average	*(11%-15% O_2?) or (2%-5% CO_2?)*	*(20.9% O_2?) or (8%-12% CO_2)*
Max % Dev		
Tag Value, ppm		

____ Max % Dev ≤ ±0.5% O_2 or CO_2 from average?

____ Average %O_2 ≤ ±0.5% O_2 or CO_2 from tag value? *If not, use the average of the six runs as the cylinder value.*

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: ________________________________ ________________________________

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

FIELD PROCEDURE 20a
Gas Turbines

Note: Before conducting this procedure, see FP 20.

A. Sampling Site and Traverse Points

1. Select a sampling site as close as practical to, but not within 5 ft or 2 D_e (whichever is less) of, the turbine exhaust to the atmosphere.
   a. Whenever possible, locate the sampling site upstream of the point of introduction of dilution air into the duct.
   b. Locate sample ports before or after the upturn elbow to accommodate the configuration of the turning vanes and baffles and to permit a complete, unobstructed traverse of the stack.
   c. For supplementary-fired, combined-cycle plants, locate the sampling site between the gas turbine and the boiler.
2. Select a minimum number of preliminary diluent traverse points as follows:
   a. For the following cross-sectional areas,
      - <16.1 ft^2, use 8 points.
      - 16.1 to 107.6 ft^2, use 8 plus one additional sample point for each 2.2 ft^2 above 16.1 ft^2.
      - >107.6 ft^2, use 49 (48 for circular stacks).
   b. For circular ducts, use a multiple of 4 points, and for rectangular ducts, use a balanced matrix, i.e., 3x3, 4x3, 4x4, 5x4, 5x5, 6x5, 6x6, 7x6, or 7x7. Round off the number of points (upward), when appropriate.
3. Use Method 1 to locate the preliminary diluent traverse points.

B. Preliminary Diluent Measurements

1. While the gas turbine is operating at the lowest percent of peak load, measure the O_2 or CO_2 concentration at each traverse point for at least 1 min plus the average system response time. Record the average steady-state concentration of O_2 or CO_2 at each point on FDS 20a.
2. Select 8 sampling points at which the lowest O_2 concentrations or highest CO_2 concentrations were obtained. Use these same points for all the test runs at the different turbine load conditions.

C. NO_x and Diluent Measurements

Conduct three test runs at each of the specified load conditions as follows:

1. At the beginning of each NO_x test run and, as applicable, during the run, record turbine data as indicated in FDS 20b. Also, record the location and number of the traverse points on a diagram (see FDS 20a)
2. Determine the average steady-state concentration of diluent and NOx at each of the selected traverse points and record the data on FDS 20c. Sample at each point for at least 1 min plus the average system response time.
3. After sampling the last point, record the final turbine operating parameters.
4. Immediately after each test run at each load condition or if adjustments are necessary for the measurement system during the tests, determine the calibration drifts at zero and the mid-level values. Make no adjustments to the measurement system until after the drift checks are made. Record the data on FDS 20. Exceedance of the specified limits invalidates the test run preceding the check. Alternatively, recalibrate the measurement system and recalculate the measurement data. Report the test results based on both the initial calibration and the recalibration data.

D. SO_2 Measurement

Determine the SO_2 concentration at only the 100% peak load condition using Method 6, or equivalent, during the test. If fuel sampling and analysis is used to demonstrate compliance and the fuel sulfur content meets the limits of the regulation, this test is not required.

1. Select at least 6 points from those required for the NO_x measurements; use two points for each sample run.
2. Sample at each point for at least 10 min.
3. Use the average of the diluent readings obtained during the NO_x test runs at the traverse points corresponding to the SO_2 traverse point, to correct the integrated SO_2 concentrations to 15% O_2.

FIELD DATA SHEET 20a
Preliminary Diluent Traverse

Client/Plant Name ______________________ Job # ______________ Date ________

City/State ______________________________ Personnel ______________________

Turbine ID: Manufacturer/Type ______________________ Serial # ______________

Sampling Site Dist from Exhaust ________ *($\leq$5 ft or 2 D_e, whichever is less?)* Cross-Section Area, A ________ ft^2

No. of Traverse Pts ________ 16.1 ft^2 = >8; 16.1 to 107.6 ft^2 = 8 + A/2.2; >107.6 ft^2 = 49 (48 for circ. ducts)

Load ____________ *(Turbine operating at the lowest percent of peak load?)*

Traverse Pt	Diluent Conc. (%)	Traverse Pt	Diluent Conc. (%)	Traverse Pt	Diluent Conc. (%)	Traverse Pt	Diluent Conc. (%)

Circle traverse points selected for NO_X measurements. Sketch a diagram of sampling site and cross-section below.

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ___

Checked by: ______________________________ ______________________________

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

FIELD DATA SHEET 20b
Gas Turbine Operation Record

Client/Plant Name ______________________ Job # ______________ Date __________

City/State ______________________ Personnel ______________________

Turbine ID: Manufacturer/Type ______________________ Serial # ______________

Fuel Ultimate Analysis		***Trace metals (used in smoke suppression)***	
C		Na	
H		Va	
O		K	
N		etc.	
S			
Ash			
H_2O			

Indicate units where applicable.

Load/Run #	Time	Fuel Flow Rate	Steam/Water Flow Rate	Amb Temp	Amb Humidity	Amb Pressure

Describe fuel flow and water or steam flow rate measurement methods.

____

____

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: ______________________ ______________________

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

FIELD DATA SHEET 20c
Gas Turbine Emissions

Client/Plant Name ______________________ Job # ____________ Date __________

City/State ______________________________ Personnel ______________________

Turbine ID: Manufacturer/Type ______________________ Serial # ______________

NO_X Analyzer Type/ID # ____________________ Diluent Analyzer Type/ID # ____________

Indicate units where applicable. Use the average steady-state value (concentrations) from recorder or instrument readout.

Load/Run #:		**Amb temp:**		**Amb pressure:**			
Sample Pt	Clock Time (min)	Diluent (%)	NO_X (ppm)	Sample Pt	Clock Time (min)	Diluent (%)	NO_X (ppm)
Load/Run #:		**Amb temp:**		**Amb pressure:**			
Sample Pt	Clock Time (min)	Diluent (%)	NO_X (ppm)	Sample Pt	Clock Time (min)	Diluent (%)	NO_X (ppm)
Load/Run #:		**Amb temp:**		**Amb pressure:**			
Sample Pt	Clock Time (min)	Diluent (%)	NO_X (ppm)	Sample Pt	Clock time (min)	Diluent (%)	NO_X (ppm)

QA/QC Check

Completeness ____ Legibility ____ Accuracy ____ Specifications ____ Reasonableness ____

Checked by: ______________________________ ______________________________

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