California Environmental Protection Agency

AIR RESOURCES BOARD

AIR QUALITY SURVEILLANCE BRANCH

ACCEPTANCE TEST PROCEDURE (ATP)

FOR

Teledyne Advanced Pollution Instrumentation Model 200E Nitrogen Oxides Analyzer

AQSB ATP 101

First Edition

MONITORING AND LABORATORY DIVISION

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California Environmental Protection Agency
AIR RESOURCES BOARD

Approval of Acceptance Test Procedure

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Teledyne API Model 200E Nitrogen Oxides Analyzer

1.0 ACCEPTANCE TEST PROCEDURE

1.1 General Information:

The following outlines the California Air Resources Board Air Quality Surveillance Branch (AQSB) acceptance test procedures for the Teledyne Advanced Pollution Instruments Model 200E Chemiluminescence Nitrogen Oxides (NO/NOx) Analyzer (API 200E).

Before beginning acceptance testing of the API 200E Analyzer, read the Instruction manual thoroughly to become familiar with the theory of operation, hardware, and software of the instrument. Initiate an acceptance test file, which will include the following AQSB documents:

1. Instrument Lab Test Log (Appendix A)
2. Instrument Lab Test Report (Appendix B).
3. Test Data Sheets (Appendix C and D).
4. Strip Chart Records

Record the dates of the individual tests, problems, contacts with the manufacturer, and any other pertinent information on the Instrument Lab Test Log.

Start an Instrument Lab Report sheet recording the instruments serial #, ARB barcode, date and technician info. Use the Lab Report sheet, Test data sheets 1 and 2(TDS1/TDS2) while following this procedure.

1.2 Physical Inspection:

The physical, operational, and performance checks listed in the Instrument Lab Test Report (Appendix B) are designed to verify that the API 200E meets or exceeds the specifications required by the AQSB. The physical and performance specifications of the instrument, as required by the AQSB, are located on the AQSB Air Monitoring Web Manual (Total Oxides of Nitrogen Analyzer Specifications). Questions about procedures and methodologies can usually be answered by referring to instructions within the Instruction manual.

1. Prior to pre-acceptance testing procedures, unpack the instrument and inventory all the parts noted in the shipping document. All documents shipped with the instrument, including any factory calibration reports, should be placed in the instrument's file.

2. The cover of the instrument should be carefully removed. Proper care and precautions should be taken to avoid electro-static discharge when

working in and around the unit, including the use of grounding straps or anti-static clothing and/or footwear. Inspect the exterior and interior of the unit for obvious shipping damage or unexpected changes. Note any optional equipment installed.

3. Check the instrument for loose or broken parts, loose or damaged boards, loose fittings or connections and any damaged or kinked sample lines.

4. Refer to the Instruction manual section ‘Getting Started’ section 3.0, to identify the location of shipping screws and the power configuration plug. Remove any screws on panel sides if necessary.

1.3 Pre-Acceptance Testing Procedures:

Prior to beginning acceptance testing of the API 200E, procure all necessary testing apparatus and refer to ARB’s specifications used to purchase the analyzer(s).

Acceptance testing will require a ‘clean air’ source, a multi-gas calibrator, a sample manifold, and the use of a certified mass-flow transfer standard capable of measuring the nominal flow-rates of the API 200E.

1. A testing station should be set up for calibration and repeatability checks. A source of zero-air and span gas should be connected to separate ports of a certified gas calibrator. It is recommended that a span gas with an NO concentration equal to 80% of the measurement range for the desired application is used.

2. The output of the calibrator should be connected to a gas manifold.

3. Connect one outlet from the manifold to the SAMPLE input of the API 200E.

4. Be sure to input the concentration information for the span gas being used into the calibrator.

For proper acceptance testing, a strip chart recorder should be connected to the analyzers analog output(s) so that instrument may be properly monitored and evaluated.

Recorder charts should be properly documented and labeled at the bottom with the following:

1. Test Performed
2. Date and Time of Test(s)
3. Manufacturer, Model Number and Serial Number
4. Instrument Range, Trace Colors, Parameter Identification

Clear and precise notations should be entered on the chart indicating when the tests were started and ended, pertinent information regarding analyzer performance and any unusual conditions observed. Charts should be cut into 24 hour sections from 0000 hrs to 2359 hrs and attached to the final instrument lab testing documents.

1.4 Operational and Performance Checks:

The steps listed in the Instrument Lab Test Report should be completed in order and as described. This will ensure that all instruments are tested in a similar fashion. When appropriate, refer to the manufacturer's Instruction manual for complete details on instrument operation.

1. Begin by connecting a ¼" Teflon® sample line from a vented testing manifold to the API 200E Sample Inlet port. The pressure of the sample gas should be equal to ambient atmospheric pressure.

2. The Exhaust port on the API 200E should be connected to the external vacuum pump supplied from the manufacturer.

Make a cable for the analog outputs. Find an 8 wire bundle and set it up to connect one side to the analog output green connector on the back of the API 200E and the other to the back of a strip chart recorder.
(see instruction manual section 3.3.2 figures 3-5 and table 3-4).

- A1 refers to NOx
- A2 refers to NO
- A3 refers to NO_2
- A4 (test channel)

Operational Checks:

1. Verify all previous connections are correct.
2. Plug in unit.
3. Plug in vacuum pump.

4. Turn unit on.
5. Check for the proper start-up sequence. (Instruction manual section 3.5.1, Start-up). Check the display for anomalies and proper contrast levels.

6. Allow the instrument to warm up at least 30 minutes. Note any abnormal warning messages which may appear in the display (Instruction manual 3.5.3 Warning Messages, and table 3-9: Possible Warning Messages at Start-Up).

7. Check to make sure that the analyzer is functioning within allowable operating parameters. Scroll through the front panel test functions (Instruction manual Section 3.5.4, Functional Check). Compare these to the expected values and the ***Final Test and Validation Data Sheet*** provided by the manufacturer upon instrument delivery.

8. Set the clock for correct ***Pacific Standard Time*** (no daylight savings) and date (Instruction manual Section 7.4.3, Clock).

9. Verify the unit's serial number and note the software revision level of the firmware installed from the configuration menu (SETUP-CFG-NEXT). Record on Instrument Lab Test Report.

10. Check the operating voltage of the API200E set from the factory under 'Voltage Signals and Outputs' on the 2nd page of manufacturer's **Final Calibrated Test and Validation data sheet.** Operating voltage must be set to 0-1vdc. If output voltage is not correct then refer to Instruction manual 8.4.1 (Accessing the Analog Output Signal Configuration submenu) and follow the Analog I/O Configuration on page 125. Change all three conc_out_ to **1v**. This will set the instrument operating range to a 0-1vdc analog output range.

11. Enable AutoCal for the analog outputs. Follow the procedure (Instruction manual 8.4.3.1. Enabling the Auto Cal for an Individual Analog Output).

12. Auto Calibration. Follow procedure (Instruction manual 8.4.3.2. Automatic Calibration of the Analog Outputs)

13. Check the accuracy and proper operation of the analog outputs. Perform an electronic analog output voltage step test at 0, 20, 40, 60, 80 and 100%. Confirm the required output voltages 0-1vdc (on chart reader) based on the above percentages. Follow procedure (Instruction manual Section 14.8.6.1, Test Channel/Analog Outputs Voltage) Record voltages on TSD1.

Performance Checks:

1. Vacuum leak and pump check:

   With the analyzer turned on, wait for flows to stabilize. Cap the Sample Inlet port (wrench-tight). After pressures have stabilized, note the SAMP (sample pressure) and the RCEL (vacuum pressure) readings. If both readings are equal to within 10% and less than 10 in-Hg-A, the instrument is free of large leaks and the pump is in good condition. If a large leak is suspected, check plumbing, tubing, fittings etc. to determine where leak may be occurring. Record readings on TSD1.

2. Air Sample flow check:

   Perform a flow verification using a certified flow meter capable of measuring approximately 1 Standard liter per minute (Slpm). Attach the outlet port of the flow meter to the Sample Inlet port on the rear panel. Ensure that the inlet to the flow meter is at atmospheric pressure. Using the equation supplied with the certified flow meter, calculate the flow rate and compare it to the nominal value listed by the manufacturer, based on the instrument's configuration. If necessary, troubleshoot any flow issues. Adjust the display on the API 200E to match the actual flow-rate. (Instruction manual Section 10.7, Gas Flow Calibration). Record readings on TSD1.

3. Ozone Sample flow check:

   Perform an ozone flow verification using a certified flow meter capable of measuring approximately 100 sccm. Note: When working with the ozone filter/purifier, be sure to cap any disconnections as quickly as possible to avoid contamination from ambient air. Disconnect the black, 1/8" tube connecting the ozone filter/purifier to the critical flow orifice on the reaction cell, at the ozone filter/purifier (see Figure 1-1 on next page). Connect the black, 1/8" tube to the outlet of the flow meter. Ensure that the inlet to the flow meter is at atmospheric pressure. Using the equation supplied with the certified flow meter, calculate the ozone flow rate and compare it to the nominal value listed by the manufacturer, based on the instrument's configuration. If necessary, troubleshoot any flow issues. Adjust the display on the API 200E to match the actual flow-rate (Instruction manual Section 10.7, Gas Flow Calibration). Record readings on TSD1.

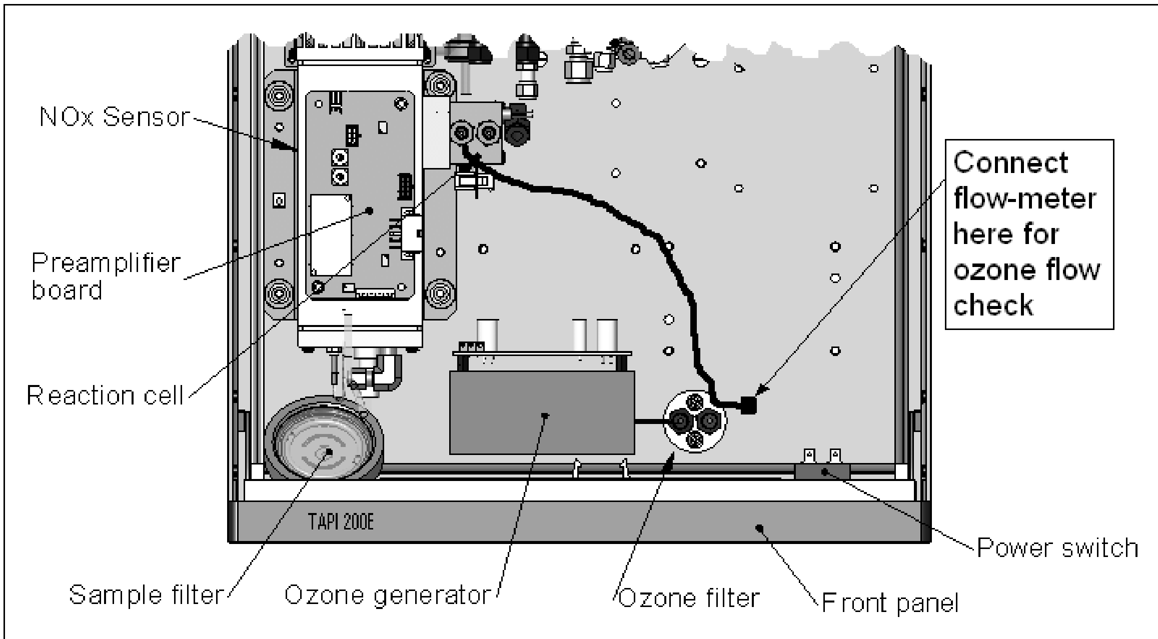

Figure 1-1: Ozone Flow Check Connection

4. Basic Calibration:

   Zero/Span calibration. Set the appropriate CONC values to match the span gas being used. (See Formula and calculations' sheet in Appendix E) of this procedure. Perform a basic calibration procedure based on the instrument's factory configuration. (Instruction manual Section 3.6.2.3., 'Initial Zero/Span Calibration Procedure'). Record the calibration values (NO/NOx slope and NO/NOx offsets) on TDS1. Compare the calibration results to the nominal factory calibration as listed on the 'Final Test and Validation Data Sheet'.

5. Linearity Check:

   Perform a multi-point linearity check against a certified gas calibrator at the rates listed on Test Data Sheet 2. You can modify TDS2 target NO depending on your gas bottle concentrations. For target 03, use 80% of your target NO numbers. Allow time for the flow rates and concentration values to stabilize (NOX STB ≤ 0.5ppb). For each target concentration, record the values from the API 200E display and the actual concentration" from the display of the gas calibrator.

   For each target, calculate the difference (in ppb) and the accuracy (in %) of the gas calibrator's actual NO output from the displayed NO value of the test instrument. In addition, perform an overall percent accuracy calculation for the entire range by taking the summation of the gas calibrator's actual NO concentrations (S2) and the summation of the test instrument's displayed concentrations (S1) and performing the following calculation:

$$\text{Overall \% Accuracy} = \left(\frac{S1 - S2}{S2}\right) * 100$$

Calculate the correlation between the displayed results on the API 200E and the results from the gas calibrator. At each set-point, the test instrument should agree to within ±1% or 3 ppb (whichever is greater) of the reference gas calibrator. The overall percent accuracy must agree to within ±2% of the reference gas calibrator. Note: the data obtained from the tests can be input into the TDS2 Excel spreadsheet to avoid calculation errors and enable work to be saved and/or printed.

Using the target values and flow-rates from the linearity test, check the NO_2 converter efficiency of the API 200E. For each NO set-point, command the gas calibrator to output ozone at a 1: 0.8 ratio. Record the actual ozone output from the calibrator, and the displayed values from the API 200E. Calculate the converter efficiency using the formula in figure 1-2, below. The converter efficiency should be between 96 - 102% as per U.S. EPA requirements.

LINEARITY CHECK								
CALIBRATOR			INSTRUMENT					
Target NO (ppb)	Actual NO (ppb)	Actual O3 (ppb)	Instrument Display NO	NO2	NOx	Difference (NO ppb)	Accuracy (NO %)	Converter Efficiency (%)
500			A		C			
500			B		D			E
400								
400								

$$E = \frac{(A - B) - (C - D)}{(A - B)}$$

Figure 1-2: Calculating Converter Efficiency

6. Repeatability Check:

   Check the repeatability of the API 200E's ability to measure NO gas. Program the gas calibration system to produce a range of NO gas through the testing manifold, including zero, low (100ppb), and high (400ppb) levels. Each level should be run for a minimum of 30 minutes in duration. Run the test program for a minimum of 72 hours. Record the output of the API 200E on a strip-chart recorder. For each target value, note the average "percentage of chart" and the percentage of deviation from the first day's values. Record on TDS2

7. Warning Messages:

   Test the instrument for warning messages by simulating failures; i.e. Disconnect pump, block flows, change pressures, etc.

8. Data Acquisition System (DAS):

   View the instrument's built-in data acquisition system (Instruction manual Section 6.10, Setup - Data Acquisition System). Review previous concentration data and other default parameters listed in the data channels (SETUP, DAS, VIEW). Look for obvious changes during daily testing or changes in concentrations due to normal diurnal variations (cycles).

9. Communication:

   Test the API 200E's ability to communicate with a computer through the RS-232 port. Connect a computer to the RS-232 port. The small switch below the RS-232 port should be set to DTE mode. Once properly connected, both of the indicator LEDs (red and green) above the RS-232 port should be lit. Further details for set-up and/or troubleshooting can be found in the Instruction manual Section 6.9, Setup – Communication Ports (COMM). Install and run the manufacturer's APICOM software on the computer, using it to operate the instrument through the virtual front panel. View and/or change various analyzer functions such as clock, time of day, analyzer range and system diagnostics. Verify the ability to obtain and view data from the iDAS function in the APICOM software.

1.5 Post-Acceptance Test Procedures:

1. Review and finalize the test reports and data sheets, noting any discrepancies from the manufacturer's specifications or specified requirements.

2. Complete the Instrument Lab Test Log.

3. Ensure copies of all testing documentation are placed in the instrument's folder, submitting separate copies for review to the Operations Support Section Manager.

4. If all test data is approved, send the instrument to the stockroom for bar-coding and field assignment. Note the newly assigned barcode on any related paperwork

INSTRUMENT LAB TEST LOG

Manufacturer: ____________________ Model # : ____________________

Technician: ____________________ S/N : ____________________

ARB Barcode #: ____________________

Date	Action

INSTRUMENT LAB TEST REPORT
Teledyne API Model 200E NO/NOx Analyzer

Serial Number: ____________________
ARB Bar Code: ____________________

Date Started: ____________________ Tested By: ____________________
Date Completed: ____________________ Reviewed By: ____________________
Overall Results: ____________________ Date: ____________________

Physical Inspection	Notes	Initials
1. Unpack and inventory parts.	____________	______
2. Check for shipping damage. Confirm installed options.	____________	______
3. Check all connections and plumbing.	____________	______
4. Check for shipping screws and proper power phasing.	____________	______

Operational Checks

1. Verify proper start-up sequence and check display.	____________	______
2. Allow instrument warm-up.	____________	______
3. Check operating parameters against nominal values.	____________	______
4. Set the clock.	____________	______
5. Verify serial number. Note software version.	____________	______
6. Configure analog outputs. Perform voltage step-test. Note results on Test Data Sheet 1 (TDS1).	____________	______

Performance Checks

1. Leak and pump check. Note results on TDS1.	____________	______
2. Flow rate check. Adjust flow display. Note results on TDS1.	____________	______

Performance Checks (continued)	Notes	Initials
3. Check ozone flow. Adjust flow display. Note results on TDS1.		
4. Perform basic calibration. Compare results to nominal values. Note results on TDS1.		
5. Check linearity. Note results on TDS2.		
6. Check converter efficiency. Note results on TDS2.		
7. Perform 72 hour repeatability check. Note results on TDS2.		
8. Simulate failures. Test for warnings.		
9. Review DAS from front panel.		
10. Connect via RS-232 port. Test connection, APICOM and iDAS functions.		

Post-Acceptance Test Procedures

1. Review and finalize test reports and data sheets. Note discrepancies.		
2. Finalize the Instrument Lab Test Log.		
3. Submit copies of all documentation to the OSS Manager for review.		
4. When approved, barcode instrument and send to the stockroom for field assignment.		

CALIFORNIA AIR RESOURCES BOARD
INSTRUMENT LABORATORY
TEST DATA SHEET 1

DATE: ______________________ **TECHNICIAN:** ______________________

Instrument Under Test		**Transfer Standard**	
Make:	Teledyne-API	Make/Model:	
Model:	200E NOx analyzer	Serial #:	
Serial #:		Bar Code:	
Bar Code:		Date Certified:	

Range: ______

Analog Output Step Test

SIGNAL %	A1	A2	A3	A4
0				
20				
40				
60				
80				
100				

Leak and Pump Check

READING	UNITS	NOMINAL	FACTORY OBSERVED	DISPLAYED AT AMBIENT	DISPLAYED DURING TEST
RCEL	in-Hg-A				
SAMP	in-Hg-A				

Sample and Ozone Flow Checks

READING	UNITS	NOMINAL	FACTORY OBSERVED	DISPLAYED	AS TESTED
SAMP FLW	cm^3/min				
OZONE FL	cm^3/min				

Calibration

READING	UNITS	NOMINAL	FACTORY OBSERVED	AFTER CALIBRATION
NOx SLOPE	-			
NOx OFFSET	mV			
NO SLOPE	-			
NO OFFSET	mV			

CALIFORNIA AIR RESOURCES BOARD
INSTRUMENT LABORATORY
TEST DATA SHEET 2

Start Date: ____________ **End Date:** ____________ **Tech:** ____________

Calibrator:

Make:	
Model:	
Serial #:	
Bar Code:	

Test Instrument:

Make:	Teledyne-API
Model:	M200E NOx analyzer
Serial #:	
Bar Code:	

LINEARITY CHECK

CALIBRATOR			INSTRUMENT					
Target NO (ppb)	Actual NO (ppb)	Actual O3 (ppb)	Instrument Display			Difference (NO ppb)	Accuracy (NO %)	Converter Efficiency (%)
			NO	NO2	NOx			
400						0.0	#DIV/0!	
400								#DIV/0!
200						0.0	#DIV/0!	
200								#DIV/0!
100						0.0	#DIV/0!	
100								#DIV/0!
50						0.0	#DIV/0!	
50								#DIV/0!
40						0.0	#DIV/0!	
40								#DIV/0!
30						0.0	#DIV/0!	
30								#DIV/0!
20						0.0	#DIV/0!	
20								#DIV/0!
10						0.0	#DIV/0!	
10								#DIV/0!
0						0.0	-	
Sigma S2=	0.0	**Sigma S1=**	0.0		**Average Converter Efficiency:**			#DIV/0!
	Overall Accuracy:		#DIV/0!					
	Correlation:		#DIV/0!					

72 Hour Repeatability

	TARGET (NO)	% of CHART	% DEV
	0		-
	90		-
	400		-
	0		#DIV/0!
	90		#DIV/0!
	400		#DIV/0!
	0		#DIV/0!
	90		#DIV/0!
	400		#DIV/0!
	0		#DIV/0!
	90		#DIV/0!
	400		#DIV/0!

Final Test and Validation Data

Parameter	Units	Value	Nom. Range
RANGE	PPB		500 (std)
NOX STB	PPB		< 2 w/ z-air
SAMP FLW	cm^3/min		530 ± 50
OZONE FL	cm^3/min		80 ± 15
PMT	mV		0 ± 50 w/ z-air
NORM PMT	mV		0 ± 10 w/ z-air
AZERO	mV		-20 to +150
HVPS	V		420 to 900
RCELL TEMP	°C		50 ± 1
BOX TEMP	°C		ambient + 3 to 7
PMT TEMP	°C		7 ± 2
MOLY TEMP	°C		315 ± 5
RCEL	in Hg A		2 - 10 (constant)
SAMP	in Hg A		ambient -1" ± 1"
NOX SLOPE	-		1.000 ± 0.300
NOX OFFS	mV		-20 to +150
NO SLOPE	-		1.000 ± 0.300
NO OFFS	mV		-20 to +150

<u>Formulas and Calculations</u>

To use **Concentration Mode** on Environics 9100

Use the values you recorded when you set up the 9100 on your rack. (Environics 9100 Flow Check Test Data Sheet) **GAS** Mass Flow.

True Gas = Slope*(Target Flow on 9100 display for gas) +/- Intercept i.e.…
1.0132(38.5) + 1.25=**40.25ccm**

True Air = Slope*(Target Flow on 9100 display for air) +/- Intercept i.e.…
1.0095(9.97) - 0.0436=10.02 lpm x 1000 to convert to ccms = **10020 ccm**

$$\text{Expected Gas} = \frac{\text{Bottle concentration x Gas flow}}{\text{Total Flow (Air+Gas)}} = \frac{104.0(\text{NO}) \times (\mathbf{40.25})}{\mathbf{10020 + 40.25}} = \mathbf{416ppb}$$

To use **Air Flow Mode** on Environics 9100 (preferred way)

Use the values you recorded when you set up the 9100 for your rack. (Environics 9100 Flow Check Test Data Sheet)**AIR** Mass Flow.

- Go to W:\ Instrument Information\Expected Concentrations.xls
- Click on "Exp.out" tab on bottom of Excel sheet.
- Put in your gas cylinder concentration in the Cylinder Conc. (ppm) section at top of Expected Concentration Calculations table.
- Next you will type in the AIR/N2 flow section table the Air flow that you are using for your 9100. (i.e. 10LPM's) But use the Xfer Std True Flow Rate from the Air mass flow sheet (i.e. 10.09 LPM's)
- Change this number to ccm's. (10.09lpm=10090ccm)
- In the next column under Gas Flow, enter the values from your 9100 Xfer Std True Flow Rate Gas.
- You will now have new numbers in Expected Gas Conc. In ppm or ppb
- These numbers will be your expected numbers on your 200E for NO and NOx. See example table below.

Cylinder Conc. (ppm) 104

AIR/N2 FLOW (ccm)	GAS FLOW (ccm)	EXPECTED GAS CONC. (ppm)	EXPECTED GAS CONC. (ppb)
10090	89.87	0.918	918
10090	80.19	0.820	820
10090	70.32	0.720	720
10090	60.34	0.618	618
10090	50.16	0.514	514
10090	40.08	0.411	411
10090	30	0.308	308
10090	19.83	0.204	204
10090	9.95	0.102	102
18080	4.86	0.028	28

For example, when you run your 9100 with the Air Flow at 10 lpm's and a Gas concentration of 90ccm's, then you should see close to 918 on your 200E for NO and NOx.