California Environmental Protection Agency
AIR RESOURCES BOARD

AIR QUALITY SURVEILLANCE BRANCH

ACCEPTANCE TEST PROCEDURE (ATP)

FOR

Teledyne Advanced Pollution Instruments Model 400 E Ozone Analyzer

AQSB ATP 002

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 400 E Ozone Analyzer

1.0 ACCEPTANCE TEST PROCEDURE

1.1 General Information:

The following outlines the California Air Resources Board Air Quality Surveillance Branch's (AQSB) acceptance test procedures for the Teledyne Advanced Pollution Instruments Model 400E Ozone Analyzer (API 400E).

Before beginning acceptance testing of the API 400E Ozone Analyzer, read the operating manual thoroughly to become familiar with the theory of operation and hardware of the instrument. Initiate an instrument test report (Appendix A) and an instrument lab test log (Appendix B). Record the dates of the individual tests, problems, and contacts with the manufacturer, and any other pertinent information on the test log.

1.2 Physical Inspection:

Unpack instrument and inventory all the parts noted in the shipping document (power cords, manuals, side rails etc.) Check for any shipping damage and incorrect or damaged parts or sub-assemblies. Visually inspect instrument for loose or broken parts, loose or damaged boards, loose fittings or connections and any damaged or kinked sample lines. Assemble all parts as necessary for proper operation of the instrument.

1.3 Pre Acceptance Testing Procedures:

Prior to beginning acceptance testing of the API 400E, procure all necessary testing apparatus and refer to ARB's specifications used to purchase the analyzer(s).

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 of Test

3. Manufacturer, Model Number and Serial Number

4. Instrument Identification (serial number), Range, Trace Color, 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. Plug unit into 115 VAC receptacle and turn on power with front panel power switch.

2. Observe display for proper start-up sequence and note software version (operating manual Section 3.2.1, Start-up).

3. Set clock (as needed) for correct Pacific Standard Time and date (operating manual Section 6.3.5, Time of day clock (CLK)).

4. Set instrument testing parameters (range, flowrate, averaging time ect.).

1.4 Physical, Performance and Operational Checks:

The physical, performance and operational checks of the API 400E are designed to verify that the instrument meets or exceed the specifications required by the ARB. The Air Quality Surveillance Branch's Operations Support Section uses the physical and performance specifications listed in Appendix D and E respectively to acceptance test the API 400E. The operational checks are as follows:

Operational Checks:

1. Connect analog output to strip chart recorder (operating manual Table 3-1, Analog Output Pin Outs).

2. Connect the test API 400E sample inlet to a ¼" Teflon sample line from test set-up manifold port.

3. Allow the instrument to warm up approximately 20-30 minutes. Note any warning messages, which may appear in the display (operating manual Table 3-3, Possible Warning Messages at Start-up).

4. Scroll through all front panel test functions and compare to factory data sheet (operating manual Section 3.2.4, Functional Check).

5. Check unit serial number in configuration menu (set-up-config-next). Edit if necessary.

6. Check user adjustable software variables (operating manual Section 6.3.7, M 400E Internal Variables).

7. Perform a system leak check. If leak check is greater than ten (10) sccm, check plumbing, tubing, fittings etc. to determine where leak may be occurring (operating manual Section 9.3.4, Performance Leak Check).

8. Set flow rate to 800 $\pm$ 80 sccm and perform flow verification using a certified flow meter. Calibrate flow if necessary (operating manual Section 6.7.6, Flow Calibration).

9. Set electronic zero/span and calibrate.

10. Perform a dark current calibration (operating manual Section 6.7.5, Dark Calibration).

11. Verify that test set-up manifold is connected to a certified gas calibrator or reference ozone analyzer and ozone generator for calibration and repeatability checks.

12. Perform a basic calibration procedure (operating manual Section 3.3.2, Basic Calibration Procedure). Note calibration results (slope and offset) on the acceptance testing log.

13. Check electronic analog output voltage for 0-1VDC and for linear output at 0, 20, 40, 60, 80 and 100% (see operating manual Section 6.7.2, Analog Output Step Test).

14. Perform a multi-point comparison against a reference ozone analyzer or certified ozone generator at the following ranges: 80, 60, 40, 20, 10, 5 and 0 percent of full-scale. This represents the linearity portion of the acceptance test. At each range, the test instrument must agree to within 1% or 3 PPB (whichever is greater) of the reference instrument or gas calibrator value. Perform an overall percent accuracy calculation for the entire range by taking the summation of the reference ozone or gas calibrator values (S1) and summation of the test instrument values (S2) and performing the following calculation.

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

The overall percent accuracy must be less than 2 percent. If the overall accuracy is greater than 2 percent, recalibrate the test instrument and repeat multi-point comparison test.

15. Program test gas calibration system or ozone generator to produce automatic Zero, Hi O_3 (approximately 400 ppb) and Low O_3 (approximately 90 ppb) levels. Each level should be a minimum of 30 minutes in duration. Run the test program for a minimum of 72 hours. Note chart for beginning repeatability checks and record zero, precision and span 24, 48 and 72 hour values.

16. Test system warning messages by simulating failures i.e. disconnect pump, lamp connector, pressure transducer, etc.

17. View the instruments built-in data acquisition system (operating manual Section 6.11, The Internal Data Acquisition System-IDAS). Review previous concentration data and other default parameters listed in (operating manual Section 6.11.4, Default IDAS Channels). Look for obvious changes during daily cal cycles or changes in concentrations due to normal diurinal variations (cycles).

18. Check and reset if necessary, measurement range mode (operating manual Section 6.5.2, Measurement Range Mode) and single or dual range mode (operating Section 6.5.3, Single Range Mode) and measurement unit type (operating manual Section 6.5.6, Setting the Measurement Range Unit Type).

19. Check the test instruments repeatability after 24 hours and after 72 hours at Zero, Hi O_3 (approximately 400 ppb), and Lo O_3 (approximately 90 ppb) levels. (Repeatability should be +/- 1% in 24 hours and +/- 2% in 72 hours of the first recorded readings).

20. Connect a computer to the RS-232 port. Check instr-port default settings (operating manual Section 6.9.1, Com Port Default Settings) and rear panel DCE-DTE switch (operating manual Section 6.9.4, DTE vs DCE Communications).

21. Bring up API-COMM software on computer and operate the instrument using the virtual front panel on the pc screen. Change and/or reset various analyzer functions using the “virtual display” such as, clock, time of day, analyzer range and system diagnostics (see section reference above).

22. If unit is equipped with internal zero and span (IZS) capability refer to (operating manual Section 6.8, Configuring the Internal Zero/Span Option). Program analyzer to perform a zero, a low-point (70 ppb) and a hi-point (400 ppb) internal calibration. Operate instrument for a minimum of 7 days and verify initial accuracy of IZS calibration is within 10% of set point, stability and repeatability are within 2% over 7 days and response is less than 5 minutes to 95% command response. Document IZS results on Instrument Test Log.

1.5 Environmental Chamber Temperature and Voltage Stability Tests:

Place the test analyzer in the Thermotron environmental chamber, and connect the analyzer power cord to the variable voltage power strip. Connect the sample inlet to the sample manifold supplied with the calibrator output. The control analyzer should remain external to the chamber running on normal house power. Run a temperature/voltage run using Thermotron program number 7 while the test and control analyzer are sampling zero air. Repeat the temperature/voltage run while the analyzers are sampling a concentration equal to 80% of full scale. Record the tests results on the environmental chamber stripchart. Compare the responses of the test analyzer to the purchase specifications. Transfer the test results to AQSB Instrument Lab Test Report 002.

1.6 Post Acceptance Test:

1. Review manufacturer's specifications (if supplied), test log, charts, test reports, data sheets and all other acceptance documentation, and submit for to the Operations Support Section manager for review.

2. Configure analyzer for current AQSB field parameters.

3. If all data is acceptable, bar code unit and ship to the stock room for field assignment.

AQSB INSTRUMENT LAB TEST REPORT
API 400E Ozone Analyzer

Serial Number: _____ ARB Bar Code Number _____
Software Version: _____ Tested By: _____
Date Started: _____ Reviewed By: _____
Date Completed: _____ Date: _____
Pass or Fail _____

Physical Inspection	Notes	Initials
1. Unpack and inventory parts		
2. Check for shipping damage		
3. Check all plumbing for leaks		
4. Check correct power phasing		

Pre Acceptance Test Checks

1. Record Serial Number and Model Number		
2. Check operation of valves, controls, meters, pumps, switches, indicator lamps, etc.		
3. Set Instrument Test Configurations		

Operational Tests

1. Leak Check (less than 10 ccm)		
2. Flow Rate Check (800 ± 80 sccm)		
3. Set Electronic Zero/Span and Calibrate		
4. Perform dark current calibration		
5. Check Analog Outputs (80, 60, 40, 20, 10 % FS)		
6. Check Linearity (80, 60, 40, 20, 10, 5, 0% FS)		
7. 24 Hour Zero Drift		

AQSB INSTRUMENT LAB TEST REPORT (Cont.)
API 400E Ozone Analyzer

Operational Tests (Cont.)	Notes	Initials
8. 24 Hour Span Drift @ _____ ppm		
9. 72 Hour Zero Drift		
10. 72 Hour Span Drift @ _____ ppm		
11. Check APIComm Software and DAS		

Environmental Chamber Test

1. Temperature and Voltage Variation (Zero)		
1a. 35°C, 115V		
1b. 35°C, 125V		
1c. 35°C, 105V		
1d. 15°C, 115V		
1e. 15°C, 125V		
1f. 15°C, 105V		
2. Temperature and Voltage Variation (Span @ _____ppm)		
2a. 35°C, 115V		
2b. 35°C, 125V		
2c. 35°C, 105V		
2d. 15°C, 115V		
2e. 15°C, 125V		
2f. 15°C, 105V		

Post Acceptance Test

1. Set field operational parameters		
2. Complete AT Report, Log and Data Sheet		
3. Submit Acceptance Test Report for review		

INSTRUMENT LAB TEST LOG

Manufacturer _____ Model # _____

S/N _____

Date	Action

CALIFORNIA AIR RESOURCES BOARD
INSTRUMENT LABORATORY

DATE: _____ **TECHNICIAN:** _____

TEST INSTRUMENT	
MAKE:	
MODEL:	
SERIAL #:	
RANGE:	

OZONE REFERENCE INSTRUMENT	
MAKE:	ENVIRONICS
MODEL:	9100
ARB PROPERTY #:	20002615
SERIAL #:	1640
LAST CERTIFIED:	

LINEARITY TEST DATA

	Ozone Reference Instrument		Recorder	Test	*Difference	*Difference
SETPOINT	Target(PPB)	Actual (PPB)	Chart	Instrument	(PPB)	(%)
80	400.0	400.0	80.2	401.00	1.00	**0.25**
60	300.0	300.0	59.8	299.00	-1.00	**-0.33**
40	200.0	200.0	39.9	199.50	-0.50	**-0.25**
20	100.0	100.0	20.0	100.00	0.00	**0.00**
10	50.0	50.0	9.6	48.00	-2.00	**-4.00**
5	25.0	25.0	4.9	24.50	-0.50	**-2.00**
0	0.0	0.0	0.0	0.00	0.00	
	Delta S1=	1075.0	Delta S2=	1072.0		

Overall Accuracy (%)	**-0.28**
Correlation	**1.0000**

*** TEST INSTRUMUMENT MUST AGREE WITHIN 1 PERCENT OR 3 PPB WHICH EVER IS GREATER TO PASS LINEARITY TEST.**

For Units With IZS Only		
Parameter	**Value**	**Nominal Range**
O3 Gen Volt		80-5000 (mV)
O3 Drive Volt		0-5000 (mV)
O3 Gen Temp		48º C +/- 1º

M400E Final Test and Validation Data

Parameter / Units	Value	Nominal Range
STABIL (PPB)		<1 PPB w/ z-air
O3 MEAS (mV)		4300 - 4700 "
O3 REF (mV)		4300 - 4700 "
Pressure (in-Hg)		Ambient +/- 1"
Sample Flow (ccm)		800 +/- 80
Sample Temp (ºC)		20 - 45
Photo Lamp (ºC)		58 +/- .2
Box Temp (ºC)		30 +/- 10
Slope		1.0 +/- 0.1
Offset (PPB)		0.0 +/- 5
Time (HH:MM:SS)		+/- 1 min of True

72-Hour Repeatability Test: Zero / Span Drift

		Zero		Span	
	Date	% FS	% FS Dev	% FS	% FS Dev
Initial:					
24 Hour:					
72 Hour:					

Ozone Analyzer Physical Specifications:

1. Each analyzer shall be modular in design fully enclosed in a metal cabinet, allowing for easy access for servicing. It shall be supplied with all the hardware, including slides and brackets, necessary for mounting in a 19" wide by 25" deep instrument rack.

2. The total weight of each analyzer shall not exceed 60 pounds.

3. The A.C. input power cord shall be 3 conductor and at least 8 feet in length with a standard 3-prong grounded plug. The A.C. input to each analyzer shall be at the rear of each analyzer. The connectors shall be wired so that the "hot" terminal (black wire) is connected to the brass terminal throughout. The supply voltage shall be nominal, 115 $\pm$ 10 VAC, 60 $\pm$ 3 Hz, single phase.

4. The front panel of each analyzer shall include all the controls necessary to operate and calibrate the analyzer.

5. The analog output voltage proportional to the ambient ozone concentration shall be accessible on at least two sets of terminals at the rear of each analyzer.

6. Each analyzer shall have a digital read-out on the front panel that continuously displays the current concentration of ozone in the ambient air.

7. Each analyzer shall be equipped with an atmospheric pressure and temperature sensor to enable automatic, instantaneous compensation of the ozone measurements.

8. Each analyzer shall be equipped with a 9-pin male RS-232 connector installed on the rear panel.

Ozone Analyzer Performance Specifications:

1. The full scale range of each analyzer shall be selectable from 100 to 10000 ppb. Each analyzer shall be U.S. EPA approved for operation on all ranges between 0 - 1000 ppb.

2. The analog output voltage shall be 0 - 1.0 volt D.C. proportional to the selected analyzer range.

3. The lower detectable limit of each analyzer shall be equal to or less than 0.2 ppb.

4. The precision of each analyzer shall be equal to or less than 1% of full scale.

5. Linearity of each analyzer shall be less than 1% of full scale.

6. The span response (80% of full scale) of each analyzer shall not drift more than 1% of full scale in seven (7) days.

7. The zero response of each analyzer shall not drift more than 1 ppb in seven (7) days.

8. The response time of each analyzer shall be such that the digital display on the front panel and the analog output voltage reach 95% of the final ozone concentration within 5 minutes after the air sample being measured is introduced into the sample inlet port.

9. While sampling certified zero air on the 0 - 1.0 ppm range, the response of each analyzer as measured by the analog output voltage shall not change more than $\pm$ 1% of full scale when the ambient temperature varies $\pm$ 10^{o}C from 25^{o}C and the input power voltage varies $\pm$ 10 volts from 115 volts A.C.

10. While sampling a constant span concentration of ozone at 0.80 ppm on the 0-1.0 ppm range, the analog output voltage shall not change more than $\pm$ 2% of full scale when the ambient temperature changes $\pm$ 10 C from 25 C and the input supply voltage to each analyzer changes $\pm$ 10 VAC from 115 VAC.

11. The noise exhibited by each analyzer shall be less than 0.3 ppb at zero and less than 1% of reading at a span value of 80% of full scale.

12. Each analyzer shall be equipped with a diagnostic function, which displays analyzer operating parameters on the front panel digital display. The parameters displayed shall include (but not limited to):

    a. Sample flow rate.

    b. Power supply voltages (may be a composite number).

    c. Analyzer lamp temperature.

    d. Pressure of the sample gas in the absorption chamber.

    e. Temperature of the sample gas in the absorption chamber.

    f. Temperature of the analyzer chassis.

13. A change in ambient temperature of $\pm$ 20 C from 25 C shall not cause a permanent change to the zero or span response of each analyzer.

14. Each analyzer shall have the ability to display warning messages on the front panel display. These messages shall include at a minimum, warnings on the parameters listed in the diagnostic requirements in line 12, above.

15. Each analyzer shall be equipped with a two-way (input - output) communications port to enable the remote control and monitoring of the operation of the analyzer and access to the ozone concentration data. Access to the analyzer through the communications port shall enable remote control (via a modem, telephone line and computer) of all the functions of the analyzer available from the front control panel (i.e., all functions and controls available at the front panel shall be available on a computer via the communications).

16. The baud rate through the communications port shall be user selectable from 300 to 19.2k CPS.

17. The analyzer software shall have the capability to store hourly average ozone concentration data covering 800 hours (33.3 days @ 24 hours/day).

18. The ozone concentration measurement shall be automatically temperature and pressure compensated for by the microprocessor and the pressure and temperature sensors.

19. For analyzers with optional zero and span internal ozone generator, the following requirements must be met:

    a. The internal ozone generator in each analyzer shall generate a constant ozone concentration of at least 1 ppm at a flowrate of 700 cc/min or the analyzer sample flowrate whichever is greater.

    b. The output concentration of the internal ozone generator in each analyzer shall not vary more than ±2% from the set concentration in 7 days.

    c. The output concentration of the internal ozone generator in each analyzer shall reach 95% of the programmed/required concentration in 5 minutes or less after the initialization.

    d. The ozone generator sequence shall be initiated from the: 1) front panel of the analyzer, 2) communication port, 3) internal timer, and 4) remote external contact closure.

    e. The internal ozone generator must have a feedback function to allow generator to monitor ozone output and adjust accordingly.