MODEL 452
PROCESS OZONE SENSOR
User Manual

www.teledyne-api.com

9970 Carroll Canyon Road
San Diego, CA 92131-1106

Toll free: **800-324-5190**
Phone: **+1 858-657-9800**
Fax: **+1 858-657-9816**
mail: **api-sales@teledyne.com**

02852G DCN8011
26 October 2018

SAFETY MESSAGES

NOTE

The only user-serviceable part in the Model 452 is the lamp, which can be adjusted or replaced; however, the cautionary safety measures provided in this manual must be followed. For all other service, call TAPI Technical Support.

CAUTION

There is risk of dangerous UV exposure when the cover is removed from the sensor. Take necessary precautions to avoid exposure.

WARNING

High voltages exist inside the sensor. Please use caution when sensor cover is removed.

Notice of Copyright

Revisions to this Manual are intended to clarify existing descriptions and are not intended to infer any changes to customers under copy exact requirements.

Trademarks

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

WARRANTY POLICY

(02024J)

Teledyne API (TAPI), a business unit of Teledyne Instruments, Inc., provides that:

Prior to shipment, TAPI equipment is thoroughly inspected and tested. Should equipment failure occur, TAPI assures its customers that prompt service and support will be available. (For the instrument-specific warranty period, please refer to the "Limited Warranty" section in the Terms and Conditions of Sale on our website at the following link: http://www.teledyne-api.com/terms_and_conditions.asp).

COVERAGE

After the warranty period and throughout the equipment lifetime, TAPI stands ready to provide on-site or in-plant service at reasonable rates similar to those of other manufacturers in the industry. All maintenance and the first level of field troubleshooting are to be performed by the customer.

NON-TAPI MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by TAPI is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturer's warranty.

Product Return

All units or components returned to Teledyne API should be properly packed for handling and returned freight prepaid to the nearest designated Service Center. After the repair, the equipment will be returned, freight prepaid.

The complete Terms and Conditions of Sale can be reviewed at http://www.teledyne-api.com/terms_and_conditions.asp

CAUTION – Avoid Warranty Invalidation

Failure to comply with proper anti-Electro-Static Discharge (ESD) handling and packing instructions and Return Merchandise Authorization (RMA) procedures when returning parts for repair or calibration may void your warranty. For anti-ESD handling and packing instructions please refer to the manual, Fundamentals of ESD, PN 04786, in its "Packing Components for Return to Teledyne API's Customer Service" section. The manual can be downloaded from our website at http://www.teledyne-api.com. RMA procedures can also be found on our website.

1 Product Descriptions

1.1 Model 452 Process Ozone Sensor

The Teledyne API Model 452 is a microprocessor-based sensor for measuring the concentration of gaseous ozone in processes such as semiconductor wafer fabrication, water treatment, and ozone research. The Model 452 can be used as a full flow process sensor or as a sensor to monitor a small flow of gas diverted from a process stream.

The Model 452 features a standard 0-5 volt analog signal for reporting process concentration as well as 4 digital status outputs for sensor diagnostics. A bi-directional serial interface is also provided for computer control.

The Model 452 operates from an external +15 vdc power source.

1.2 Model 452 High Purity Process Ozone Sensor

The Model 452 High Purity Process Ozone Sensor includes a 316L manifold with a 10Ra finish. ¼” stainless steel compression fittings are standard.

2 Specifications

Note: All specifications contained herein are subject to change without notice. Please contact Teledyne API to obtain the current specifications.

2.1 Mechanical Specifications

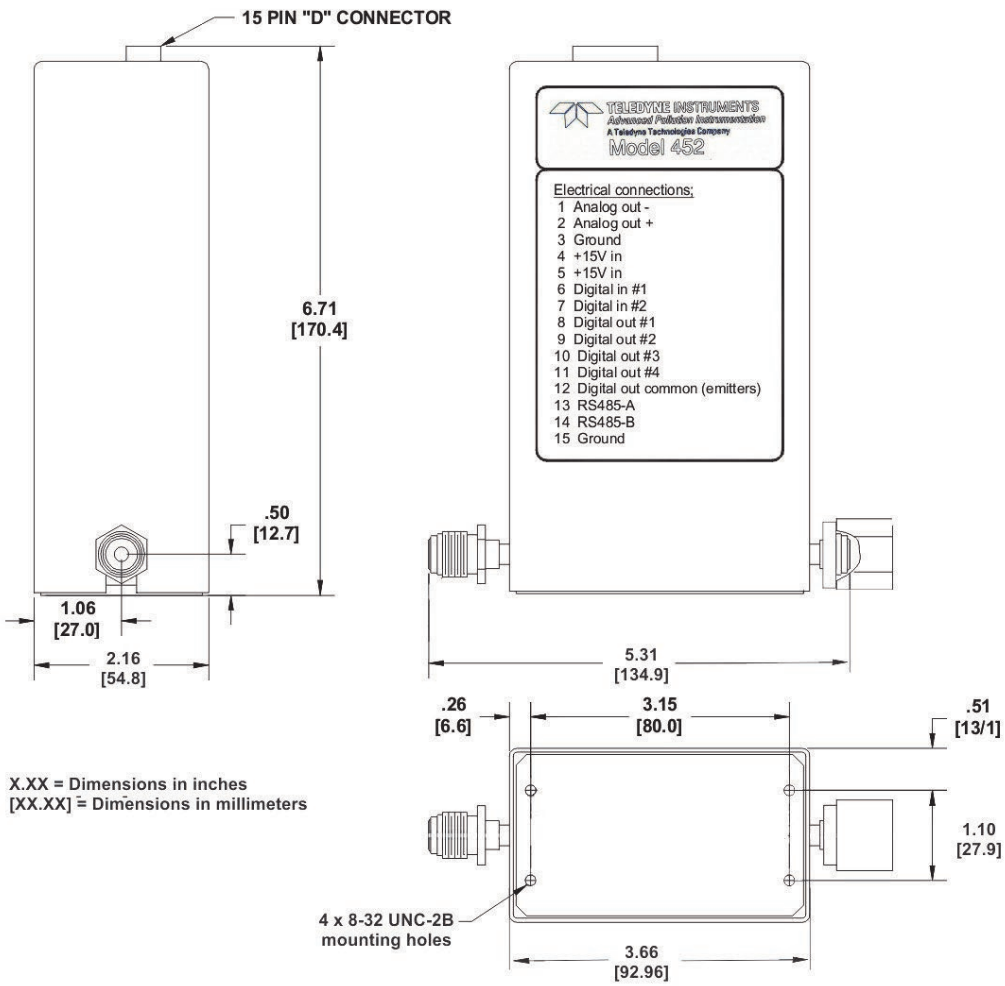

Figure 2-1: Model 452 High Purity Ozone Sensor

Weight:	2.8 lbs. (1.27 kg)
Fittings:	¼" stainless steel compression (tube)
Wetted Materials:	316 Stainless Steel, PTFE, Sapphire

2.2 Performance Specifications

Accuracy:	±1% of Full Scale.
Repeatability:	1% of Full Scale
Response Time:	2 sec. to 95%
Zero Drift:	1% Full Scale/month (non –cumulative)

2.3 Operating Limits

Measurement Range:	0-5, 0-10, 0-15, 0-20, 0-25% w/w 0-100, 0-200, 0-300, 0-400, 0-500 g/Nm3
Pressure Compensation:	Up to 3 Bar absolute
Proof pressure:	115 psia
Flow:	0.5-25.0 SLPM (See Figure 2-2)
Temperature range:	5 to 45 °C
Warm-Up Period:	15 minutes

2.4 Electrical Specifications

Power Input:	+15 volts ±1.0 volt (1.0A maximum)
Analog Output:	0-5V Full Scale
Zero Cal:	Contact Closure Input
Status Indicators:	4 status LEDs
Digital Outputs:	Sensor OK, Invalid Reading, Lamp Low, Cell Dirty (Opto-isolated)
Serial Data Interface:	RS232 or RS485, Half-Duplex, 9600 Baud

2.5 Calibration Reference

Span Calibration:	Traceable to Buffered KI laboratory calibration
Standard Temperature and Pressure (g/Nm3 only):	0°C and 760 mmHg

2.6 Options

High Purity (VCR™ or HTC®) fittings, 316L, 10 Ra Finish)
AC Adapter

2.7 Pressure Drop

Figure 2-2 below shows the approximate pressure drop from the inlet fitting to the outlet fitting as a function of volumetric flow rate.

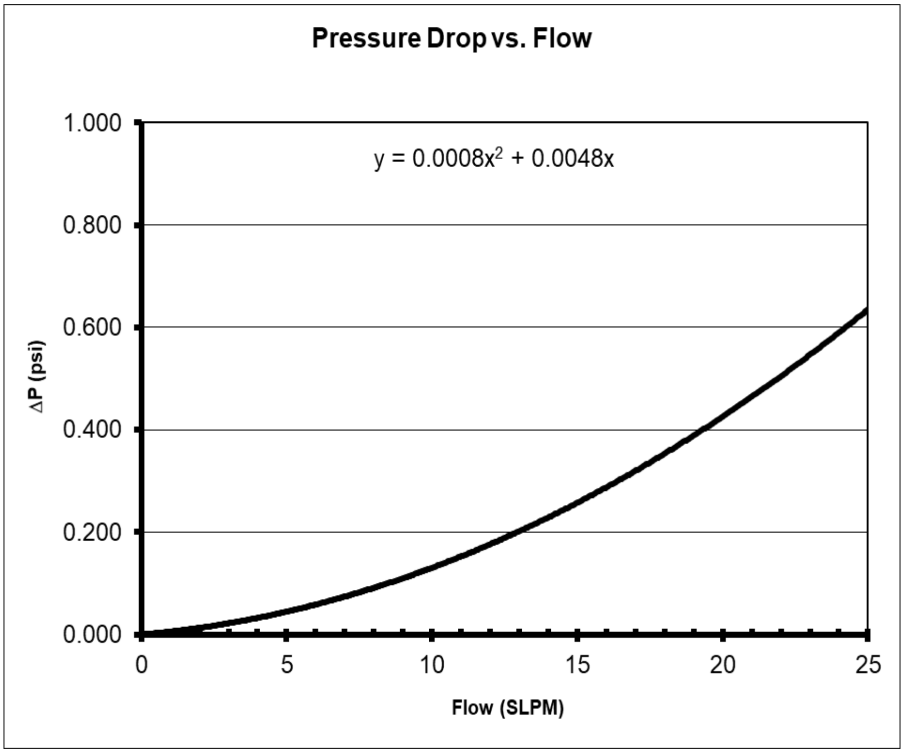

Figure 2-2: Pressure Drop vs. Flow (High Purity Version)

3 Theory of Operation

The detection of ozone molecules is based on absorption of 254 nm UV light due to an internal electronic resonance of the O_3 molecule. The Model 452 uses a mercury lamp constructed so that a large majority of the light emitted is at the 254 nm wavelength. Light from the lamp shines through an absorption cell through which the sample gas being measured is passed. The ratio of the intensity of light passing through the gas to a reference measurement, which does not pass through the gas, forms the ratio I/I_o. This ratio forms the basis for the calculation of the ozone concentration.

The Beer-Lambert equation, shown below, calculates the concentration of ozone from the ratio of light intensities.

$$C_{O_3} = -\frac{1}{\alpha \times \ell} \times \frac{\mathrm{T}}{273^o\mathrm{K}} \times \frac{14.695\,psi}{\mathrm{P}} \times \ln\frac{\mathrm{I}}{\mathrm{I}_o}$$

Where:

I	= Intensity of light passed through the sample
I_o	= Intensity of light through sample free of ozone
α	= Absorption coefficient
P	= Path length
C_{O_3}	= Concentration of ozone
T	= Sample temperature in degrees Kelvin
psi	= Pressure in pounds per square inch (absolute)

As can be seen the concentration of ozone depends on more than the intensity ratio. Temperature and pressure influence the density of the sample. The density changes the number of ozone molecules in the absorption cell, which impacts the amount of light, removed from the light beam. These effects are addressed by directly measuring temperature and pressure and including their actual values in the calculation. The absorption coefficient is a number that reflects the inherent ability of ozone to absorb 254 nm light. Lastly, the absorption path length determines how many molecules are present in the column of gas in the absorption cell.

The intensity of light is converted into a voltage by the detector/preamp module. The voltage is converted into a number by a voltage-to-frequency (V/F) converter capable of 80,000 count resolution. The digitized signal, along with the other variables, is used by the CPU to compute the concentration of ozone using the above formula.

4 Installation

4.1 Unpacking

Upon receiving the Model 452 please verify that no apparent shipping damage has occurred. If damage has occurred please advise shipper first, then Teledyne API.

4.2 Mechanical Installation

Mount the Model 452 to a stable platform using four #8-32UNC screws. See Figure 2-1 for mounting-hole dimensions.

NOTE – Prevent Damage to Instrument

Do not allow the mounting screws to penetrate beyond 1/8 of an inch (3.2 mm) into the bottom of the instrument.

NOTE

If the mounting platform is non-conductive or not connected to earth ground, then a separate connection to earth ground should be made using one of the mounting screws. Failure to provide a proper earth ground connection may make the Model 452 susceptible to electrical interference from external sources.

4.3 Electrical Connections

Electrical connections are made to the Model 452 using the 15 pin D-Sub connector on the top of the device. Figure 4-1 shows the pin-out of the 15-pin connector and typical connections.

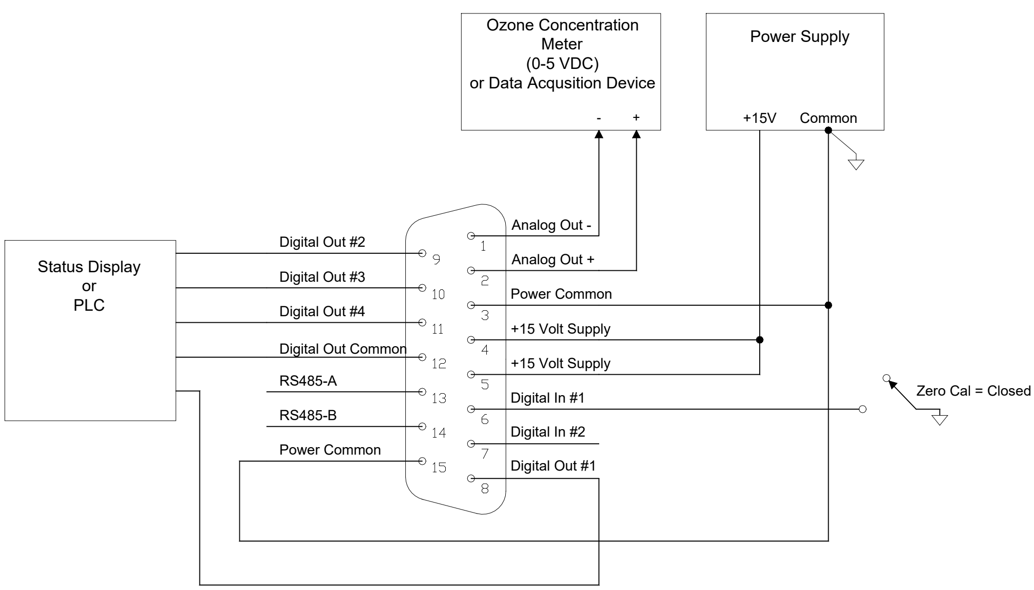

Figure 4-1: Electrical Connections

4.3.1 Power Supply

The Model 452 requires a +15 VDC power source capable of supplying 1.0 A. DC power can be connected through the male DB-15 connector or through the coaxial power jack. The coaxial power jack is configured so that the ground connection is on the outside (shield) and the +15V connection is on the center pin.

If power is to be supplied through the DB-15 connector, the positive terminal of the power supply should be connected to pins 4 and 5 on the 15-pin connector and the common terminal should be connected to pins 3 and 15.

If the optional AC Power Adapter is used to provide power, it should be connected to the coaxial power connector adjacent to the DB-15 connector on the top of the Model 452. Use only the approved AC Power Adapter provided by Teledyne API.

4.3.2 Analog Output

The analog output is a 0-5 volt signal representing the ozone concentration measured by the sensor. The output is scaled to the concentration range that the sensor has been set to measure. Check the serial number label on the Model 452 to determine the concentration range.

For best performance, the analog output should be connected to a voltmeter or A/D converter with a differential input and a minimum input impedance of 2KΩ.

4.3.3 Zero Calibration Input

The zero calibration input is located on Digital Input #1. To zero the Model 452, Digital Input #1 should be connected to the power common for at least 1 second. This can be accomplished using a Normally Open switch or relay.

4.3.4 Status Outputs

The Model 452 has four digital status outputs for indicating error status and when operational parameters have moved out of normal limits. These outputs are in the form of opto-isolated open-collector transistors. They can be used to drive status LED's on a display panel or interface to a digital device such as a Programmable Logic Controller (PLC).

Figure 4-2 below shows the most common way of connecting the digital outputs to an external device such as PLC. Note: Most devices, such as PLC's, have internal provision for limiting the current that the input will draw from an external device. When connecting to a unit that does not have this feature, external dropping resistors must be used to limit the current through the transistor output to 50mA or less.

See Section 1 for details on using the Status Outputs for diagnosing sensor and system-level malfunctions.

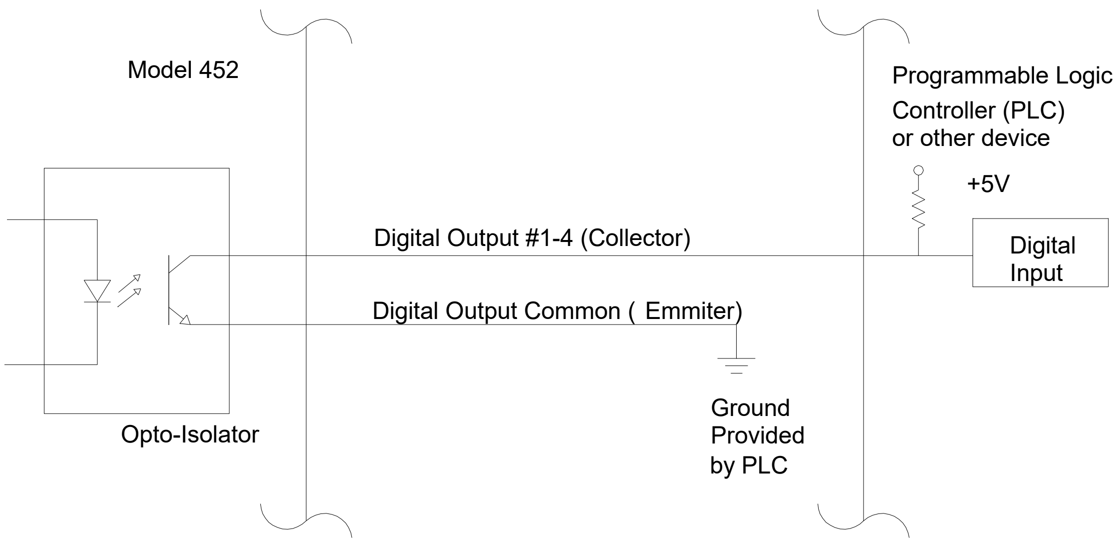

Figure 4-2: Digital Output Connections

4.3.5 RS232/485 Interface

The Model 452 features a bi-directional digital serial interface that can be used for sensor control and data acquisition. Please contact Teledyne API for documentation on the use of the RS232/485 interface.

4.4 Gas Connections

Gas connections to the Model 452 are made using ¼" compression tube fittings (Model 452) or ¼" VCR™ face seal fittings (Model 452). The ¼" compression fittings can be used with ¼" O.D. Stainless Steel or Teflon™ tubing. The Model 452 is not sensitive to flow direction; it does not matter which of the two fittings is used as the gas inlet.

To avoid contamination of the optical cell in the Model 452, ensure that all tubing upstream of the Model 452 is properly cleaned and purged **before** the Model 452 is installed.

In order to achieve an acceptable response time and to avoid sample degradation, the system should be set up so that a minimum flow rate of 0.1 SLPM is established through the Model 452. If long tubing runs are used between the measurement point and the Model 452, then higher flow rates should be used to avoid sample degredation. Appropriate tests should be conducted to determine minimum flow requirements.

4.5 Start-Up and Calibration Procedure

1. Verify that the proper electrical connections have been made (See Section 4.3) and apply power to the Model 452. Allow the Model 452 to warm up for at least 15 minutes.

2. Purge the Model 452 with zero gas (usually oxygen) at a minimum flow rate of 0.1 SLPM for at least 2 minutes.

3. Check that the Status Outputs (See Section 4.3.4) are in their normal states and no errors are indicated.

4. Close the zero calibration input (See Section 4.3.3) for a minimum of 1 second to perform the automatic zero calibration.

5. Re-check the Status Outputs to ensure that no errors are indicated.

6. Check the voltage on the analog output (See Section 4.3.2) and verify that it reads 0.000 ± 0.010 volts.

7. The Model 452 is now ready for operation.

5 Maintenance

The only user-serviceable part in the Model 452 is the lamp, which can be adjusted or replaced. For all other service, contact TAPI Technical Support.

WARNING

High voltages exist inside the sensor. Use caution when sensor cover is removed.

CAUTION – Avoid Warranty Invalidation

Failure to comply with proper anti-Electro-Static Discharge (ESD) handling instructions may void your warranty. Refer to the manual, Fundamentals of ESD, PN 04786, which can be downloaded from our website at http://www.teledyne-api.com.

CAUTION

There is risk of dangerous UV exposure when the cover is removed from the sensor. Take necessary precautions to avoid exposure and to protect eyes.

5.1 UV Lamp Adjustment and Replacement

The electronics used in TAPI analyzers are sensitive to Electrostatic Discharge (ESD). When working on any TAPI device, please ensure that you are properly grounded prior to handling or touching any electronic circuitry in the analyzers. For more information on how to protect sensitive components from ESD during handling, please refer to the manual, Fundamentals of ESD, PN 04786, which can be downloaded from our website at http://www.teledyne-api.com

NOTE

Use only distilled or de-ionized water with clean, lint-free towels and swabs when cleaning any components in TAPI equipment unless otherwise instructed.

For the procedures in this section, refer to Figure 5-1, Figure 5-2, and Figure 5-3.

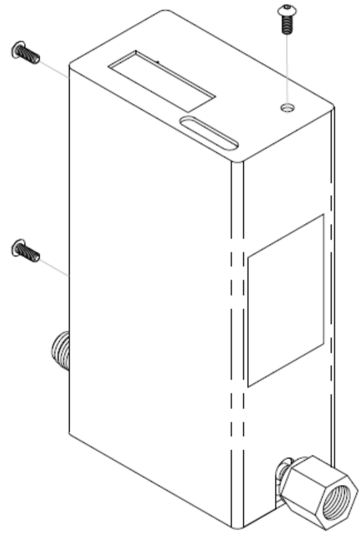

Figure 5-1. Cover Assembly Screws

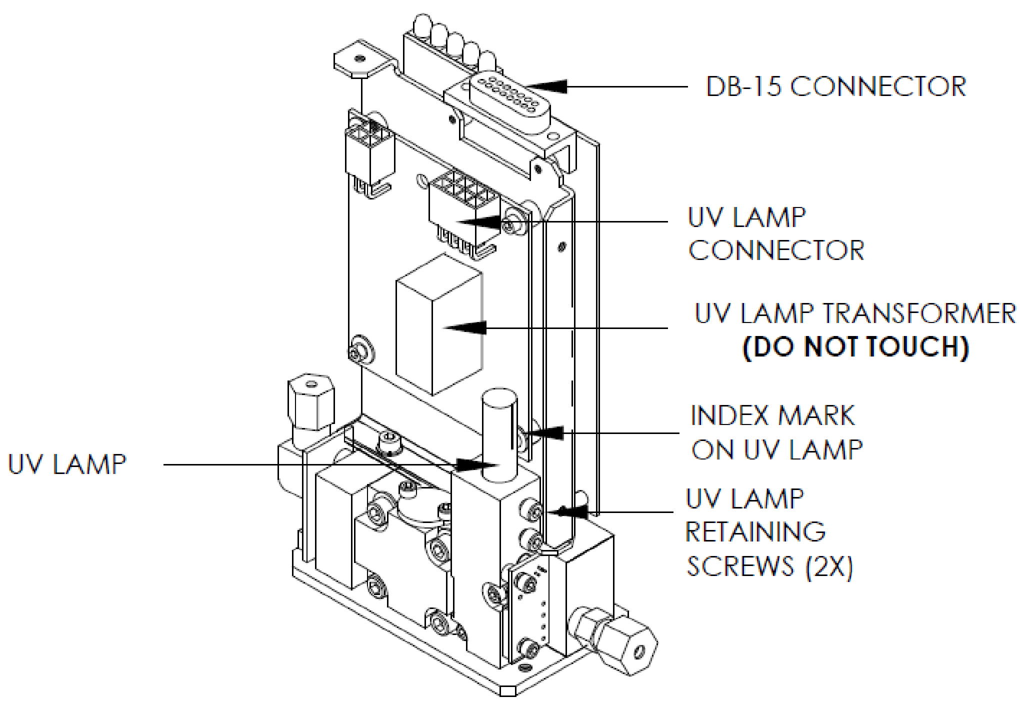

Figure 5-2. UV Lamp Orientation

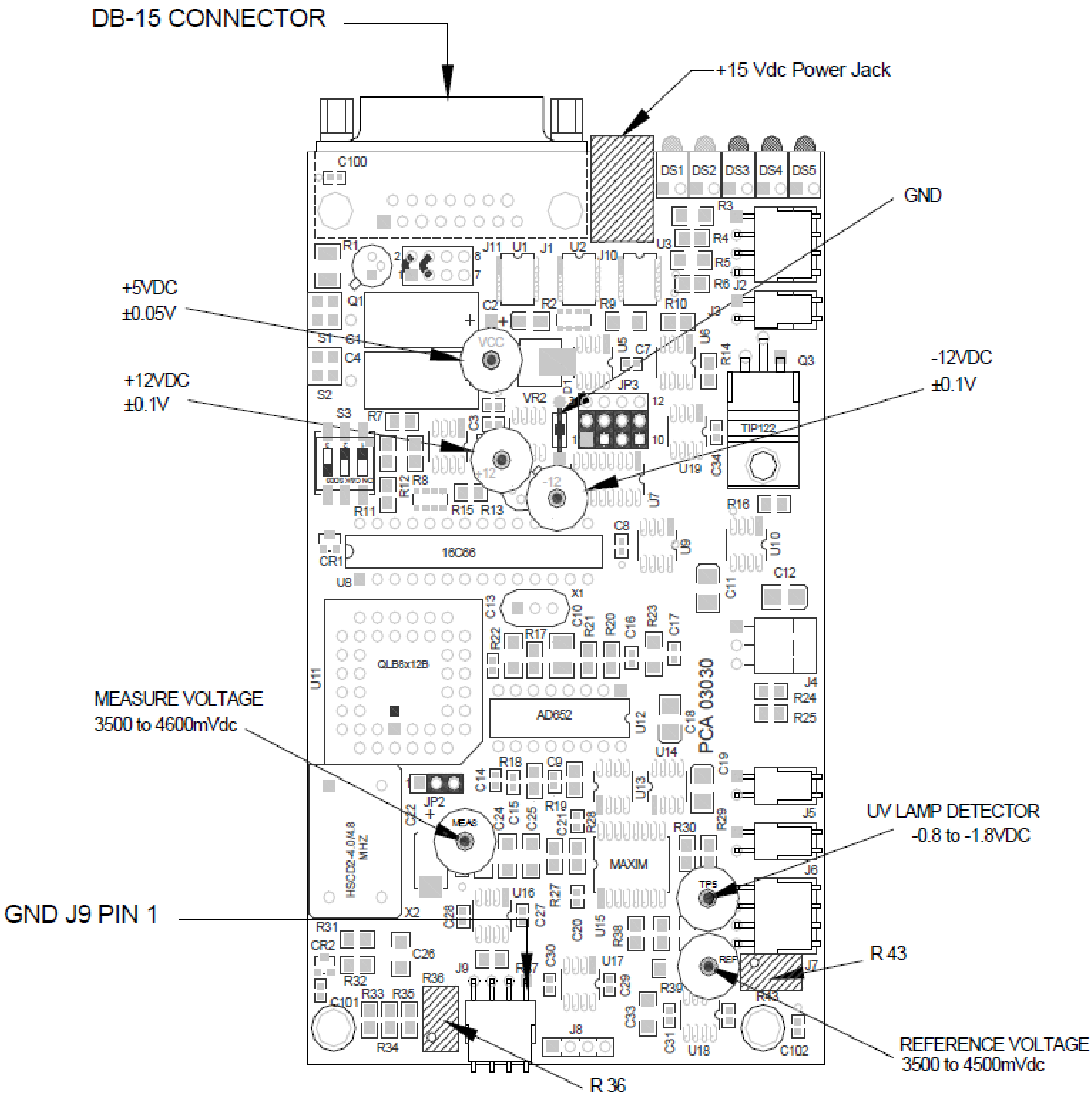

Figure 5-3. Voltage Adjustment Locations

5.1.1 Measuring and Adjusting UV Lamp Reference and Measurement Voltages

1. Flush the analyzer with zero gas to exhaust any possible residual high concentration of O_3.
2. Remove the analyzer from the equipment (if necessary) to access the cover screws and the internal components of the analyzer.
3. Remove the three screws shown in Figure 5-1.
4. Carefully slide cover up and off of instrument.
5. Apply +15VDC Power to J10 (+15 VDC Power Jack) or through DB-15 connector (Figure 5-3).
6. Allow the analyzer to warm up for at least 15 minutes (the lamp output changes during warm up.
7. Measure and record the Reference voltage.
    a. Measure the DC Voltage from GND J9 pin 1 to TP REF (Figure 5-3).
    b. Adjust R43 as high as possible within range of 3500-4600mv.
8. Measure and record the Measure voltage.
    a. Measure the DC Voltage from GND J9 pin 1 to TP MEAS (Figure 5-3).
    b. Adjust R36 as high as possible within range of 3500-4600mv.
9. If the minimum voltage of 3500mV cannot be attained for the REF or MEAS, the lamp must be adjusted or replaced.
10. If the voltages are correct, reinstall and perform a zero calibration on the analyzer.

5.1.2 Adjusting the Lamp

The object of the adjustment procedure is to get the voltage above 3500mV and below 4600mV by either “peaking” the lamp to increase the voltage or “de-tuning” the lamp to decrease the voltage. A new lamp should easily be able to get up to 4600mV. Over time, the lamp may need positional adjustments and adjustments to the potentiometers to get maximum usage from a lamp.

At peak, a new lamp may put out so much power that the detectors may become saturated even with the detector amplifier gain potentiometers turned all of the way down. If the lamp generates more than 4600mV on the REF and MEAS test points at “peak” (with the potentiometers turned all of the way down), then the lamp will have to be “de-tuned” to “off peak” by rotating it until its output does not exceed 4600mV on the REF and MEAS test points.

Conversely, if an older lamp is only putting out 3500mV or below with the lamp peaked (for instance a lamp that is near the end of its life), make sure the lamp is peaked and that both REF and MEAS potentiometers are adjusted all of the way up to get the voltages above 3500mV. If 3500mV is not attainable at peak (with the potentiometers turned all of the way up), the lamp must be replaced.

1. Monitor the DC Voltage from GND J9 pin 1 to TP 5 (Figure 5-3). This voltage must read between –0.8 and –1.8 Vdc. If the voltage does not read correctly, loosen the two UV lamp retaining screws (Figure 5-2) and rotate the UV lamp (avoid touching the transformer on the UV lamp power supply) until this voltage (-.8 to -1.8 Vdc) is reached and then tighten the screws back down again. If unable to get the voltage below -.8Vdc (-.8V to -1.8V), the lamp must be replaced. If a positional adjustment lowers TP5 voltage to below -.8V, adjust the Reference and Measure voltages as follows.

2. Measure and record the Reference voltage.

   a. Measure the DC Voltage from GND J9 pin 1 to TP REF (Figure 5-3).

   b. Adjust R43 as high as possible within range of 3500-4600mv.

3. Measure and record the Measure voltage.

   a. Measure the DC Voltage from GND J9 pin 1 to TP MEAS (Figure 5-3).

   b. Adjust R36 as high as possible within range of 3500-4600mv.

4. If the Reference and Measure readings are above 3500mV and below 4600mV, no further adjustment is necessary. Proceed to reinstall the analyzer and perform a zero calibration.

5. If the minimum voltage of 3500mV cannot be attained, the lamp must be replaced.

5.1.3 Replacing the Lamp

NOTE

Be careful to keep the lamp free from contaminants such as fingerprints. If the lamp becomes contaminated, clean the lamp's optical surface with alcohol first, then with distilled or deionizedwater. Do NOT allow any liquid to infiltrate the analyzer

1. Remove +15VDC Power to J10 (+15 VDC Power Jack) or DB-15 connector (Figure 5-3).

2. Loosen two UV Lamp Retaining screws (Figure 5-2) approximately one turn counter-clockwise.

3. Press in on the UV lamp connector (Figure 5-2) and pull up on connector to disconnect lamp.

4. Slide the UV lamp up and out of UV Lamp Block.

5. Install the new UV lamp, make sure that the UV lamp is all the way down in the UV lamp block and the index mark or inverted "V" notch is aligned as shown in Figure 5-2.

6. Tighten the UV Lamp retaining screws very carefully. They only need to be torqued to about 6 in/lbs (8 in/lbs Maximum).

7. Apply +15VDC Power to J10 (+15 VDC Power Jack) or through DB-15 connector (Figure 5-3).

8. Allow the new lamp and analyzer to warm up for at least 15 minutes.

9. Check the DC Voltage from GND J9 pin 1 to TP 5 (Figure 5-3). This voltage must read between –0.8 and –1.8Vdc. If the voltage does not read correctly then loosen the two UV lamp retaining screws and rotate the UV lamp until this voltage is reached and then tighten the screws back down again. If this voltage can not be reached then contact API for further assistance.

10. Measure and record the Reference UV voltage.

    a. Measure the DC Voltage from GND J9 pin 1 to TP REF (Figure 5-3).

11. Measure and record the Measure UV voltage.

    a. Measure the DC Voltage from GND J9 pin 1 to TP MEAS (Figure 5-3).

12. Adjust R43 for REF and R36 for MEA to get the voltages as high as possible within the 3500-4600mv range. If the voltages can't go below 4600mV with the potentiometers turned all theway down, loosen the two UV lamp retaining screws and rotate the UV lamp (de-tune) untilthe voltages goes below 4600mV and then tighten the screws back down again.

13. Ensure both REF and MEAS voltages are 3500mV to 4600mV.

14. If proper voltages cannot be attained or the voltages are not stable, contact TAPI Technical Support Department for assistance or to arrange for return and repair of the analyzer.

15. Remove +15VDC Power to J10 (+15 VDC Power Jack) or from DB-15 connector (Figure 5-3).

16. Carefully slide the cover onto the instrument.

NOTE

Take extreme care to not catch any of the cables with the cover.Tuck the cables upward first, then slide the cover down over them. If you feel any of the cables catch on the cover, remove the cover and ensure that all the cables are seated correctly.

17. Replace the three screws, reinstall the analyzer and perform a zero calibration.

6 Sensor and System Troubleshooting

This chapter gives guidelines for diagnosing system and sensor malfunctions using the four digital Status Outputs provided by the Model 452. All troubleshooting should be done after the Model 452 has been turned on and allowed to warm up for at least 15 minutes.

6.1 Status LED's

On the top of the Model 452 are five status LED's.

The Status LED labeled 'CPU STATUS' is used to verify the status of the CPU inside the Model 452. This LED should blink on and off continuously while the sensor is on. If this LED stops blinking while power is applied to the sensor, a CPU failure is indicated.

The other four Status LED's on the Model 452 exactly mirror the four Status Outputs described in the following sections.

6.2 Status Outputs

Table 6-1below describes the function of the status outputs. More details as to the meaning of the status outputs are described in the following sections.

Table 6-1: Status Outputs

Output #	Name	On State	Off state
1	Sensor O.K.	Normal State	Reference or Measure > 4995mV; Reference < 400mV
2	Invalid Reading	Pressure > 45 psia, Negative Ozone Concentration	Normal State
3	Lamp Low	Reference Detector<600mV	Normal State
4	Cell Dirty	Measure/Reference ratio < 0.5 (zero gas)	Normal State

6.3 Sensor O.K.

The normal state for the Sensor O.K. output in ON. During the warm-up period on start-up this output will stay off until the UV lamp reaches a minimum intensity. If this output remains off after the 15 minute warm-up period, or goes off during normal operation, then the Model 452 is in need of servicing.

If the Sensor O.K. output turns off AND the Lamp Low output is on, this indicates that the lamp intensity has below the minimum level required for proper operation.

If the Sensor O.K. output turns off and the Lamp Low output is also off, then one of the analog voltages in the sensor has exceeded the range of the internal A/D converter. Adjustment by qualified service personnel is required.

6.4 Invalid Reading

The normal state for the Invalid Reading output is OFF. If this output turns on, this indicates that the Model 452 is still operational, but a system fault or calibration fault exists that may make the current ozone reading invalid.

The Invalid Reading output is turned on for any of the following conditions:

1. When the measured pressure in the Model 452 exceeds 45 psia.
2. When the measured concentration has exceeded the full-scale concentration range of the sensor. Check the serial number tag for the full-scale concentration range.
3. The sensor is indicating an excessive negative reading.

6.5 Lamp Low

The normal state for the Lamp Low output is OFF. If this output turns on, this indicates that the UV lamp intensity as measured by the reference detector has dropped below 600mV.

If the Lamp Low output turns ON and the Sensor O.K. output is ON, this indicates that the lamp intensity is still adequate for measurement, but adjustment should be made when possible.

If the Lamp Low output turns ON and the Sensor O.K. output is OFF, this indicates a failure condition and accurate measurement is no longer possible.

6.6 Cell Dirty

The normal state for the Cell Dirty output is OFF. If this output turns on, then the ratio of the measure detector to the reference detector (at zero) is < 0.5. This value is calculated when the zero calibration is performed.

When this output is on, it indicates a loss of optical transmission through the windows in the absorption cell or a calibration fault.

6.7 Status Output Summary Table

Table 6-2 below is a logic truth table summarizing the recommended actions based on the states of the four status outputs. A ‘1’ indicates the output is ON, a ‘0’ indicates the output is OFF, and ‘X’ indicates the output is in either state.

Table 6-2: Status Output Truth Table

Sensor OK	Invalid Reading	Lamp Low	Cell Dirty	Actions
1	0	0	0	Normal operation, no action required
0	X	X	X	Service required
1	1	X	X	Check Pressure > 45 psia Verify that concentration has not exceeded full scale range of sensor. Calibrate at Zero.
1	X	1	X	Lamp adjustment useful, though not required
1	X	X	1	Calibrate at zero Clean Cell

6.8 Technical Assistance

If this manual and its trouble-shooting / repair sections do not solve your problems, technical assistance may be obtained from:

Teledyne API Technical Support

9970 Carroll Canyon Road, San Diego, CA 92131

Phone: +1 858 657 9800 or 1-800 324 5190

Fax: +1 858 657 9816

Email: api-techsupport@teledyne.com.

There is also a problem report form for electronic submission on our website at http://www.teledyne-api.com under the Service & Support section.