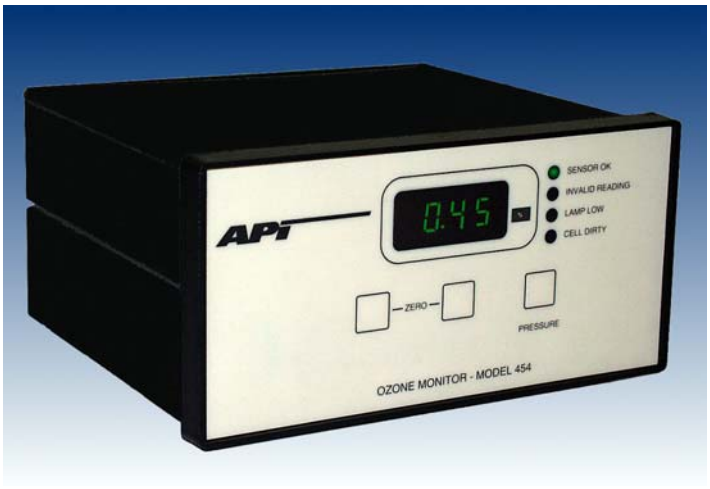

MODEL 454
OZONE MONITOR

Teledyne Instruments
© Advanced Pollution Instrumentation Division
(T-API)
9480 Carroll Park Drive
San Diego, CA 92121-5201

TOLL-FREE: **800-324-5190**
TEL: **858-657-9800**
FAX: **858-657-9816**
E-MAIL: **api-sales@teledyne.com**
WEB SITE: **www.teledyne-api.com**

SAFETY MESSAGES

NOTE

The M454 contains no user serviceable parts.

CAUTION

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

CAUTION

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

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WARRANTY POLICY

ADVANCED POLLUTION INSTRUMENTATION, INC.
02024c

Prior to shipment, API equipment is thoroughly inspected and tested. Should equipment failure occur, API assures its customers that prompt service and support will be available.

COVERAGE

After the warranty period and throughout the equipment lifetime, API 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-API MANUFACTURED EQUIPMENT

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

GENERAL

API warrants each Product manufactured by API to be free from defects in material and workmanship under normal use and service for a period of one year from the date of delivery. All replacement parts and repairs are warranted for 90 days after the purchase.

If a Product fails to conform to its specifications within the warranty period, API shall correct such defect by, in API's discretion, repairing or replacing such defective Product or refunding the purchase price of such Product.

The warranties set forth in this section shall be of no force or effect with respect to any Product: (i) that has been altered or subjected to misuse, negligence or accident, or (ii) that has been used in any manner other than in accordance with the instruction provided by API or (iii) not properly maintained.

THE WARRANTIES SET FORTH IN THIS SECTION AND THE REMEDIES THEREFORE ARE EXCLUSIVE AND IN LIEU OF ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR

PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY, WHETHER EXPRESSED OR IMPLIED. THE REMEDIES SET FORTH IN THIS SECTION ARE THE EXCLUSIVE REMEDIES FOR BREACH OF ANY WARRANTY CONTAINED HEREIN. API SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR RELATED TO THIS AGREEMENT OF API'S PERFORMANCE HEREUNDER, WHETHER FOR BREACH OF WARRANTY OR OTHERWISE.

TERMS AND CONDITIONS

All units or components returned to 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.

1 Product Descriptions

1.1 M454 Ozone Monitor (1/2 DIN Package)

The API M454 is a microprocessor-based monitor for measuring the concentration of gaseous ozone in processes such as semiconductor wafer fabrication, water treatment, and ozone research. The M454 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 ½ DIN package can be panel mounted (panel mount hardware is included) or operated as a bench-top monitor.

The M454 features a 4-digit front panel display/keypad as well as a standard 0-5 volt (optional isolated 4-20mA) analog output for reporting ozone concentration. A bi-directional serial interface (RS232 or RS485) is also provided for computer control and data acqusition. A front panel membrane keypad provides buttons for zero calibration and cell pressure display.

Four digital status outputs are provided for sensor diagnostics. These are displayed as front panel indicators and are provided as opto-isolated outputs on the rear panel I/O connector.

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2 Specifications

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

2.1 Mechanical Specifications

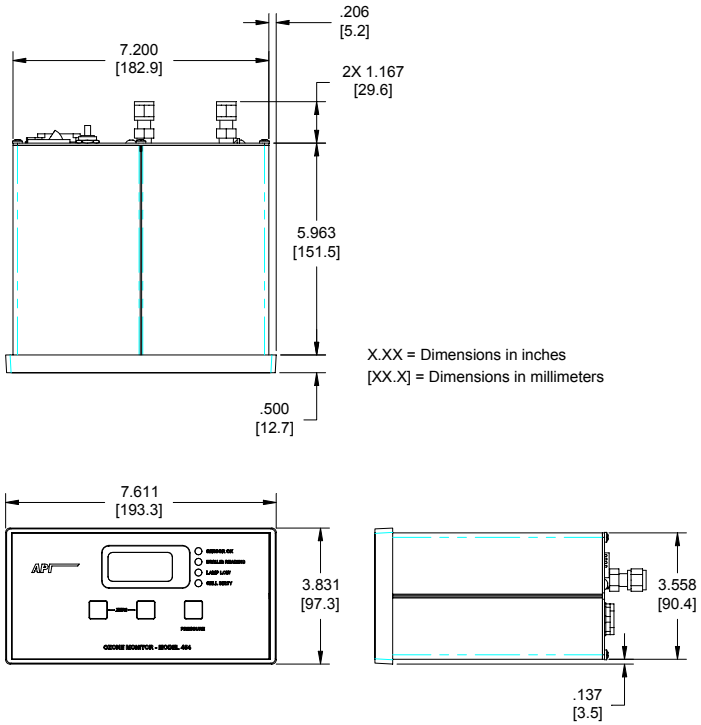

Figure 2-1: M454 ½ DIN Ozone Monitor

Weight:	4.0 lbs. (1.80 kg)
Gas Fittings:	M454 – ¼" Gyrolok™
Wetted Materials:	Type 316 Stainless Steel, Sapphire, Virgin PTFE

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)
Display:	4 Digit LED

2.3 Operating Limits

Measurement Range:	5, 10, 15, 20% w/w 25, 50, 100, 200, 400 g/Nm3
Proof pressure:	115 psia
Flow:	0.1-5 L/min
Temperature range:	5 to 45 °C
Warm-Up Period:	15 minutes

2.4 Electrical Specifications

Power Input:	90-265 VAC, 47-63 Hz, 30 VA
Analog Output:	0-5V Full Scale (4-20mA optional)
Zero Cal:	Contact Closure Input
Digital Outputs:	Sensor OK, Invalid Reading, Lamp Low, Cell Dirty
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

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 454 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
ℓ	= Path length
C_{O_3}	= Concentration of ozone
T	= Sample temperature in degrees Kelvin
P	= 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 and Operation

4.1 Unpacking

Upon receiving the M454 please verify that no apparent shipping damage has occurred. If damage has occurred please advise shipper first, then API.

4.2 Mechanical Installation

4.2.1 Bench Top Installation

Affix the four(4) self-adhesive rubber feet to the bottom of the chassis as shown in Figure 4-1 below.

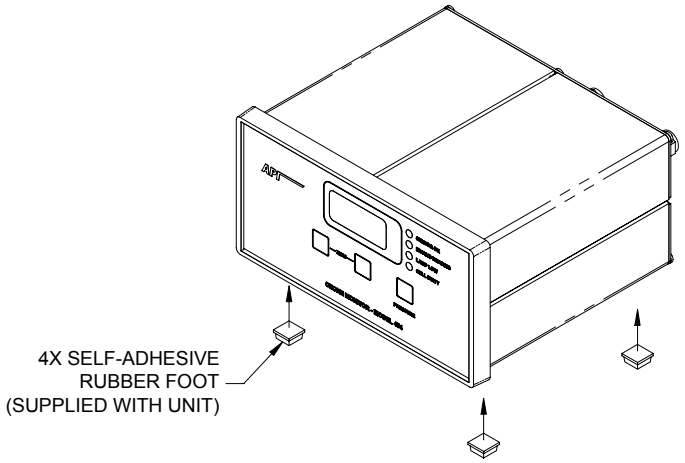

Figure 4-1: Bench Top Installation

4.2.2 Panel Mount Installation

The M454 can be mounted in a standard ½ DIN panel cut-out as shown below in Figure 4-2. Simply slide the M454 into the cut-out from the front. Next, slide the Panel Mount Clamps into the grooves on either side of the chassis. Next, thread the Clamp Screws into the rear openings of the grooves until the Panel Mount Clamps are snug against the rear of the panel. Thread locking compound can be used on the screws to prevent them from vibrating loose.

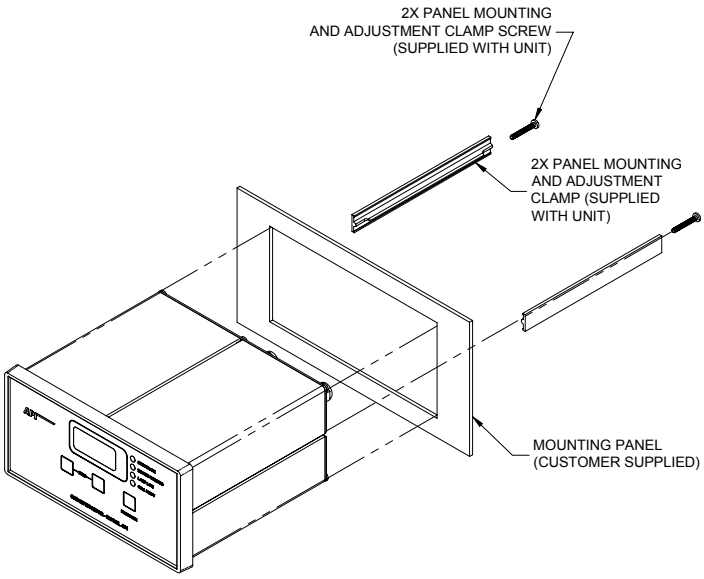

Figure 4-2: Panel Mount Installation

4.3 Electrical Connections

All electrical connections to the M454 are accessible on the rear panel of the instrument.

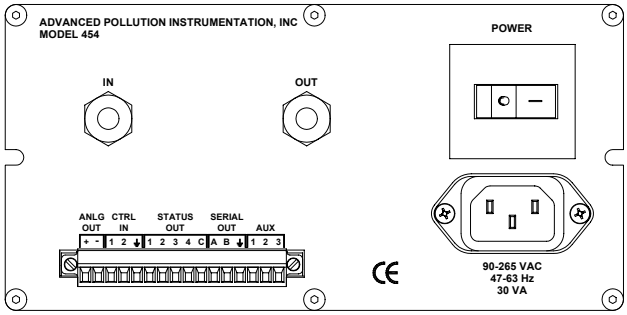

Figure 4-3: M454 Rear Panel

4.3.1 AC Power Connection

AC power should be connected to the IEC320 receptacle on the rear panel. Any AC voltage from 90-265 VAC may be used to power the M454.

CAUTION

Make sure that the power cord is connected to a properly grounded AC outlet.

4.3.2 Analog Output

The analog output is a 0-5 volt signal representing the ozone concentration measured by the sensor. This output is provided on the 16-pin modular connector and is labeled "ANLG OUT" (See Figure 4-3). The output is scaled to the concentration range that the sensor has been configured to measure. Check the serial number label on the M454 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.

If the isolated current output has been installed, this output will be a 4-20mA current source.

4.3.3 Control Inputs

Two control inputs are provided on the 16-pin modular connector and are labeled "CTRL IN" (See Figure 4-3).

Control Input #1 is used for remote zero calibration. To zero the M454, Control Input #1 should be connected to the ground pin provided for at least 1 second. This can be accomplished using a Normally Open switch or relay.

Control Input #2 is used to activate the pressure display on the front panel. Connecting Input #2 to the ground pin will switch the front panel readout to display the cell pressure. When this input is released, the normal concentration display will resume. This function does not affect the analog output. The analog output will continue to reflect the ozone concentration while the pressure is being displayed on the front panel.

4.3.4 Status Outputs

Four digital status outputs are provided on the 16-pin modular connector and are labeled "STATUS OUT" (See Figure 4-3). The outputs are labeled 1-4 and the common ground pin for the outputs is labeled "C."

The four outputs are used 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 4-4 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.

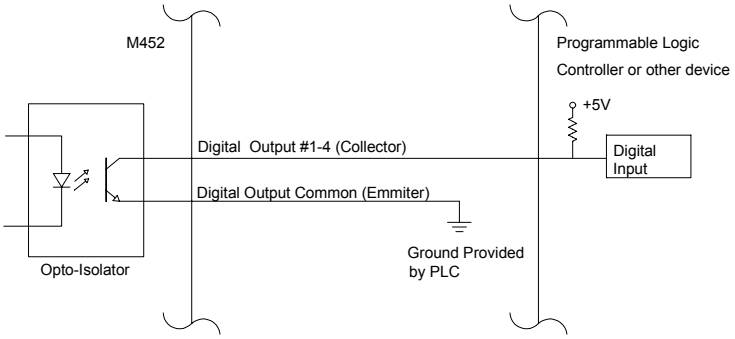

Figure 4-4: Digital Output Connections

Table 4-1 below describes the function of the status outputs.

Table 4-1: 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 Full-scale concentration range exceeded	Normal State
3	Lamp Low	Reference Detector<600mV	Normal State
4	Cell Dirty	Measure/Reference ratio < 0.5 (zero gas)	Normal State

See Section 5 for details on using the Status Outputs for diagnosing sensor and system-level malfunctions.

4.3.5 Serial Digital Interface (RS232/485)

The M454 features a bi-directional digital serial interface that can be used for sensor control and data acquisition. The interface can be configured for RS232 or RS485 operation. Please contact API for documentation on the use of the RS485 interface.

4.4 Gas Connections

Gas connections to the M454 are made using ¼" compression tube fittings. The ¼" compression fittings can be used with ¼" O.D. Stainless Steel or Teflon™ tubing. Connect the ozone supply tubing to the inlet fitting labeled "IN." Connect the exhaust tubing to the outlet fitting labeled "OUT." Note that an external flow control device must be used to ensure that the flow rate into the monitor is maintained in the range of 0.1 to 5.0 L/min.

CAUTION

The exhaust gas from the monitor may contain dangerous levels of ozone. Make sure that the gas connections are leak-tight and the exhaust line is connected to a suitable ozone destruct unit.

To avoid contamination of the optical cell in the M454, ensure that all tubing upstream of the M454 is properly cleaned and purged **before** the M454 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 LPM is established through the M454. If long tubing runs are used between the measurement point and the M452, 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 M454. Allow the M454 to warm up for at least 15 minutes.
2. Purge the M454 with zero gas (usually oxygen) at a minimum flow rate of 0.5 LPM for at least 2 minutes.
3. Check that the Status Outputs (See Section 4.3.4) or Status LED's (See Section 4.6.2) are in their normal states and no errors are indicated.

4. Close the zero calibration input (See Section 4.3.3) or press the zero keys (See Section 4.6.3) on the front panel to perform the automatic zero calibration.
5. Re-check the Status Outputs or Status LED's 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 M454 is now ready for operation.

4.6 Front Panel Display and Keypad

The M454 front panel features a 4-digit display, four Status LED's, and push-button keys for performing zero calibration and displaying cell pressure. Figure 4-5 below shows the front panel of the M454.

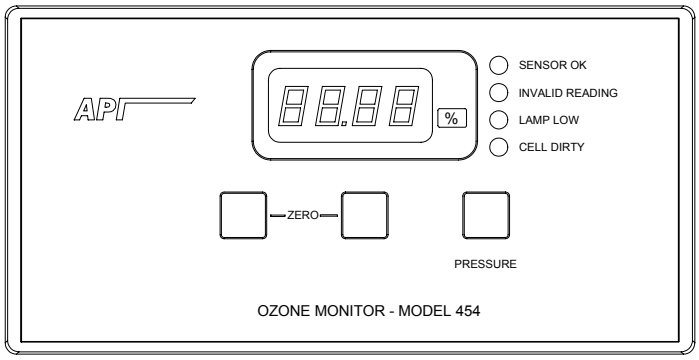

Figure 4-5: Front Panel

4.6.1 4 Digit Display

The 4-digit display gives a continuous, real-time display of ozone concentration in units of weight percent (%), grams per cubic meter (g/m3), or grams per Normal (or Standard) cubic meter (g/Nm3). The Standard conditions for the grams per Normal cubic meter units are 0°C (273 K), and 760 mmHg. The selection of measurement units is a factory configuration.

4.6.2 Status LED's

Four status LED's are displayed on the front panel. The green 'Sensor OK' LED should be on during normal operation, and the other three red error LED's should be off. The function of these LED's is identical to the Status Outputs described in Section 4.3.4 and Section 5.

4.6.3 Zero Calibration Keys

To perform a zero calibration, press both 'Zero' keys simultaneously. The display should momentarily show four dashes (----), indicating that the zero calibration has been performed. See Section 4.5 for details on all the steps required to successfully perform a zero calibration.

4.6.4 Pressure Display Key

Pressing the 'Pressure' key will display the cell pressure in psia (pounds per square inch absolute). This is a momentary function and the real-time ozone concentration display will resume when the key is released. This function does not affect the analog output. The analog output will continue to reflect the ozone concentration while the pressure is being displayed on the front panel.

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5 Sensor and System Troubleshooting

This chapter gives guidelines for diagnosing system and sensor malfunctions using the four digital Status Outputs or front panel Status LED's. All troubleshooting should be done after the M454 has been turned on and allowed to warm up for at least 15 minutes.

5.1 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 M454 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.

5.2 Invalid Reading

The normal state for the Invalid Reading output is OFF. If this output turns on, this indicates that the M454 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 when the measured pressure in the M454 exceeds 45 psia, the sensor is indicating an excessive negative reading, or the concentration has exceeded the full-scale range of the sensor.

5.3 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 measurement is no longer possible.

5.4 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.

5.5 Status Output Summary Table

Table 5-1 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 5-1: 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 Calibrate at Zero Check for concentration over-range
1	X	1	X	Lamp adjustment useful, though not required
1	X	X	1	Calibrate at zero Clean Cell

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