OWNER'S MANUAL

OXYGEN SENSOR

Models SO-130

Rev: 17-June-2025

APOGEE INSTRUMENTS, INC. | 721 WEST 1800 NORTH, LOGAN, UTAH 84321, USA
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CERTIFICATE OF COMPLIANCE

EU Declaration of Conformity

This declaration of conformity is issued under the sole responsibility of the manufacturer:

Apogee Instruments, Inc.
721 W 1800 N
Logan, Utah 84321
USA

for the following product(s):

Models: SO-110, SO-130, SO-120, SO-210, SO-220
Type: Oxygen Sensor

The object of the declaration described above is in conformity with the relevant Union harmonization legislation:

2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Hazardous Substances (RoHS 2) Directive
2015/863/EU	Amending Annex II to Directive 2011/65/EU (RoHS 3)

Standards referenced during compliance assessment:

EN 61326-1:2013	Electrical equipment for measurement, control, and laboratory use – EMC requirements
EN 63000:2018	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

Please be advised that based on the information available to us from our raw material suppliers, the products manufactured by us do not contain, as intentional additives, any of the restricted materials including lead (see note below), mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyls (PBDE), bis (2-ethylhexyl) phthalate (DEHP), butyl benzyl phthalate (BBP), dibutyl phthalate (DBP), and diisobutyl phthalate (DIBP). However, please note that articles containing greater than 0.1 % lead concentration are RoHS 3 compliant using exemption 6c.

Further note that Apogee Instruments does not specifically run any analysis on our raw materials or end products for the presence of these substances, but we rely on the information provided to us by our material suppliers.

Signed for and on behalf of:
Apogee Instruments, August 2022

Bruce Bugbee
President
Apogee Instruments, Inc.

CERTIFICATE OF COMPLIANCE

UK Declaration of Conformity

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Apogee Instruments, Inc.
721 W 1800 N
Logan, Utah 84321
USA

for the following product(s):

Models: SO-110, SO-120, SO-130, SO-210, SO-220
Type: Oxygen Sensor

The object of the declaration described above is in conformity with the relevant UK Statutory Instruments and their amendments:

2016 No. 1091	The Electromagnetic Compatibility Regulations 2016
2012 No. 3032	The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

Standards referenced during compliance assessment:

BS EN 61326-1:2013	Electrical equipment for measurement, control, and laboratory use – EMC requirements
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UK
CA

INTRODUCTION

Oxygen (O_2) is the second most abundant gas in the atmosphere and is essential to life on Earth. Oxygen availability determines the rate of many biological and chemical processes and is required for aerobic respiration. As described in this manual, it is the absolute amount of oxygen (measured as partial pressure in kilopascals) that nearly always determines oxygen availability, but we think of oxygen as a percentage of the total number of molecules in the air (20.95 %). The best example of this is the oxygen on top of Mount Everest, which is 20.95 %, but most climbers need supplemental oxygen to get to the top.

There are two types of oxygen sensors: those that measure gaseous O_2 and those that measure dissolved oxygen in a solution. The Apogee sensor measures gaseous O_2.

There are multiple techniques for measuring gaseous oxygen. Three widely used approaches for environmental applications are galvanic cell sensors, polarographic sensors, and optical sensors. **The Apogee sensor is a galvanic cell type.** Galvanic cell and polarographic sensors operate by electrochemical reaction of oxygen with an electrolyte, which produces an electrical current. The electrochemical reaction consumes a small amount of oxygen. Unlike polarographic oxygen sensors, galvanic cell sensors are self-powered. Optical oxygen sensors use fiber optics and a fluorescence method to measure oxygen via spectrometry.

Typical applications of Apogee oxygen sensors include measurement of oxygen in laboratory experiments, monitoring gaseous oxygen in indoor environments for climate control, monitoring of oxygen levels in compost piles and mine tailings, and determination of respiration rates through measurement of oxygen consumption in sealed chambers or measurement of oxygen gradients in soil/porous media. Apogee oxygen sensors are not intended for use as medical monitoring devices.

Apogee Instruments oxygen sensors consist of a galvanic cell sensing element (electrochemical cell), Teflon membrane, reference temperature sensor (thermistor or thermocouple), heater (located behind the Teflon membrane), and signal processing circuitry mounted in a polypropylene plastic housing and lead wires to connect the sensor to a measurement device. Sensors are designed for continuous gaseous oxygen measurement in ambient air, soil/porous media, sealed chambers, and in-line tubing (flow through applications). The SO-130 oxygen sensor outputs an analog voltage that is linearly proportional to the partial pressure of gaseous oxygen.

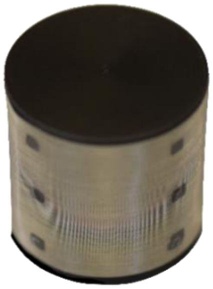
SENSOR MODELS

Sensor model number and serial number are located on a label between the sensor and pigtail lead wires. If you need the manufacturing date of your sensor, please contact Apogee Instruments with the serial number of your sensor.

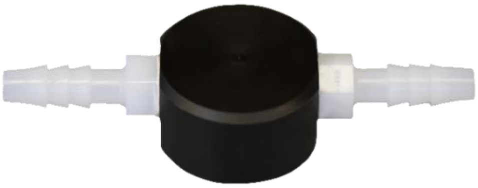
Accessories

All Apogee oxygen sensors can be purchased with attachments to facilitate measurements in soil/porous media or in-line tubing.

Model AO-001: Diffusion head designed for measurements in soil/porous media. The diffusion head maintains an air pocket and provides protection to the permeable Teflon membrane where gas diffusion occurs.



Model AO-002: Flow through head designed for in-line measurements. The flow through head allows connection of tubing via ¼ inch barbed nylon connectors.



Model AO-003: Connection Nut. The custom-size nut and o-ring used to connect and seal Apogee Oxygen sensors to jar lids and other containers for gaseous oxygen studies.

SPECIFICATIONS

	SO-130 Specifications
Response Time (time required to read 90 % of saturated response)	15 s
Measurement Range	0 to 30 % O_2
Sensitivity (at sea level, 101.3 kPa)	10 to 15 mV at 20.95 % O_2; 0.6 mV per % O_2
Output at 0 % O_2	Less than 0.5 mV
Measurement Repeatability	Less than 0.1 % of mV output at 20.95 % O_2
Non-linearity	Less than 1 %
Signal Decrease per Year	3 % per year
Oxygen Consumption Rate	0.1 µmol O_2 per day at 20.95 % O_2 and 23 C (galvanic cell sensors consume O_2 in a chemical reaction with the electrolyte, which produces an electrical current)
Operating Environment	-20 to 60 C; 0 to 100 % relative humidity (non-condensing); 60 to 140 kPa; Note: Electrolyte will freeze at temperatures lower than -20 C. This will not damage the sensor, but the sensor must be at a temperature of -20 C or greater in order to make measurements.
Input Voltage Requirement	12 V DC continuous (for heater); 2.5 V DC excitation (for thermistor)
Heater Current Draw	6.2 mA
Thermistor Current Draw	0.1 mA DC at 70 C (maximum, assuming input excitation of 2.5 V DC)
Dimensions	32 mm diameter, 68 mm length
Mass	175 g (with 5 m of lead wire)
Diffusion Head (Accessory)	3.5 cm diameter; 3.5 cm length; 125 mesh screen
Flow Through Head (Accessory)	3.2 cm diameter; 8.56 cm length; ¼ inch barbed nylon connectors
Cable	5 m of six conductor, shielded, twisted-pair wire; additional cable available in multiples of 5 m; TPR jacket (high water resistance, high UV stability, flexibility in cold conditions); pigtail lead wires
Influence from Various Gases	Sensors are unaffected by CO, CO_2, NO, NO_2, H_2S, H_2, and CH_4. There is a small effect (approximately 1 %) from NH_3, HCl, and C6H6 (benzene). Sensors are sensitive to SO2 (signal responds to SO2 in a similar fashion to O2). Sensors can be damaged by O3.
Response to Temperature	0.015 mV/C (<0.03 % O_2/C) in 0-40 C

DEPLOYMENT AND INSTALLATION

The SO-130 is built with a polypropylene housing and are designed to be installed in soil/porous media or sealed chambers or flow-through applications.

To facilitate the most stable readings, sensors should be mounted vertically, with the opening pointed down and the cable pointed up. This orientation allows better contact between the electrolyte and signal processing circuitry.

The sensor is resistant to 2.7 G of shock, but vibration may influence sensitivity and should be minimized.

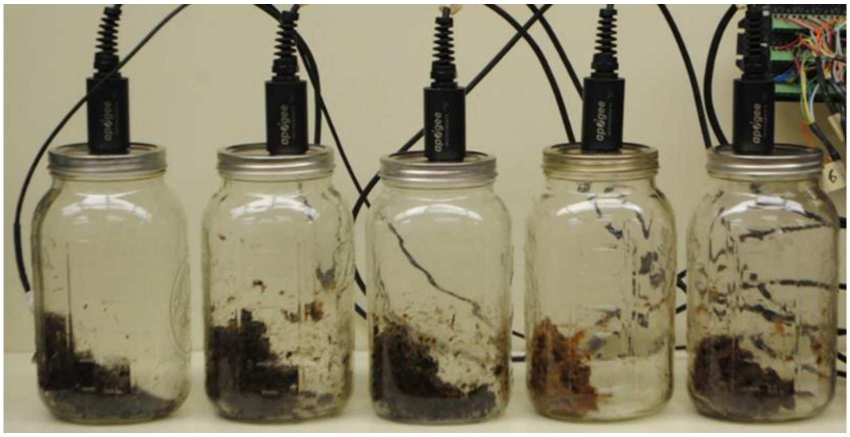
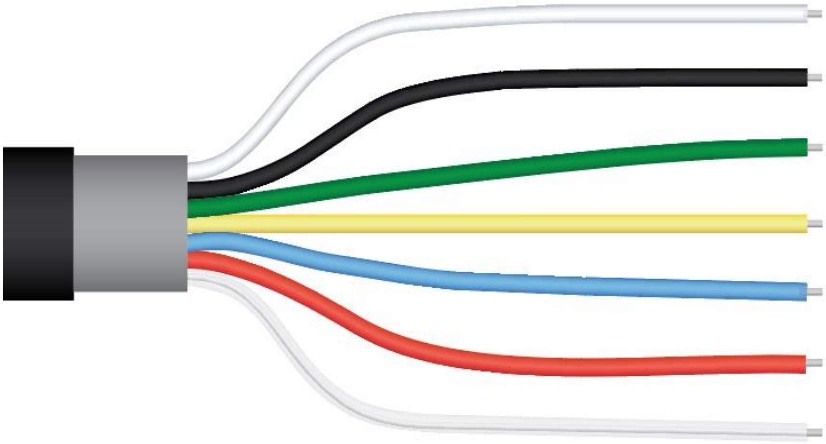


Image courtesy of Utah State University Crop Physiology Lab

OPERATION AND MEASUREMENT

Connect the sensor to a measurement device (meter, datalogger, and controller) capable of measuring and displaying or recording a microvolt (µV) signal (the sensor output is 6 to 21 microvolts per 0.01 % O2 depending on the model). Measurement resolution and signal-to-noise ratio are maximized when the input range of the measurement device matches the output range of the sensor.

Wiring for SO-130



White: High side of differential channel (positive lead for O_2 sensor)

Black: Low side of differential channel (negative lead for O_2 sensor)

Green: Single-ended channel (positive lead for thermistor)

Yellow: 12 V port (positive lead for heater)

Blue: Ground (negative lead for **thermistor** and **heater**)

Red: Excitation channel (excitation for thermistor)

Clear: Shield/Ground

Note: the O_2 signal output can be measured either differential or single-ended with a preference to differential if the extra channels are available.

ABSOLUTE AND RELATIVE GAS CONCENTRATION

Gas concentration is described in two ways, absolute and relative concentration. The ideal gas law yields absolute gas concentration, often expressed in quantity per volume [mol m^{-3}] or partial pressure [kPa]:

$$PV = nRT \tag{1}$$

where P is pressure [Pa], V is volume [m^3], n is gas quantity [mol], T is temperature [K], R is the ideal gas constant (8.314 J mol^{-1} K^{-1}), and rearrangement of equation (1) to solve for n / V or P yields absolute gas concentration (in mol m^{-3} or kPa, respectively). However, a simple and common way to report concentration of a specific gas in a mixture is by expressing it relative to other gases in the mixture, as a fraction or percentage. For example, the amount of oxygen in the atmosphere, assuming a dry atmosphere (no water vapor), is 0.2095 kPa O_2 per kPa air, or 20.95 %. Atmospheric concentration of oxygen has remained constant for several hundred years at 20.95 %, and this percentage is the same at all elevations. However, absolute oxygen concentration does not remain constant (e.g., pressure decreases with elevation, thus, absolute oxygen concentration decreases with elevation). Absolute oxygen concentration determines the rate of most biological and chemical processes, but relative oxygen concentration is often reported. This is analogous to measuring and reporting relative humidity when absolute humidity is what determines evaporation rates. Absolute and relative gas concentration measurements can be expressed using several different units.

Units Used to Describe Absolute and Relative Gas Concentration Measurements

Absolute Amount of Gas	Relative Amount of Gas
moles of O_2 per unit volume (e.g., moles per m^3 or moles per liter)	**% O_2 in air** (e.g., 20.95 % in ambient air)
mass of O_2 per unit volume (e.g., grams per liter; O_2 has a mass of 32 g per mole)	**mole fraction** (e.g., moles of O_2 per mole of air; 0.2095 mol O_2 per mole of ambient air; this can also be expressed as 0.2095 kPa O_2 per kPa air)
partial pressure (e.g., kilopascals [kPa])	

Sensor Calibration

All Apogee oxygen sensors respond to absolute oxygen concentration in air, where common units of absolute gas concentration are partial pressure (e.g., kilopascals, kPa), mass per unit volume (e.g., grams per liter, g l^{-1}), and number of molecules per unit volume (e.g., moles per liter, mol l^{-1}). The absolute amount of oxygen in air is dependent on absolute (barometric) pressure and temperature, in addition to oxygen content of air. Therefore, Apogee oxygen sensors are not calibrated at the factory and must be calibrated by the user, where onsite calibration before first use is highly recommended.

The output of Apogee oxygen sensors is a linear function of absolute oxygen concentration. A simple linear calibration is generally used to derive a calibration factor used to convert sensor output to relative oxygen concentration. The calibration factor (CF, in kPa O_2 mV^{-1}) is derived by dividing ambient oxygen partial pressure (21.23 kPa at sea level assuming standard pressure of 101.325 kPa) by the measured voltage output from the sensor under ambient conditions (in air or over water in a sealed chamber) minus the measured voltage output under conditions of zero oxygen (0 kPa O_2):

$$CF = \frac{0.2095\, P_B}{mV_C - mV_0} \tag{2}$$

where P_B is barometric pressure [kPa], 0.2095 multiplied by P_B equals partial pressure of oxygen under ambient conditions [kPa], mV_C is sensor voltage output [mV] during calibration, mV_0 (on average = 3.0 mV for the SO-110/120 and 0.3 mV for the SO-210/220) is sensor voltage output [mV] under zero oxygen (0 kPa O_2), and CF is a linear multiplier that converts voltage measurements from the sensor to partial pressure of oxygen [kPa] using the equation:

$$O_2 = CF \cdot mV_M - Offset \tag{3}$$

where mV_M is measured voltage output [mV] and Offset is derived by multiplying CF by mV_0. The voltage output during calibration, mV_C, should be measured in a well-ventilated area. Do not breathe on the sensor, as exhaled breath has a much lower oxygen concentration than ambient air. If mV_0 is not measured, it can be estimated to be 3.0 mV for SO-100 series sensors and 0.30 mV for SO-200 series sensors. It is recommend that mV_0 be measured (in pure nitrogen gas) for applications where low values of oxygen (less than 10 kPa) will be measured. Precise measurements of hypoxic and anaerobic conditions can be made by making a periodic zero calibration of the sensor with ultra-pure nitrogen gas.

To convert sensor voltage output to partial pressure of oxygen (in kPa), multiply the measured voltage signal by the calibration factor, and then subtract the offset. For example, at sea level and 20.95 % O_2:

Calibration Factor [kPa O_2 per mV] * Sensor Output Signal [mV] - Offset [kPa] = Oxygen [kPa]

0.379 * 59.0 - 1.14 = 21.23

The calibration factor and offset are variable from sensor to sensor (those listed above are examples), and a sensor-specific calibration factor should be derived for each individual sensor. For routine oxygen measurements, the generic offset described above can be used. For measurements in air with less than 10 kPa (approximately 10 %) oxygen, a sensor-specific offset should be derived for each individual sensor.

Sensors can also be calibrated to measure relative oxygen concentration. The same procedure described for calibration to absolute oxygen is used, except ambient oxygen is set equal to 20.95 % (instead of 0.2095 multiplied by barometric pressure) to derive the calibration factor [% O_2 mV^{-1}]:

$$CF = \frac{20.95\%}{mV_C - mV_0} \tag{4}$$

where mV_C and mV_0 are as described above. The offset is also derived in the same manner, where mV_0 is multiplied by the calibration factor calculated from equation (4). Equation (3) is then used to produce relative oxygen measurements, when the calibration factor and offset derived from 20.95 % are used.

Changes in barometric pressure and temperature cause changes in absolute oxygen concentration, and as a result, changes in sensor signal output. This causes apparent changes in relative oxygen concentration, even though the relative amount of oxygen remains constant. Thus, barometric pressure and temperature corrections must be applied to relative oxygen measurements. Changes in absolute humidity (water vapor pressure of air) cause changes in absolute and relative oxygen concentration, as water vapor molecules displace and dilute oxygen molecules. Even though changes in water vapor content cause actual (not apparent) changes in relative oxygen concentration, water vapor effects are often corrected for to yield relative oxygen concentrations for a dry atmosphere.

Effect of Barometric Pressure on Oxygen Concentration

The ideal gas law, equation (1), shows that absolute gas concentration increases by 0.987 % at sea level for every 1 kPa increase in pressure (1 kPa / 101.325 kPa = 0.00987). For a sensor that measures absolute gas concentration, but is calibrated to read out in relative units, a 1 kPa pressure increase at sea level results in an apparent oxygen increase of 0.207 % (0.00987 * 20.95 % = 0.207 %) and an apparent relative oxygen concentration of 21.157 %. Relative gas concentration didn't really increase, but absolute concentration, which is what sensors measure, did change. This shows up as an apparent change in relative concentration.

Due to lower barometric pressure at higher elevations, the percentage increase in absolute gas concentration per kPa increases with elevation. For example, at an elevation of 1378 m (Logan, Utah), barometric pressure is approximately 86 kPa and absolute gas concentration increases by 1.16 % for every 1 kPa increase in pressure (1 kPa / 86 kPa = 0.0116). Again, for a sensor that measures absolute gas concentration, but is calibrated to read out in relative units, this results in an apparent oxygen increase. In this example, 0.243 % for every 1 kPa increase in barometric pressure (0.0116 * 20.95 % = 0.243 %) and an apparent relative oxygen concentration of 21.193 %.

A barometric pressure correction should be applied to all oxygen sensors that are calibrated to read relative oxygen concentration. The equation to correct relative oxygen measurements for barometric pressure at any elevation is:

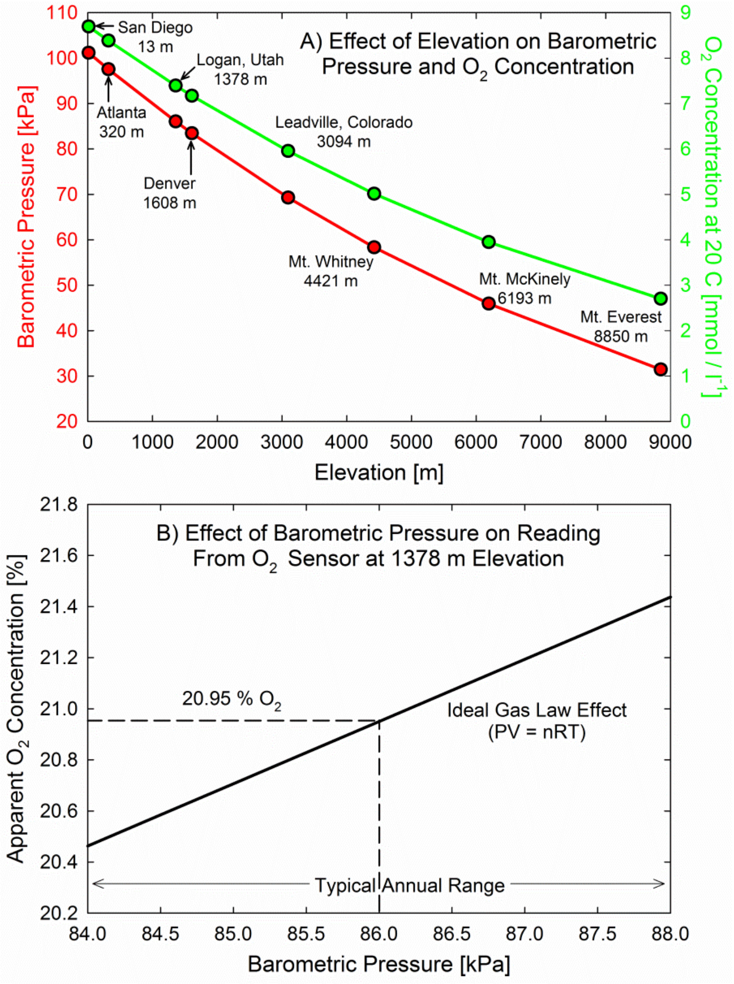
$$\mathrm{O_2} = \mathrm{O_{2M}}\left(\frac{\mathrm{P_C}}{\mathrm{P_M}}\right) \tag{5}$$

where O_{2M} is measured oxygen concentration [%] (apparent oxygen concentration), P_C is barometric pressure [kPa] at the time of calibration, and P_M is barometric pressure [kPa] at the time of the current measurement. Approximate barometric pressure (P_B, in kPa) for a given elevation is calculated from:

$$\mathrm{P_B} = 101.325 - 101.325\left[1 - \left(1 - \frac{\mathrm{E}}{44307.69231}\right)^{5.25328}\right] \tag{6}$$

where E is elevation [m]. In order to make a barometric pressure correction on gas measurements, it must be continuously measured as it changes over time (see Apogee webpage for a barometric pressure sensor that can be used for continuous measurements of barometric pressure: http://www.apogeeinstruments.com/barometric-pressure/). The typical annual barometric pressure range is approximately 4 kPa, or the average pressure for a given elevation +/- 2 kPa.

The apparent effect of barometric pressure on relative oxygen measurements, based on calculations from equation (5), is plotted in the figure below for 1378 m elevation to show the significance of measuring and correcting for barometric pressure. If not accounted for, barometric pressure fluctuations show up in oxygen measurements as a change in relative oxygen concentration because sensors respond to absolute oxygen concentration, but are generally calibrated to read out in relative units.



A) Barometric pressure and absolute oxygen concentration at 20 C as a function of elevation. Equation (6) was used to calculate barometric pressure. B) Effect of barometric pressure on apparent relative oxygen concentration. Oxygen sensors respond to absolute oxygen concentration but are often calibrated to yield relative oxygen concentration. As barometric pressure fluctuates, absolute oxygen concentration, thus, oxygen sensor output, fluctuates with it, producing an apparent change in relative oxygen concentration if this pressure effect is not accounted for. It is assumed the sensor was calibrated at 86 kPa, and the solid line shows how the apparent relative oxygen concentration is dependent on barometric pressure.

Effect of Temperature on Oxygen Concentration

The ideal gas law, equation (1), shows that absolute gas concentration decreases by 0.341 % for a 1 C increase in temperature from 20 C (1 K / 293 K = 0.00341). For a sensor that measures absolute gas concentration, but is calibrated to read out in relative units, a 1 C temperature increase from 20 C results in an apparent decrease of 0.0714 % O_2 (0.341 % * 0.2095 = 0.0714 %) and a relative oxygen concentration of 20.878 %. As with barometric pressure, to obtain accurate oxygen measurements with a sensor that is calibrated to read relative oxygen concentration, a correction should be applied to compensate for temperature effects. The equation to correct relative oxygen measurements in air for temperature effects is:

$$O_2 = O_{2M}\left(\frac{T_M}{T_C}\right) \tag{7}$$

where O_{2M} is as given above, T_C is air temperature [K] at calibration, and T_M is air temperature [K] at the time of measurement (note that temperatures in equation (7) must be in K). The effects of temperature on relative oxygen concentration measurements, based on calculations from equation (7), are plotted in the figure below to show the significance of measuring and correcting for temperature. If not accounted for, temperature fluctuations show up in the measurement as an apparent change in relative oxygen concentration because sensors respond to absolute oxygen concentration, but are calibrated to read out in relative units.

Effect of Humidity on Oxygen Concentration:

As absolute humidity in the atmosphere increases, water vapor molecules displace and dilute other gas molecules. This causes the signal output of a gas sensor to decrease. The water vapor effect on relative oxygen concentration as a function of relative humidity (RH) and at a constant temperature is a linear decrease with increasing RH, as shown in the figure below. Conversely, the effect as a function of temperature at constant RH is a curvilinear decrease with increasing temperature, essentially the inverse of the slope of vapor pressure curves from a psychrometric chart. Even though water vapor molecules dilute and displace oxygen molecules, and cause an actual and not an apparent decrease in relative oxygen concentration, humidity effects are often accounted for to yield relative oxygen concentrations for a dry atmosphere. The equation to correct for humidity effects is:

$$O_2 = O_{2M}\left(\frac{P_C + \left(e_{AM} - e_{AC}\right)}{P_C}\right) \tag{10}$$

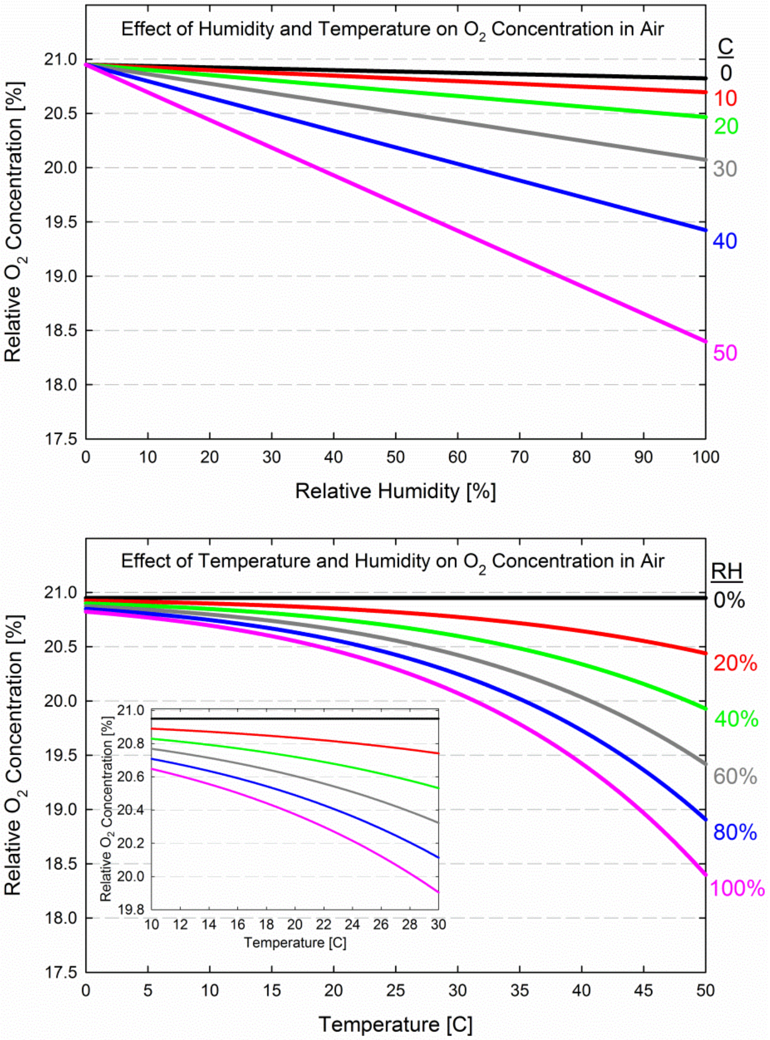
where P_C is barometric pressure at calibration [kPa], e_{AM} is vapor pressure [kPa] of air at the time of measurement, and e_{AC} is vapor pressure [kPa] of air at calibration. Vapor pressures in equation (10) are calculated from:

$$e_A = e_S\left(\frac{RH}{100}\right) \tag{11}$$

where RH is in % and e_S is saturation vapor pressure [kPa] of air calculated from air temperature (T_A, in C):

$$e_S = 0.61121\exp\left(\frac{T_A\left(18.678 - \frac{T_A}{234.5}\right)}{257.14 + T_A}\right). \tag{12}$$

In soil environments relative humidity is generally between 99 and 100 %, unless the soil is extremely dry (below the permanent wilting point of -1,500 kPa). Thus, the water vapor effect can be accounted for as a function of temperature by correcting oxygen measurements based on the shape of the curve for 100 % RH in the graph below.



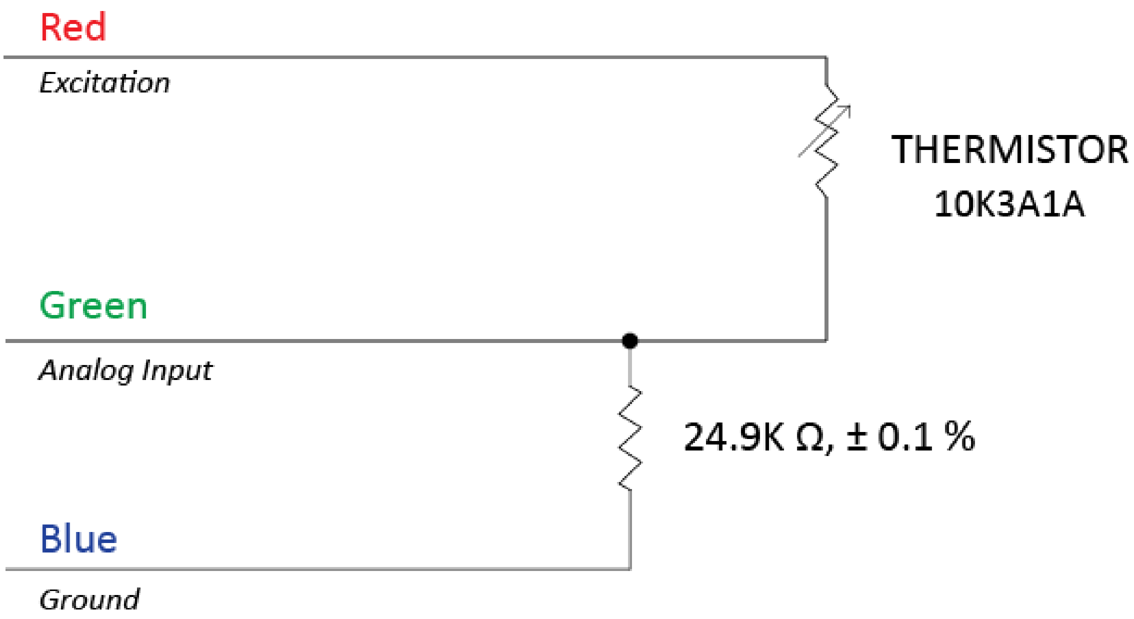
A) Relative humidity effects on relative oxygen concentration shown as a function of relative humidity at temperatures increments of 10 C and B) as a function of temperature at relative humidity increments of 20 %. The air in soil is typically always saturated with water vapor (100 % relative humidity) unless the soil is very dry.

As with temperature, humidity also causes a slight effect on the sensor electronics. For measurements in soil or saturated air (100 % relative humidity), it is recommended that Apogee oxygen sensors are calibrated in conditions where relative humidity is 100 %. A simple way to accomplish this is to mount the sensor in a sealed chamber over water, with ambient air filling the headspace, as shown below.

Apogee oxygen sensor mounted in a sealed chamber over water. For measurements in environments where relative humidity is 100 %, sensors should be calibrated in conditions where relative humidity is 100 % in order to account for any humidity effects on sensor electronics.

Temperature Measurement with Internal Thermistor

Measurement devices (e.g., datalogger, controller) do not measure resistance directly, but determine resistance from a half-bridge measurement, where an excitation voltage is input across the thermistor and an output voltage is measured across the bridge resistor.



An excitation voltage of 2.5 V DC is recommended to minimize self-heating and current drain, while still maintaining adequate measurement sensitivity (mV output from thermistor per C). However, other excitation voltages can be used. Decreasing the excitation voltage will decrease self-heating and current drain, but will also decrease thermistor measurement sensitivity. Increasing the excitation voltage will increase thermistor measurement sensitivity, but will also increase self-heating and current drain.

The internal thermistor provides a temperature reference for correction of relative oxygen measurements for temperature changes. Resistance of the thermistor changes with temperature. Thermistor resistance (R_T, in Ω) is measured with a half-bridge measurement, requiring an excitation voltage input (V_{EX}) and a measurement of output voltage (V_{OUT}):

$$R_T = 24900\left(\frac{V_{EX}}{V_{OUT}} - 1\right) \tag{13}$$

where 24900 is the resistance of the bridge resistor in Ω. From resistance, temperature (T_K, in Kelvin) is calculated with the Steinhart-Hart equation and thermistor specific coefficients:

$$T_K = \frac{1}{A + B\ln(R_T) + C(\ln(R_T))^3} \tag{14}$$

where A = 1.129241 x 10^{-3}, B = 2.341077 x 10^{-4}, and C = 8.775468 x 10^{-8}.

Heating Sensor with Internal Heater

All Apogee oxygen sensors are equipped with an internal resistance heater. The heater is designed to maintain the temperature of the sensing element at approximately 2 C above ambient temperature in condensing (100 % relative humidity) environments (e.g., soil). Heating the sensing element keeps condensation from forming on the membrane, which would block the oxygen diffusion path and result in erroneous measurements. To operate the heater, apply continuous 12 V DC across the yellow (positive) and blue (negative) wires.

MAINTENANCE AND RECALIBRATION

Visual inspection of the Teflon membrane should be made periodically to verify that the oxygen path is free from obstruction, as shown below. Avoid placing sharp objects inside the sensor opening, as the membrane can easily be punctured.

Life Expectancy

The life expectancy of the SO-130 is approximately five years of continuous use in 20.95 % oxygen and the signal decrease after five years is expected to be 60%. Lifetime can be lengthened by storing sensors in cold temperatures (e.g., fridge or freezer) when not in use.

Sensor recalibration can be conducted periodically and should be determined by the level of measurement accuracy required for the application. Apogee recommends the SO-130 sensors be recalibrated every year. Sensor signal decrease over one year when exposed to 20.95 % oxygen is shown in the figure below. SO-100 and SO-200 series sensors decrease by approximately 1 and 0.8 mV per year, respectively, or approximately 2 and 6 % of signal output at 20.95 % oxygen. This signal decrease yields increases in calibration factor of approximately 2 and 6 % for SO-100 and SO-200 series sensors, respectively.

Helpful Links

For tips on how to make calibration corrections for changes in environmental conditions, check out our technical support video at https://youtu.be/xnIyjfzFpa0.

For more information on sensor operation and calibration, as well as a link to the oxygen readings calculator, go to https://www.apogeeinstruments.com/oxygen-sensor-support/.

Sensor Storage

To prolong the life expectancy of Apogee sensors, storage at low temperature (in a refrigerator) and at low oxygen concentration is recommended. Care should be taken to not short the positive and negative leads for the O_2 sensor as this may have an effect on the response time to oxygen.

If the sensor is stored in a 0% O2 environment for an extended period of time, the sensor's offset becomes lower and response speed to O2 will become slower. In this case, the sensor will be able to recover to normal response speed after exposure to a normal environment for a period of 24 hours.

TROUBLESHOOTING AND CUSTOMER SUPPORT

Independent Verification of Functionality

The oxygen sensing element inside Apogee SO-130 oxygen sensors is a self-powered device that outputs a voltage signal proportional to partial pressure of gaseous oxygen. A quick and easy check of sensor functionality can be determined using a voltmeter with millivolt (mV) resolution. Connect the positive lead of the voltmeter to the white wire from the sensor and the negative lead (or common) to the black wire from the sensor. SO-130 sensors should read approximately 60 mV at sea level in ambient air (20.95 % O_2).This voltage will decrease by approximately 1 % per 100 meters of elevation increase above sea level.

The thermistor inside Apogee's oxygen sensors yields a resistance proportional to temperature. A quick and easy check of thermistor functionality can be accomplished with an ohmmeter. Connect the lead wires of the ohmmeter to the red and green wires from the sensor. The resistance should read 10 kΩ at 25 C. If the sensor temperature is less than 25 C, the resistance will be higher. If the sensor temperature is greater than 25 C, the resistance will be lower. Connect the lead wires of the ohmmeter to the green and blue wires from the sensor. The resistance should read 24.9 kΩ and should not vary. Connect the lead wires of the ohmmeter to the red and blue wires from the sensor. The resistance should be the sum of the resistances measured across the red and green wires, and green and blue wires (e.g., 10 kΩ plus 24.9 kΩ at 25 C).

The thermocouple inside Apogee SO-120 and SO-220 oxygen sensors yields a voltage proportional to the temperature difference between the hot (thermocouple tip inside sensor) and cold (thermocouple pigtail lead wires) junctions. A quick and easy check of thermocouple functionality can be determined using a voltmeter in continuity mode. Connect the leads of the voltmeter to the leads of the thermocouple (polarity does not matter), and test for continuity. Continuity indicates a functional thermocouple.

Compatible Measurement Devices (Dataloggers/Controllers/Meters)

SO-100 series oxygen sensors have a calibration factor of approximately 0.39 kPa O_2 per mV, yielding a sensitivity of approximately 2.6 mV per kPa O_2. SO-200 series oxygen sensors have a calibration factor of approximately 1.7 kPa O_2 per mV, yielding a sensitivity of approximately 0.6 mV per kPa O_2. Thus, a compatible measurement device (e.g., datalogger or controller) should have resolution of at least 0.02 and 0.006 mV, in order to provide pressure resolution of 0.01 kPa O_2 for the SO-100 and SO-200 series oxygen sensors, respectively.

The signal output range of SO-100 and SO-200 series oxygen sensors is approximately 3 to 250 mV and 0.3 to 60 mV, respectively. A compatible measurement device should also have a full-scale range spanning the sensor signal output range.

An example datalogger program for Campbell Scientific dataloggers can be found on the Apogee webpage at http://www.apogeeinstruments.com/content/Oxygen-Sensor.CR1.

Modifying Cable Length

When the sensor is connected to a measurement device with high input impedance, sensor output signals are not changed by splicing on additional cable in the field. Tests have shown that if the input impedance of the measurement device is 1 mega-ohm or higher, then there is negligible effect on SO-100 and SO-200 series oxygen sensor calibrations, even after adding up to 100 m of cable. See Apogee webpage for details on how to extend sensor cable length (http://www.apogeeinstruments.com/how-to-make-a-weatherproof-cable-splice/). For cable extensions, shielded, twisted pair cable is recommended, in order to minimize electromagnetic interference. This is particularly important for long lead lengths in electromagnetically noisy environments.

RETURN AND WARRANTY POLICY

To view our complete returns and warranty policy, visit https://www.apogeeinstruments.com/content/Warranty-Policy.pdf.

If you have any questions or issues viewing this document, please contact techsupport@apogeeinstruments.com.