PID (TVOC) Sensor Guide

PID Sensor (for measuring Total Volatile Organic Compounds) Usage and Troubleshooting Guide

Relevant Products: DSII, IQ610, TG502, TG503, VOC-103 Probes

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PID Theory of Operation

Total Volatile Organic Compounds (TVOC) can be measured using a Photo Ionization Detector (PID). The PID sensor is comprised of filter membrane, a ultra-violet lamp and a detector electrode. Gas passes through the filter membrane to exclude particles and liquids, and is exposed to high energy ultra violet (UV) radiation which ionizes some percentage of the molecules. Some of the molecules are converted into either positively or negatively charged ions. These ions are measured by a collection electrode and converted into a current corresponding to a concentration. This relationship can be seen below:

$$M + \gamma \rightarrow M^{+} + e^{-}$$

Where:
M=Target molecule
γ=Photon

In order for a molecule to be ionized by the UV lamp, the ionization potential (IP) must be lower than the energy of the UV lamp. GrayWolf utilizes a 10.6 electron volt (eV) lamp, so anything that has a higher ionization potential will not be detected. Major components of air such as nitrogen, oxygen, methane and carbon dioxide have a higher ionization potential then the UV lamp so they are not detected by a PID sensor, as can be seen in table below. Because PIDs are not affected by the ambient air, they are used for total volatile organic compounds (TVOC)

Compound	IP (eV)
Nitrogen	14.54
Oxygen	13.61
Carbon Dioxide	13.79
Methane	12.98

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Getting Accurate Readings with your GrayWolf VOC Probe

The PID sensor is a very sensitive device. Proper care, storage, use and calibration of the PID sensor is required to yield optimal results for this product; whether your application is for low range applications, such as IAQ testing, or for high range toxic exposure screening.

Warm-up

A 20-minute warm-up and stabilization time should be sufficient for most applications. If the sensor readings are pinned at zero or are continuing to rise (or to fall) while in a stable environment, the probe may require additional warm-up time, calibration or an overnight burn-in (see Troubleshooting, Burn-In sections below).

Storage

The probe should ideally be stored in a closed plastic bag (one that doesn't emit VOCs) with one or two small desiccant packs.

For long term storage (> 2 weeks) remove the batteries. Note that probes fitted with Nitric Oxide or Ethylene Oxide sensors will require 12 hours, once probe batteries are reconnected, before use.

Storage in humid conditions greater than 60%RH may cause sensor drift, and cause long stabilization times. However, the standard 20 minute warm-up, prior to recalibration and use, should minimize high %RH storage bias.

If the sensor has been stored for a significant amount of time, it may become contaminated. This in turn may cause excessive drift of the background signal. Therefore, it is highly recommended (for ppb range sensors in particular) to run the sensor for an extended period of time before operating it after prolonged storage. Refer to the section on **Contamination** and **Burn-In** for more information.

Use

Don't blow directly on the sensor. Do not use the probe in high humidity (>90%RH) environments as condensation moisture that may result could degrade performance. At humidity's above 80%, sensor response becomes sluggish longer stabilization times are required.

Allow the probe to equilibrate to the ambient room temperature before using. Do not use the probe if you observe condensation or moisture on any part of it.

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Calibration

As a rule, a daily User calibration (or check) of the sensor is recommended for excellent accuracy. However, if the sensor is used in a clean environment, calibration/check frequency can be reduced to just once per week for very good results. For generally adequate results, calibrations can be performed once a month. **Note: any sensor(s) used for life safety critical situations, such as OSHA TWAs or STELs of specific volatile organic compounds, must be User calibrated (or checked) *each day of use* with a span reference gas close to the critical level.**

A typical User calibration, for the low point, is performed utilizing a hydrocarbon-free air (nitrogen is not recommended as there could be trace amounts of VOCs present). Hydrocarbon-free reference gas supplied in portable (e.g. 110L) cylinders, generally have an uncertainty up to 100 ppb, although check with the specific manufacturer for clarification. Due to the uncertainty in the gas, GrayWolf recommends a positive set point of 100 ppb to account for the uncertainty of the gas. It should be noted that larger gas cylinders (e.g. 3993L which GrayWolf employs for Factory calibrations) can have uncertainty down to 10 ppb. In such cases a positive set point of 10 ppb can be used, but verify with the gas supplier.

For User calibrations for IAQ, green building or IVF applications, the high point typically utilizes isobutylene ranging between 7-10 ppm, depending on local access to reference gas, although lower concentrations (>2 ppm) can be implemented for specific applications. For toxic exposure applications, the span gas utilized for the application should be closer to the high range of the specific PID installed, or near the exposure level (e.g. TWA or STEL) of concern.

If the sensor is being exposed to dirty samples (containing substantial compound concentrations and/or particles), the lamp window may get contaminated. The rate of the window contamination is a function of the sample gas condition, i.e. how badly it is contaminated with chemicals and particles. Contamination of the lamp window can cause partial UV light blocking, which in turn will rapidly reduce the detector's sensitivity. In this case, more frequent calibration is needed, and an overnight "burn-in" of the sensor, leaving it turned on for 12+ hours, is advised.

Storage (sensor "off") in high humidity conditions >60 %RH may cause sensor drift, which takes time to re-stabilize after power-up. A 20-minute warm-up, prior to recalibration and use, should minimize high %RH storage bias. Utilize desiccant to maintain lower %RH during storage.

If the sensor has been stored for a significant amount of time, it may become contaminated with VOCs or other compounds. This in turn may cause excessive drift of the background signal. Therefore, it is highly recommended to run the sensor for an extended period of time before

operating it after prolonged storage, especially if it is going to be used for low-range applications. An overnight burn-in period should be sufficient in most cases. During this time, the detector will clean itself and the baseline signal will drop and stabilize. If the sensor is used on a frequent basis, the user should still let it stabilize for 20 minutes before use. If high accuracy is not important (for example, in a blood-hounding application) or in the case of measuring relatively high concentrations (> 10 ppm), this stabilization procedure can be bypassed after a few minutes (click on the TVOC reading, then click "Bypass Stabilization"). However, NEVER bypass the 20 minute stabilization period ahead of performing a calibration. Ideally, power the probe overnight ahead of calibration.

Another way to improve the accuracy of measurement of a known specific compound is to calibrate the sensor span at a concentration of the specific target gas, within the expected application range, rather than with isobutylene.

Bump Test

You can perform a bump-test of the sensor to verify its calibration by exposing the sensor to a known concentration of test gas**.** Using the regulator and hood supplied with the GrayWolf Calibration Kit, attach a cylinder of gas and start gas flow. After 5-10 minutes, the readings should stabilize. If the reading is within an acceptable tolerance range of the actual concentration as shown on the gas cylinder label, then its calibration is verified. If the bump test results are not within the acceptable range, a full user calibration must be performed.

For ppb range PID sensors, zero readings should be within +/- 100 ppb, span readings within +/- 10% of the cal gas value (i.e. for 7.5 ppm isobutylene; +/- 750 ppb).

For ppm range PID sensors, zero readings should be within +/- 1 ppm, span readings within +/- 10% of the cal gas value (i.e. for 3500 ppm isobutylene; +/- 350 ppm).

Note: These ranges are provided as a guideline.

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User Cal (recommended over Bump Test)

Essentially the same procedure as a Bump Test, except that you follow the User Calibration instructions on WolfSense, to not only check, but also adjust the readings to match the calibration gas. As long as you are already expending the known reference gas, and as GrayWolf makes User Cal so simple, you might as well adjust the reading!

Factory Cal

Annual calibration at a GrayWolf facility or at a GrayWolf *authorized* calibration lab for the PID (and all other sensors) is recommended for optimal performance.

Using for Specific Compound

Under certain conditions a TVOC meter is able to be utilized for a specific compound. The compound of interest must be the only gas present that can elicit a response from the 10.6 eV lamp. If other compounds are present that have an ionization potential (IP) less than 10.6 eV then the sensor will still detect those compounds.

The linearity of the sensor may vary somewhat depending on the specific target compound. As a rule, the greater the sensor's response to some compounds the narrower the linear range, and vice versa. If the target gas is the only compound present then there are two ways that you can measure for that compound:

-The PID must have a known correction factor for the gas of interest. GrayWolf meters have a list of some VOCs with their correction factors listed onboard under Sensor Tips. In the cases of a known correction factor the compound can be displayed on the device. This will have an accuracy of +/-25% when just using the correction factor and does not take into consideration %RH and temperature effects, nor linearity over the full range of the sensor response.

- If an application requires high accuracy, linearity characteristics of the sensor should be experimentally measured for the target compound. If access to a span gas, within the application range, of the target compound is available it can be used to perform a User Calibration with. This would eliminate the need to use the correction factor for a specific gas as the PID would be calibrated to that gas and have a 1:1 response. GrayWolf uses a calibration gas of 7500 ppb isobutylene for the high point calibration as standard.

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Background Readings

Ambient air, absent unusual pollutants, will typically read 50 to 400 ppb due to the "typical" background levels of VOCs and other ionizing compounds, although higher levels are not uncommon in indoor air.

Contamination

In polluted environments, excessive lamp window contamination can substantially degrade the sensor's performance, especially the low range ppb sensor.

If the sensor is being exposed to dirty samples (containing heavy compounds and/or particles), the lamp window will get contaminated. The rate of the window contamination is a function of the sample gas condition, i.e. how badly it is contaminated with chemicals and particles. Contamination of the lamp window can cause partial UV light blocking, which in turn will rapidly reduce the detector's sensitivity. In this case, more frequent calibration is needed.

If the sensor has been stored for a significant amount of time, it may have become contaminated. This in turn may cause excessive drift of the background signal.

Burn-In

To correct most contamination and high humidity exposure problems, an overnight burn-in should be sufficient. During this time, the detector will clean itself and the baseline signal will drop and stabilize.

To perform a burn-in, the probe must be powered on. Hook the probe up to the AdvancedSense, Tablet PC or LapTop PC that is running WolfSense software. Power the device display device via its AC adapter.

Note: Excessive contamination may required longer burn-in times (up to 48 hours), or lamp replacement. If you suspect your sensor is significantly contaminated, contact GrayWolf for additional assistance.

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Troubleshooting

Symptom:	Solution:
Readings are pinned at zero, sensor appears non-responsive -or- Zero reading, Check Cal icon is present on-screen.	Perform a quick "Sensor Response Test" (see section at end of this document) to verify sensor is responding. If sensor is responding but the reading then returns to zero, the sensor should be recalibrated. Note that it is normal that PID sensors will drift over time, and calibration each day that you utilize the equipment is recommended (although you may find from experience that weekly or even broader calibration intervals are sufficient for your specific application). Take care that calibration is not rushed, before probe stabilizes, as this could yield readings below zero (WolfSense will lock at zero and will not display negative numbers). Conservatively, allow the probe to warm up for an extended time period, and then recalibrate. It may be necessary to restore the factory default settings to erase any user calibration values that are causing unusual readings before another calibration is performed. Position the gas outlet from the cal hood directly at the PID sensor and make sure the reading on gas has stabilized before accepting the calibration (may take up to 10 minutes). If the TVOC readings respond to the Sensor Response Test but continue to lock on zero *after* the calibration, it may be necessary to adjust the low calibration edit point to 50-100ppb. The specification for the Scott® Gas HC Free Air supplied by GrayWolf guarantees less than 100ppb THC, and may not be precisely at zero. If the ambient conditions have very low TVOC concentrations, then it is possible that the ambient conditions are lower than the HC Free Air which will force a negative value, causing WolfSense to display zero. If there is no response during the Sensor Response Test (and you are certain you haven't used a water based product, rather than an appropriate alcohol based product or VOC containing product for your test), it is likely that the lamp in your PID sensor has failed. Contact GrayWolf or a GrayWolf authorized distributor for a Return Authorization Number to initiate PID lamp replacement.

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Symptom:	Solution:
Readings will not stabilize.	Be patient, especially with the PID sensor which is a very sensitive sensor. Try to avoid sudden temperature or %RH changes which will result in longer stabilization time. Each time the sensor is powered on, tiny amounts of contamination, which accumulate on the lens and lamp while the probe is powered down, are burned off. The stabilization time will vary depending on contaminant and moisture exposure during storage conditions. If possible, store the probe in a clean, low RH environment with desiccant to minimize the stabilization time.
Sensor readings are not as expected.	It may be necessary to restore the factory default settings to erase any user calibration values that may be causing unusual readings before another calibration is performed. Perform a quick "Sensor Response Test" (see section at end of this document). If sensor is responding, but the reading then returns to zero, the sensor should be recalibrated.

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Sensor Response Test

You can use readily available retail/commercial products to perform a simple response test of the PID sensor. This will verify the basic operation of the sensor but will not verify that it is properly calibrated.

Suitable commercially available substances for Sensor Response Tests:

Product	Contains	Suggested Use
Sharpie® Permanent Markers	Alcohols. May also contain ethylene glycol monobutyl ether	Wave the marker near the slotted openings in the probe. Do not insert marker inside the probe.
Windex® Glass and Multi-Surface Cleaners	detergents, solvents, fragrance, Ammonia and alcohol	Spray some Windex on a paper towel (or use pre-treated wipes) and wave probe several inches above the towel or wipe.
Purell® Hand Sanitizer	Ethyl Alcohol Also: Glycerin, Isopropyl Myristate, Propylene Glycol, Tocopheryl Acetate, Aminomethyl Propanol	Place a drop on a paper towel and wave probe several inches above towel.
PaperMate® Liquid Paper	Naptha	Wave the (wetted) dabber near the slotted openings in the probe.
Kensington® Surface Guardian Computer Screen Cleaner	Isopropanol and ethanol	Wave probe several inches above moist towel/wipe.
Rubbing Alcohol (any brand)	Alcohol	Dip a cotton swab in the alcohol and position it close to the probe slit closest to the PID sensor.

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Important: Do not spray or apply the product directly onto the sensor; do not immerse the probe in a container of the product; and do not insert anything inside the probe housing as you may contaminate or permanently damage the sensor or electronics.

Accuracy

There are no accuracy values listed for any of the GrayWolf supplied photoionization detector sensors. This is due to a number of reasons. All of the sensors are calibrated in the laboratory at set temperature and relative humidity values. After a factory calibration all sensors are checked to ensure that they are within a certain percentage within the set point for verification. This ultimately ensures that the values are accurate within one or two percent of the set point. When using the unit in an environment different than the calibration environment the accuracy will diminish. The sensitivity of photoionization detectors drift over a short time scale (day) so the accuracy is optimized by operating a calibration at a regular interval. The drift for the low range PID, 0-40 ppm, is 6-10 ppb/day. Other factors are small response to humidity transient (when humidity changes abruptly) and small responses to large temperature changes. Long exposure to a very dry atmosphere can also result in a small reduction in output.

All GrayWolf total volatile organic compounds (TVOC) sensors are calibrated to isobutylene in the factory, so all readings must be compared against isobutylene. The GrayWolf PID utilizes a 10.6 eV lamp which means that it will illicit a response from any compound with an ionization potential (IP) below 10.6 eV. Comparing the accuracy for a specific compound, except the gas the sensor was calibrated against, will not provide accurate readings. Because a PID has a different response from each gas below 10.6 eV the only way to see the accuracy is to compare it against the gas it was calibrated against.

In addition the quality and accuracy of the calibration gas plays as important a role as sensor accuracy in the overall uncertainty of the readings. Each gas cylinder has an associated uncertainty, for example isobutylene at 7.5 ppm +/-10%. This means that the gas could really be anywhere between 6.75.5-8.25 ppm. The sensor accuracy is based off how close to the set point of the gas being used. This means if the sensor is calibrated to 7.5 ppm, the readings that would be expected would be +/- a very small percentage from 7.5 ppm after a calibration. The actual concentration of gas, anywhere between 6.75 ppm to 8.25 ppm, will not change which is why the accuracy is compared against the set point value of 7.5 ppm even though the uncertainty of gas is +/-10%. Therefore to calculate the total error in a reading you need to consider multiple factors most notable the uncertainty of the gas, the accuracy of the sensor, the precision of the measuring process, the operator's skill, and the stability of the environment.

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