ADDRESSING PID INSTRUMENTS MOISTURE SENSITIVITY

HUMIDITY EFFECT ON PID INSTRUMENTS.

High Humidity quench effect

Water vapor is ubiquitous in ambient air and can reduce PID response. Various PIDs have reduced response at high relative humidity. The quenching effect is independent of lamp type for 10.6 and 11.7 eV lamps, but different PID sensors design has different sensitivity to the Humidity. The highest quenching effect is observed for the RAE 3000 PID instrument family. At changing Relative Humidity (RH) from 0% to 90%, instrument response drops by 60% (Figure 1).

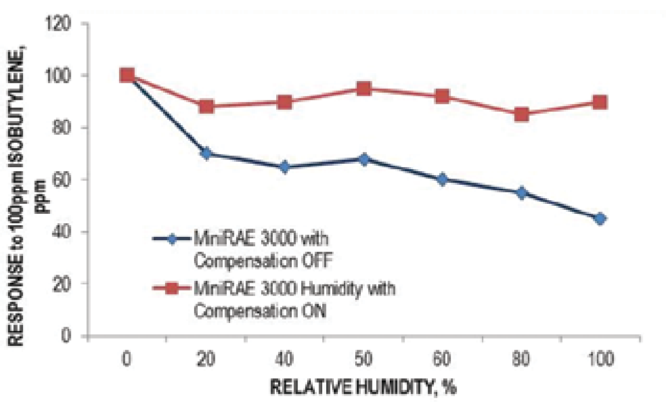


Figure 1. MiniRAE 3000 response to the 100 ppm Iso-Butylene vs. RH with Humidity compensation ON (red curve) and OFF (blue curve)

The RAE Systems' photoionization detectors (PIDs) have been designed to deliver consistent accurate performance in various humidity conditions and for the design like MiniRAE 3000 the compensation with Humidity Sensor was implemented. With this compensation, instrument reading is way more accurate and deviation doesn't exceed 20%.

Humidity-Induced Current Leakage

A secondary effect that is a common occurrence is the condensation of water vapor on the PID sensor, causing a false-positive "leak" current. These two phenomena have opposite effects on the response and must be distinguished carefully (Figure 2). When making measurements at high relative humidity, PIDs may exhibit an apparent response that appears as a rising drift.

This signal is due to a current leakage between the electrodes in the sensor, caused by condensation on the sensor. A similar phenomenon, although usually less severe, can occur when some high-boiling compounds deposit onto the sensor. When water vapor deposits, it causes a slight short-circuit that results in current leakage and an apparent VOC response. Condensation occurs most obviously when a PID is brought from a cool, dry indoor environment to a warm, humid outdoor environment. This condition can be avoided by warming the PID to the measurement temperature before entering the humid environment. Water vapor can only condense on a clean sensor when the relative humidity is very close to 100%. However, water can be absorbed by dust particles when the RH is somewhat lower. Therefore, the current leakage is exacerbated when minute, invisible dust or dirt particles collect on the sensor.

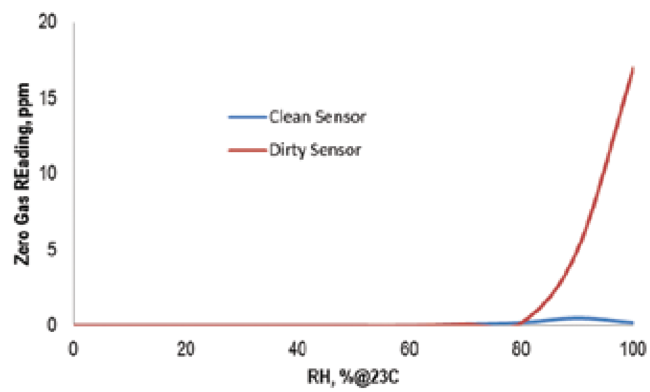
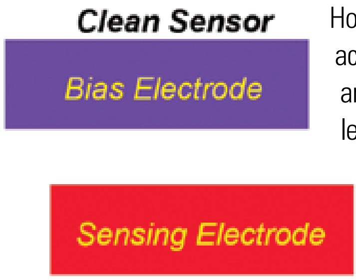


Figure 2. MiniRAE 3000 response to Zero air vs. RH. The clean sensor is blue curve, the dirty sensor is red curve.

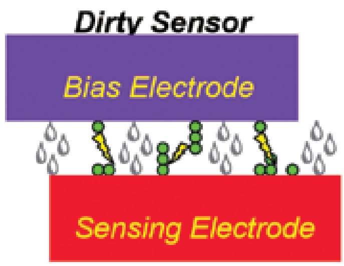
Dirty Sensor Causes Current Leakage

A dirty sensor is the number-one reason for the humidity response. The sensor has two electrodes: a bias electrode and a sensing electrode. One has a greater positive charge than the other. As the UV light breaks down chemicals into positive ions and negative electrons, they migrate to the oppositely charged electrodes. With clean, dry air and sensor components, no current can leak across the air space between the two electrodes.



No dirt build-up to foster a decrease in airspace resistance

However, even microscopic dirt accumulations on the electrodes and Teflon parts can promote leakage, especially when the relative humidity is greater than 85%. This is because water adheres more readily onto dust particles than onto a clean Teflon or glass surface. A sensor may appear to be visually clean, but actually can be dirty enough to cause current (electron) leakage. This current leakage is interpreted by the PID as a drifting reading of typically more than 10, and as much as hundreds of ppm, with no VOC present (over 1 ppm for a ppbRAE 3000).



Dirt build-up absorbs water breaks down airspace resistance leading to sensor "leakage" or moisture response

PREVENTION IS THE BEST CURE

Preventing dirt and dust from entering the PID sensor is the best cure for moisture response. Make sure that all of the filters in the instrument are clean and effective. In dirty environments, it may be necessary to add an additional filter. However, under normal circumstances there should be no response to humidity with just the standard sintered metal and external filter installed.

QUICK HUMIDITY RESPONSE TESTS

Try exhaling gently into a MiniRAE 3000, ppbRAE 3000, for 10 to 15 seconds or cupping your clean hand over the inlet probe; moisture from your hand provides a fairly continuous high humidity stream. Be sure not to block the air flow. This test can also be performed on the UltraRAE 3000 and MultiRAE in a similar manner.

The instrument should show little or no response from these tests. If the MiniRAE 3000 shows more than 5 ppm isobutylene units or the ppbRAE 3000 shows more than 500 ppb increase in reading, then the probe, lamp and sensor may need cleaning. The design of the instruments makes it quick and easy to remove and clean the probe, lamp, and sensor to address this problem. Focus on the following areas:

1. Replace filters
2. Clean the probe, PID lamp, and sensor
3. Inspect the sensor for damage or corrosion
4. Clean the sensor housing
5. Clean the sensor using an ultrasonic bath

UltraRAE 3000

When testing the UltraRAE monitor, make sure that the tube of interest is installed before proceeding with the test. If you plan to test for Benzene, install the Benzene tube and use the same moisture test discussed for the MiniRAE 3000 and ppbRAE 3000. If the readings increase more than 2 ppm Benzene units, then there is a problem with dirt in the monitor.

CLEANING PROCEDURE

Replace Filter

The MiniRAE 3000, ppbRAE 3000, and UltraRAE 3000 all use two filters, an external filter and a sintered metal filter. The external filter (PN 002-3022-005 for a pack of 5, 002-3022-010 for a pack of 10, and PN 002-3022-100 for a pack of 100) is attached to the end of the probe and is white. If it appears to have any discoloration, then it is time to replace the filter. If the instrument goes into pump alarm with the filter attached and is able to run without any problems when not attached, it is time to replace the filter.

When the instrument is responding to moisture, it is time to replace the filter. The metal sintered filter (PN 490-0047-005 for a pack of 5) should be replaced when it is dirty and when the instrument responds to moisture.

Figure 3. Sintered filter of UltraRAE 3000 on the left and MiniRAE 3000 one on the left.

To reach the sintered filter, un-switch the lamp housing cap by holding the instrument and rotating probe counterclockwise; inspect the sintered metal filter at the bottom of the probe. If it appears to be dirty, it needs to be replaced. A dirty internal filter indicates that the probe has dirt inside and requires cleaning.

Clean the Probe

Cleaning the probe depends on the kind of exposure or dirt that has contaminated the probe. If it is a chemical that might affect the reading of the PID, use Isopropanol to clean the probe. If it is just dirt or dust that has been sucked into the instrument, blow clean, dry air through the probe to clear the internal tubing.

Clean the PID Sensor and the Lamp

Access to both the lamp and the sensor of a MiniRAE 3000, ppbRAE 3000 and UltraRAE 3000 requires no tools. After removing the probe (in UltraRAE 3000 together with tube extention), remove the PID sensor; grasp the top lip of the sensor and pull straight out, to avoid bending the electrical pins on the sensor. If the sensor does not pull out immediately, a gentle rocking motion should help loosen the sensor. Also try rotating your grip as you pull the sensor. Once the PID sensor is removed, set it aside to clean or to inspect for damage or corrosion. If the sensor appears corroded or damaged, it should be replaced since it can show increased response to moisture. Check Teflon mask, if it is warped, the sensor need replacement as well.

Note: A warped Teflon mask can be a sign that the sensor has been exposed to too much heat.

Figure 4. Sensor Module: PID Sensor, Teflon Mask and Holding Pins

The PID lamp has a white O-ring that keeps it from sitting too low in the lamp housing. Before reaching for the lamp, get out the Isopropanol-based lamp cleaning kit (PN 081-0017-000), which includes Isopropanol, finger cots, cotton swabs, and lens tissue. Use finger cots on the fingers that will handle the lamp.

CAUTION: Never touch the lamp window surface with anything that might scratch it, including your fingers, or any liquid that might leave a film or stains.

Carefully remove the lamp by grabbing onto the white O-ring, and set the instrument aside. Dip a cotton swab into the Isopropanol and wipe the window surface of the lamp. The sides of the lamp can be cleaned if it is obviously dirty, but the flat-surface window of the lamp is the only part of the PID lamp housing prior to placing the lamp back into the instrument. Do not force the lamp all the way down to the bottom of the lamp housing. Allow the PID sensor to push the lamp the rest of the way into place.

Clean the PID Housing

Once the PID sensor and the lamp are removed from their places, inspect PID Housing for the dust and contaminations.

Use the same Isopropanol-based lamp cleaning kit (PN 081-0017-000) and clean housing with Q-tips cotton swabs.

Figure 5. The PID housing

Clean the sensor using an ultrasonic bath

Cleaning the lamp and sensor that are very dirty using the lamp cleaning kit with cotton swabs may not be sufficient enough to remove humidity response. In fact, cotton swabs can leave behind fibers that continue to cause moisture issues after cleaning. An ultrasonic cleaning bath MUST be used in such cases. Ultrasonic cleaners are available from laboratory suppliers.

Alternatively, a jewelry cleaner from a department store can be used. To clean the sensor, remove it from the instrument and immerse it in lamp-cleaning solution (anhydrous Isopropanol) in a small beaker or baby food jar. Fill the ultrasonic cleaning bath with water. Place the beaker containing the sensor into the water bath of the ultrasonic cleaner. The ultrasonic waves pass through the water and container and assist in cleaning the sensor. The lamp-cleaning solution in the jar can be reused a few times until it becomes dirty.

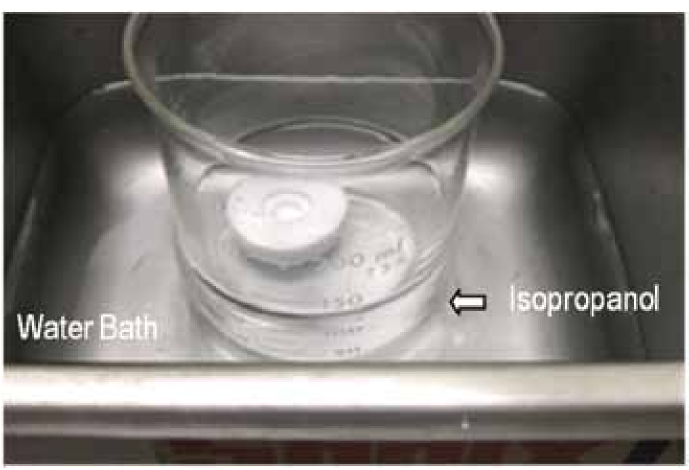


Figure 5. Sensor is cleaning in the ultrasound bath.

It is very important to blow or shake out any residual lamp-cleaning solution from the sensor before letting it air dry. Otherwise, some of the dirt that was just extracted into the cleaning solvent could be deposited back onto the sensor components as they dry. Allow the sensor and the lamp to dry for at least a few hours, and preferably overnight (warm, but not hot air will speed the drying process).

Reassemble the PID, and perform a humidity response test. Exhale into the instrument and check the response. If it shows no response to the moisture in your breath, calibrate the instrument and return it to service.

Caution! Do not overheat the sensor!

OTHER WAYS TO BATTLE HUMIDITY EFFECTS

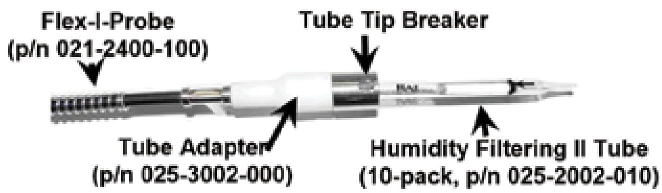
PIDs are commonly calibrated with dry calibration gas and then used to measure in ambient air with various degrees of relative humidity. In this case, corrections are necessary if the absolute concentration of the measured vapor is desired. Alternatives to performing corrections are to either humidify the calibration gas, or to dry the sample gas during measurements.

Using Humidifying Tubes

Correcting the response by humidifying the calibration gas is possible using moisture exchange tubes (p/n 030-3018-000) consisting of a Nafion membrane. Such tubes allow humidification of the calibration gas close to the ambient level. The moisture exchange tube has limitations: the humidity equilibration is not exact, and it only compensates correctly at one humidity, but not when humidity changes. Such changes are commonly encountered when a PID is calibrated indoors and then used outdoors for measurements. Nevertheless, the readings will be closer than if no compensation were performed at all, and may be adequate for many purposes. For more details and limitations, see TN-157.

Using Humidity Filtering Tubes

Drying the sample gas using desiccant filter tubes is possible for non-polar compounds like gasoline and trichloroethylene. These tubes are of great advantage in removing both quenching and "leak current" effects during continuous PID readings, and reduce the need for sensor cleanings. However, heavy and polar compounds tend to adsorb to the reagent, causing slower response, particularly at low temperatures and low concentrations. Some compounds such as amines absorb completely and cannot be measured using the desiccant tubes. Humidity Filtering Tubes (Type II) can be used to dry the sample gas and measure many VOCs for about 15 minutes to 1 hour. Their use prevents moisture effects, even on a dirty sensor. The tubes (PN 025-2002-010) are inserted into an adapter (PN 025-3002-000) attached to a Flex-I-Probe (PN 021-2400-000).



Many compounds such as trichloroethylene and gasoline pass through the tube easily. Some heavy vapors such as diesel fuel or polar compounds such as acetone and alcohols require extended sampling times. See Technical Note TN-178 for more details and cautions on use.

Note: Type I Humidity Filtering tubes cannot be used during measurements.)

OTHER RAE PID FAMILY MONITORS

While the others RAE PID family monitors do not normally have as many issues with high humidity quenching effect, the contamination the PID sensors is possible. Periodical moisture test can be done the same way as for the RAE 3000 PID instruments family by cupping your hand over the probe end or breathing gently into the probe end of the instruments or the sensor vicinity (ToxiRAE Pro PID), being careful not to block the air flow. If the VOC reading increases over 5 ppm isobutylene, there is a problem with dirt. In this case follow the lamp and sensor cleaning section of the manuals for the instruments:

Area RAE:
http://www.raesystems.com/customer-care/resource-center/manuals?title=AreaRAE+All+in+One+User%27s+Guide

MultiRAE:
http://www.raesystems.com/customer-care/resource-center/manuals?title=MultiRAE+User%E2%80%99s+Guide

RAEGuard 2 PID:
http://www.raesystems.com/sites/default/files/content/resources/Manual_RAEGuard-2-PID-Combined_D03-4001-000_RevJ.pdf

ToxiRAE Pro PID:
http://www.raesystems.com/customer-care/resource-center/manuals?title=toxiRAE+pro+pid