HUMIDITY FILTERING II TUBE FOR PID MEASUREMENTS IN HUMID ENVIRONMENTS

Introduction

RAE Systems' photo-ionization detectors (PIDs) are designed to make real-time monitoring of VOCs practical through out a wide humidity range. However, PID response can be reduced by high humidity (Figure 1). In addition a false positive reading can result if the sensor is dirty or if water condenses in the sample line and the sensor (Figure 2). For false positives, the preferred solution is good sensor cleanliness and instrument maintenance, as described in Technical Note 163. The humidity filtering tubes described in this Technical Note address both humidity issues and allow more accurate measurements for many chemicals.

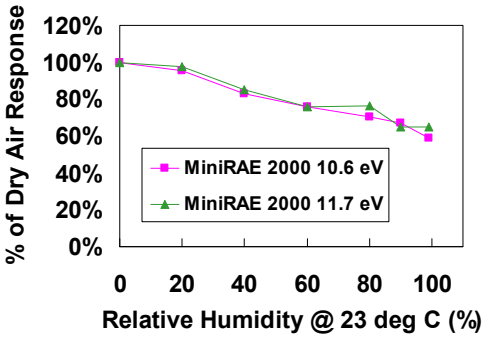

Figure 1. Response to test gas with clean sensor

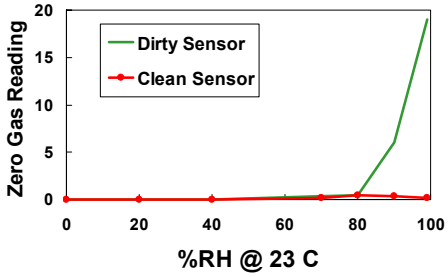

Figure 2. Response to zero gas vs humidity on "dirty" vs "clean" sensor

High humidity situations that can cause problems include:

- Soil vapor extraction systems
- Combustion stack gases
- Moving from a cool location to a hot humid area, such as calibrating in an air-conditioned lab and moving outdoors.

Humidity Filtering II Tubes

The Humidity Filtering II tube (p/n 025-2002-010), attached to the inlet of a PID, can reduce humidity for the times listed in Table 1. The tube can be used while measuring organic vapors, with some precautions (see below). Do not confuse this tube with the Humidity Filtering I tube (p/n 025-2001-010), which cannot be used while measuring organic vapors.

Table 1. Run times for the Humidity Filtering II tubes.

T (°C)	T (°F)	RH (%)	10% RH Breakthrough time (min @ 500 mL/min)	20% RH Breakthrough time (min @ 500 mL/min)
45	113	100	12	14
		75	17	18
		50	35	>40
		25	>40	>40
40	104	100	18	20
		75	25	30
		50	40	>40
30	86	100	22	26
		75	28	32
		50	40	>40
20	68	100	23	~30
		75	34	>40
		50	40	>40

At extreme sample conditions such as 45 °C (113 °F), 100% RH and 500 mL/min flow rate, the humidity filtering tube can maintain <20% RH downstream for at least 14 min, as shown in Table 1. At this low RH the effects shown in Figures 1 and 2 are almost completely removed. Under more typical conditions, the protection time can be expected to be much longer (see Table 1). A worst-case humidity breakthrough curve is shown in Figure 3.

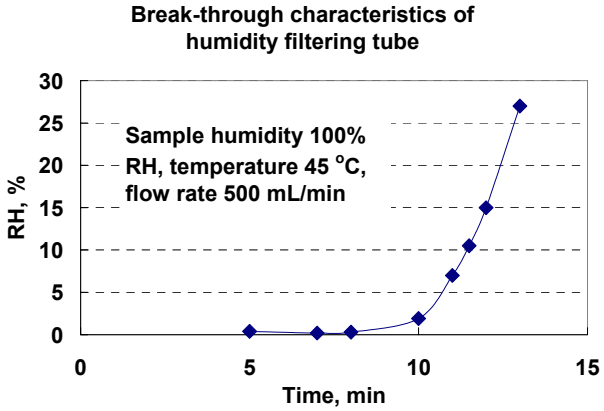

Figure 3. Worst-case breakthrough curve. (Note: 45°C is higher than some instrument ratings.)

The tubes are sealed and broken open immediately before use. They are intended for single use, but might be used for a few

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samples if within a short time or if the tube ends are capped. There is no color change in the tube, but a spent tube can be identified by a glassy gel formation on the solid absorbent. **Caution:** The tube contents may liquify after very long sampling or if a tube is left open in ambient air for several days. We recommend disposing of tubes soon after use to avoid leakage or having liquid sucked into the instrument.

Effect of Mist

The tubes can be used to measure VOCs in the presence of water mist. As shown in Figure 4, when mist is drawn into a PID with no tube, a false positive reading occurs similar to that in Figure 2. The Humidity Filtering II tube (diamonds on Fig. 4) prevents this and keeps the readings very close to ambient response for at least 20 minutes. The bump check at the end of the test with the tube with about 7 ppm (7000 ppb) shows that the tube still responds to VOCs even when it is almost completely saturated with water.

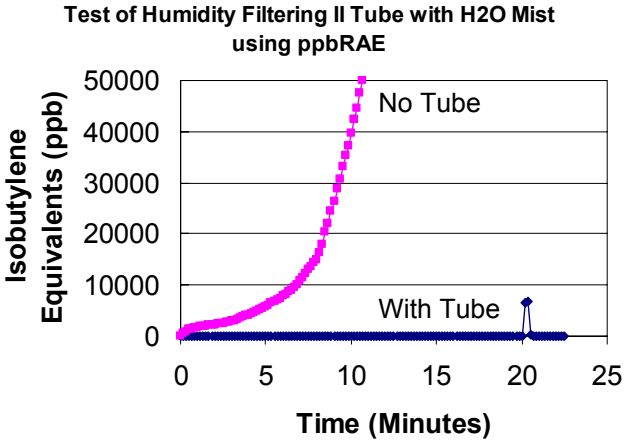


Figure 4. Test of Humidity Filtering II tube in the presence of water mist using a ppbRAE.

Precautions

- **Use the tube immediately after opening to avoid loss of absorption capacity.**
- **Use with caution when making PID measurements with the tube in place, as some compounds may be lost or exhibit delayed response (See Table 2). Contact RAE Systems if the compound to be measured is not listed in Table 2 or the data sheet shipped with the tube.**
- **Use particular caution at low temperatures and low concentrations because adsorption losses can be relatively more severe. Extended sampling times may be required.**
- **If unexpectedly low readings are obtained, remove the tube and measure again to check for absorption losses. A rapid rise in a few seconds indicates VOC presence, while a slow rise suggests a false humidity response.**
- **DO NOT confuse this tube with the Humidity Filtering I tube (p/n 025-2001-010), which CANNOT be used while measuring organic vapors.**
- **Be sure that all connections are tight, or the sample gas will not be properly dried and may be diluted.**
- **The tube forms a gel and then liquid after excessive moisture has been drawn through. Remove the tube before such a gel fills the tube or the liquid may be sucked into the PID, causing possible damage.**
- **It is still desirable to maintain a clean sensor to prevent drifting readings during measurements in high humidity.**
- **The contents of the tube are non-toxic and can be disposed of in a landfill. However, the tube may absorb some toxic compounds during use and become contaminated.**

Effect on VOC Response

Table 2. Effect of Humidity Filtering Tube on VOC Response.

Compound	Concentration (ppm)	T (°C)	t_{90} (sec)	HCF[#]
Isobutylene	100	22	3	1.0
Isobutylene	10	0	5	1.17
Cyclohexane	10	22	3	1.0
Octane	100	22	3	1.0
Undecane	100	22	60	1.1
Benzene	5	22	3	1.0
Toluene	10	22	3	1.0
Xylenes	100	22	10	1.05
Styrene	50	22	10	1.0
Gasoline	100	22	15	1.05
Gasoline	10	22	15	1.0
Gasoline	10	0	28	1.6
Jet Fuel JP-5	10	22	65	1.0
Diesel Fuel	100	22	110	1.3
Vinyl Chloride	10	22	3	1.0
Trichloroethylene	10	22	3	1.0
Trichloroethylene	10	0	5	1.2
Perchloroethylene	10	22	4	1.0
Glutaraldehyde	10	22	NR* (480)	NR* (1.05)
Ethanol	1000	22	3	1.0
Ethanol	100	22	40	1.0
Isopropanol	10	22	90	1.15
Acetone	1000	22	3	1.0
Acetone	100	22	20	1.0
Acetone	10	22	80	1.0
Acetone	10	0	115	1.17
PGMEA (propylene glycol methyl ether acetate)	10	22	240	1.1
Phenol	20	22	150	1.0
Methyl methacrylate	10	22	150	1.05
Dimethyl sulfide	10	22	3	1.0
Ethyl mercaptan	10	22	4	1.05
Butyl mercaptan	10	22	5	1.05
Hydrogen sulfide	7	22	3	1.0
Ethylamine	high	22	NR*	NR*
Ammonia	50	22	NR*	NR*

[#]HCF = Humidity Correction Factor. Multiply by reading to get true concentration to correct for some loss. If calibrating with isobutylene, must also multiply by the Correction Factor in Technical Note 106 to get true concentration. * Not recommended because of severe losses.

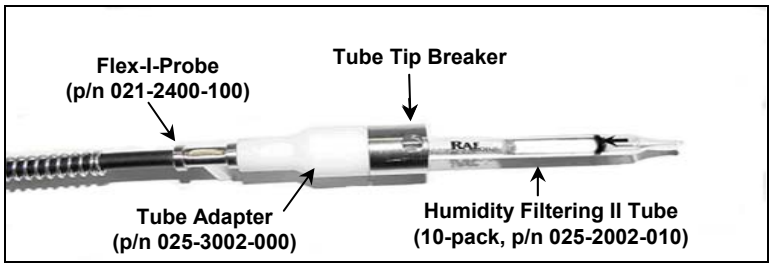
Note: The data in Table 2 were generated in dry air at about 22°C (72°C). Tests showed that 50% RH does not affect the response time to isobutylene, benzene, PGMEA, dimethyl sulfide, phenol, acetone or ethanol, but causes total loss of ammonia. 80% RH does not affect the response time of isobutylene, benzene, or H_2S. The response time for polar compounds is not significantly different between a fresh tube and a partially used tube up to 20% humidity breakthrough.

Other compounds: Volatile ethers, esters, haloalkanes, and olefins should not be affected except for possible slower response. Glycols, aldehydes and alcoholamines are expected to have slower and/or lower response. Acids and bases maybe lost on the tube. Compounds that hydrolyze easily, such as acetic anhydride, isocyanates or hexamethydisilazane may be lost.

The tubes can be used to measure a variety of volatile organic compounds (VOCs). The tubes have no effect on the response of nonpolar compounds such as isobutylene, hexane, benzene, and vinyl chloride but may affect the response time and efficiency of other compounds (see Table 2). Response time is faster at higher concentrations and higher temperature; therefore at low levels or low temperatures extra measurement time may be required.

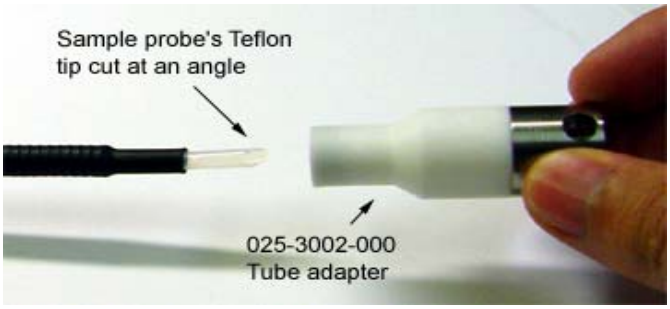
Connections

- **ppbRAE and MiniRAE 2000**



For the ppbRAE and MiniRAE the tube is best connected to the Flex-I-Probe (p/n 021-2400-100, as shown above). It is easy to replace the old sample probe with the Flex-I-Probe. All new ppbRAE and MiniRAE 2000 instruments now come with this probe as standard.

- **UltraRAE and MiniRAE Plus Classic**



The UltraRAE and MiniRAE Plus Classic products can also use the humidity filtering tube adapter directly. Cut the Teflon probe tip at an angle, as shown above, to make it easy to insert into the O-ring of the tube adapter. The same can be done with the older style sample probe of the ppbRAE and MiniRAE 2000.

- **Multi-gas Monitors with PID Sensor**

To use the humidity filtering tube with RAE Systems' pumped multi-gas monitors with PID sensor, such as MultiRAE, SentryRAE, IAQRAE, and AreaRAE, a 1-inch-long Teflon tube (RAE Systems P/N 411-0005-000) can be press fitted into the water-trap filter to connect with the tube adapter, as shown above. The end inserted into the tube adapter is also cut at an angle for ease of insertion into the O-ring as described above for the UltraRAE.

Procedures

1) Insert the tip of the Flex-I-Probe or other probe into the smaller end of the tube adapter;
2) Break the two ends of a humidity filtering tube using the smaller side hole of the tube adapter;
3) Immediately insert one end (an arrow on the tube indicates the direction) of the open humidity filtering tube into the bigger end of the adapter;
4) Measure the sample gas;
5) Discard the used humidity filtering tube after the maximum time has elapsed as shown in Table 1, or when the tube becomes saturated as shown by a glassy gel formation.

If moving from a cool to a hot, humid environment:

4a) Run the instruments for at least 15 min with the humidity filtering in place to warm up the sample line and the instrument sensor. This is useful even if the sensor is clean and shows no humidity effect, in order to prevent liquid condensation.

Sensor cleaning

Sensor:

- Dip the entire sensor into clean anhydrous methanol for at least 3 min. (do not disassemble).
- Use of an ultrasonic cleaner is is highly recommended.

Lamp crystal: use a cotton swab to scrub the crystal surface with anhydrous methanol

Inlet probe: flow anhydrous methanol through it.

Use clean air to dry out all parts.

See Technical Note 163 for more details on PID maintenance for avoiding humidity effects.