VOC Room Sensor

Installation and Operation Instructions

Product Identification

Humans exhale Volatile Organic Compounds (VOCs) as well as CO_2. The BAPI sensor is able to measure these VOCs, therefore it is as good an indicator of space occupancy as a CO_2 sensor.

The BAPI Sensor is different from other VOC sensors because it has been optimized for Demand Controlled Ventilation (DCV). Using a calibration algorithm, the sensor value is converted to an output with a high correlation to a CO_2 level. This lets you use ASHRAE's occupancy-based VRP schedule to ventilate. (More information on this correlated output is available on our website at www.bapihvac.com)

The sensor also picks up VOCs from other sources such as building materials, perfumes, colognes and furniture off-gassing. Using this sensor to ventilate is a way of achieving true indoor air quality and not just CO_2 dilution.

The unit is available as a VOC sensor alone or in combination with temperature and humidity. The optional display alternates between the measured values and is field adjustable between °F and °C. An optional three color LED indicates a "VOC Level" of Good, Fair or Poor.

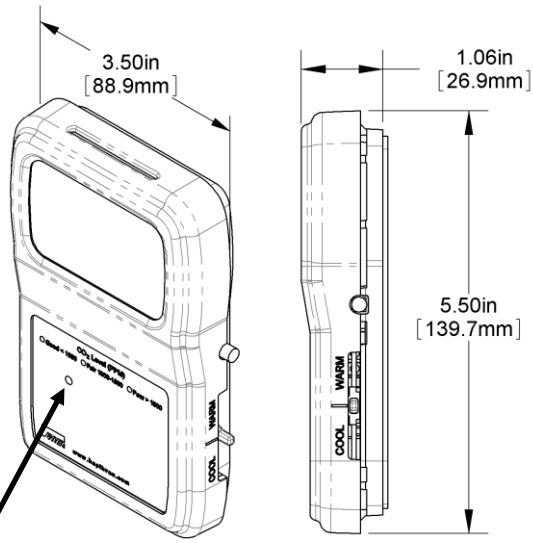


Figure 1: BAPI-Stat 3 Room VOC Sensor

Specifications

Power:

9-35 VDC @ 50 mA Max (9-15VDC recommended) for 0–5 VDC Outputs
15-35 VDC @ 50mA Max (15VDC recommended) for 0-10 VDC Outputs
No AC Power

Sensing Elements:

Humidity - Capacitive Polymer, ±1.8% RH Accuracy
Air Quality - Micro-machined Metal Oxide

Temperature Sensor: Thermistor, RTD or Semiconductor

Mounting: 2" x 4" J-Box or drywall mount - screws provided

VOC Detection Range:

0 - 2,000ppm CO_2 Equivalent, Analog Output
0 - 5,000ppm CO_2 Equivalent, Display

Response Time: Less Than 60 Seconds (after start-up)

Start-up Time: 15 minutes

Operating Environment:

32 - 122°F (0 - 50°C)
0 - 95%RH non-condensing

LCD Display:

Main Display 0.76" (19mm) 4-digit Numeric (Numeric Values)
Minor Display 0.34" (8.6mm) Alpha-Numeric (VOC, %RH, °F & °C)
Occupied/Un-occupied BAPI Man Icon (Black = Occupied)

Measurement Offsets (field adjustable):

±5° (F or C) in 0.1° increments
±5% RH in 0.1%RH increments
±100 ppm CO_2 Equivalent Contaminants in 1ppm increments

Analog Outputs:

(0-5, 0-10 or 2-10VDC (%RH only), >10KΩ impedance)

VOC Contaminants 0 - 2,000ppm CO_2 Equivalent
RH% 0 - 100% or 35 - 70%RH

Override Output:

Contact SPST
Sensor Shorts out direct Temperature sensor (TP+ to TP-)
Setpoint Contact In parallel (SET to GND), resistive setpoint only

LED VOC CO_2 Equivalent Indicator:

Good, Green < 1,000 ppm
Fair, Yellow = 1,000 to 1,500 ppm
Poor, Red > 1,500 ppm

Dimension: 5.50"H x 3.50"W x 1.06"D (139.7 x 88.9 x 26.9 mm)

Material: ABS Plastic, Material Rated UL94V-0

Certifications: RoHS

Warranty Period: Two years from manufacture date

Note: The VOC contaminant output (CO_2/VOC terminal on the circuit card) is scaled for 0 to 2,000ppm equivalent CO_2 for use in an ASHRAE Standard 62.1 Demand Control Ventilation algorithm. The display shows contamination to an equivalent 5,000ppm CO_2. This allows additional troubleshooting for a building manager to determine if there is a very large VOC contamination when the transmitted output is at its maximum value.

Specifications subject to change without notice.

Mounting

Mounting hardware is provided for both junction box and drywall installation (junction box installation shown).

Junction Box

1. Pull the wire through the wall and out of the junction box, leaving about six inches free.
2. Pull the wire through the hole in the base plate.
3. Secure the plate to the box using the #6-32 x 5/8 inch mounting screws provided.
4. Terminate the unit according to the guidelines in the **Termination** section. (page 3)
5. Mold the foam on the unit's base to the wire bundle to prevent drafts. (see note below)
6. Attach cover by latching it to the top of the base, rotating the cover down and snapping it into place.
7. Secure the cover by backing out the lock-down screw using a 1/16" Allen wrench until it is flush with the bottom of the cover.

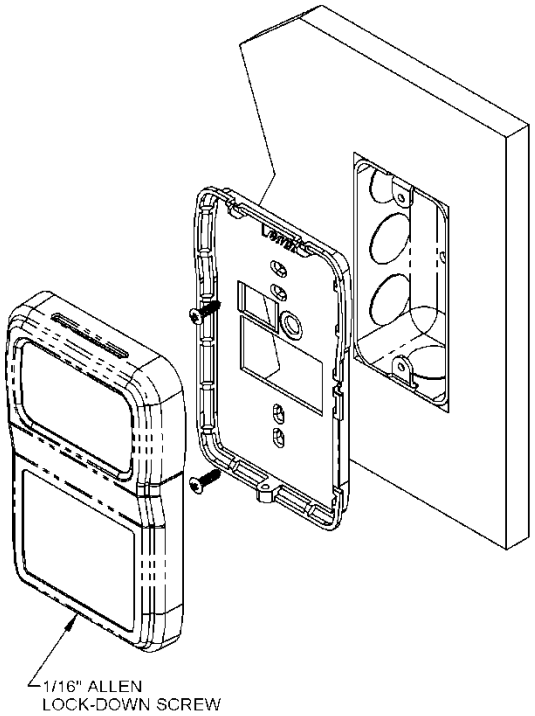


Fig 2: Mounting to a Junction Box

Drywall Mounting

1. Place the base plate against the wall where you want to mount the sensor.
2. Mark out the two mounting holes and the area where the wires will come through the wall.
3. Drill two 3/16" holes in the center of each marked mounting hole, DO NOT punch the holes or the drywall anchors will not hold. Insert a drywall anchor into each hole.
4. Drill one 1/2" hole in the middle of the marked wiring area.
5. Pull the wire through the wall and out of the 1/2" hole, leaving about six inches free.
6. Pull the wire through the hole in the base plate.
7. Secure the base to the drywall anchors using the #6 x 1 inch mounting screws provided.
8. Terminate the unit according to the guidelines in the **Termination** section. (page 3)
9. Mold the foam on the unit's base to the wire bundle to prevent drafts. (see note below)
10. Attach cover by latching it to the top of the base, rotating the cover down and snapping it into place.
11. Secure the cover by backing out the lock-down screw using a 1/16" Allen wrench until it is flush with the bottom of the cover.

NOTE: *In any wall-mount application, the wall temperature and the temperature of the air within the wall cavity can cause erroneous readings. The mixing of room air and air from within the wall cavity can lead to condensation, erroneous readings and sensor failure. To prevent these conditions, BAPI recommends sealing the conduit leading to the junction box, filling the junction box with fiberglass insulation or sealing the wall cavity.*

Termination

BAPI recommends using twisted pair of at least 22AWG and sealant filled connectors for all wire connections. Larger gauge wire may be required for long runs. All wiring must comply with the National Electric Code (NEC) and local codes.

Do **NOT** run this device's wiring in the same conduit as AC power wiring of NEC class 1, NEC class 2, NEC class 3 or with wiring used to supply highly inductive loads such as motors, contactors and relays. BAPI's tests show that fluctuating and inaccurate signal levels are possible when AC power wiring is present in the same conduit as the signal lines. If you are experiencing any of these difficulties, please contact your BAPI representative.

BAPI recommends against wiring the sensor with power applied as accidental arcing may damage the product and void the warranty.

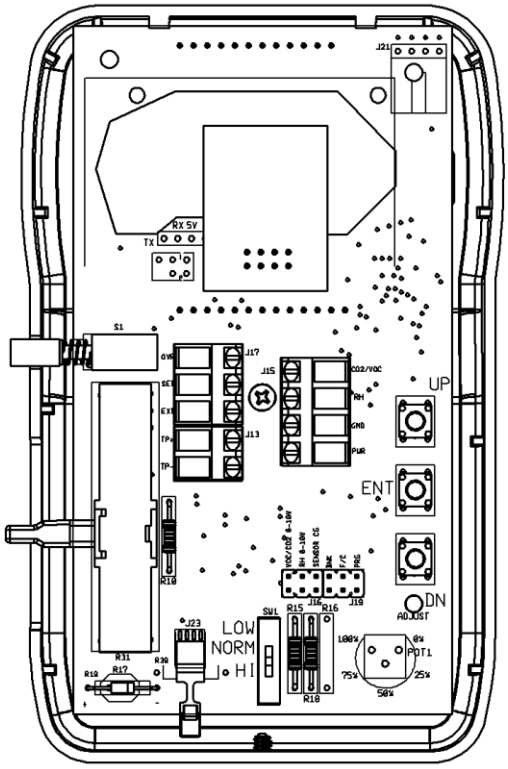


Figure 3: Circuit Board

Terminal	Function
OVR	Override Output (Dry Contact Switch). When Override switch is pushed this terminal is connected to GND.
SET	Setpoint output. Referenced to ground.
EXT	External occupied LCD indicator is activated by logic LOW or ground at this terminal.
TP+ & TP-	Temperature Sensor Output (Resistive Output). When a jumper is on J16, TP- is connected to the GND terminal. When the jumper is off of J16, the temperature sensor is floating. (Semiconductor TP+ = +, TP- = -)
CO2/VOC	Voltage output VOC Signal (0 to 2,000 ppm) referenced to GND
HUM	Voltage output Humidity Signal referenced to the GND terminal
GND	To controller Ground [GND or Common]
PWR	Power, referenced to GND 9 - 35 VDC @ 50 mA Max (9 – 24VDC recommended) for 0 – 5 VDC Outputs 15 - 35 VDC @ 50mA Max (15 - 24VDC recommended) for 0 - 10 VDC Outputs

Note: Unit is not ready for operation until the fifteen-minute start-up time has elapsed. (See Page 6)

Optional Test and Balance Switch

Low: Will set sensor value low

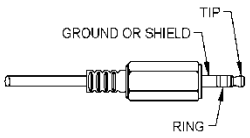
Norm: Sensor will operate normally

High: Will set sensor value High

Figure 4: Test and Balance Switch Operation

Sensor Type	Low Temp	High Temp
1000 Ω RTD	1.02K Ω (41.2°F)	1.15K Ω (101.5°F)
3000 Ω Thermistor	7.87K Ω (39.8°F)	1.50K Ω (106.8°F)
10K-2 Thermistor	30.1K Ω (34.9°F)	4.75K Ω (109.1°F)
10K-3 Thermistor	26.7K Ω (35.9°F)	5.11K Ω (108.4°F)
10K-3(11K) Thermistor	7.32K Ω (43.7°F)	3.65K Ω (105.2°F)

Optional Communications Jack Wiring



C35 Wiring	
	Wire Color
Ground	Black
Tip	White
Ring	Red

Note: Male Jack shown for clarity

C35 Communications Jack

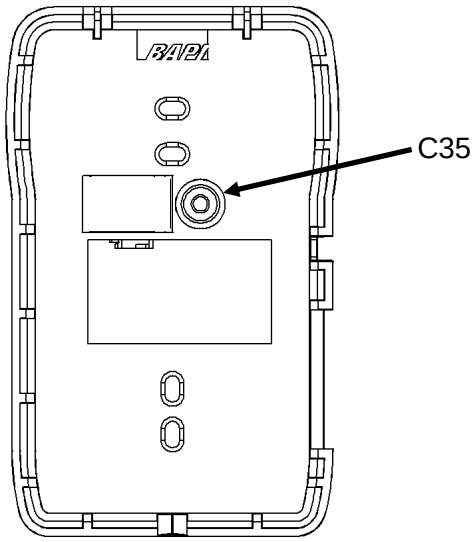


Figure 5: Communications Jack

User Operation

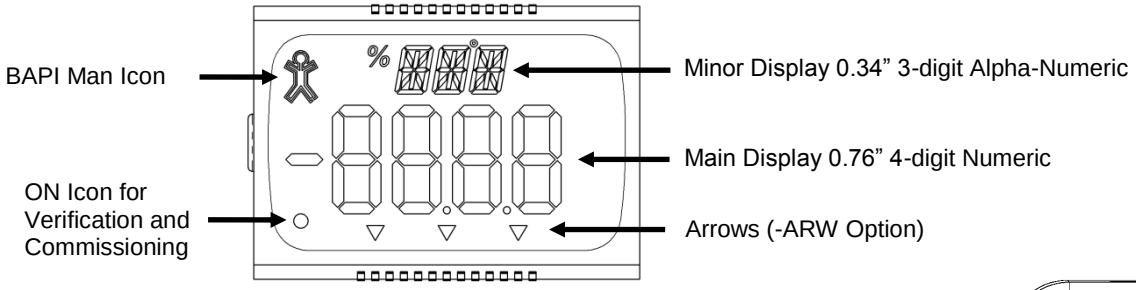


Figure 6: Optional Display

The display indicates VOC in PPM, air temperature in degrees Fahrenheit or Celsius, relative humidity in %RH, temperature setpoint in degrees Fahrenheit or Celsius and override using the BAPI Man icon. The three arrow icons are used with the –ARW option to show VOC levels and their meaning.

The main display indicates the numeric value of the quantity being displayed. The minor display indicates the engineering units of the value, such as VOC, °F, °C or %RH.

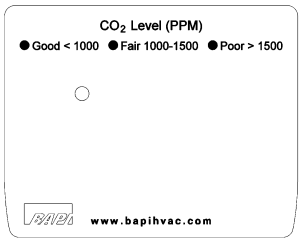
Temperature Setpoint Slide-Pot: Moving the slide pot enough to change the setpoint by one degree will display the setpoint on the main LCD display if equipped with display. The setpoint display will hold for five seconds after moving the slide pot.

Override Button: When the override button is pressed on display units, the BAPI Man icon will display. A dry resistance of less than 1 Ohm appears from the override output (OVR) to the Ground terminal (GND). Latching the BAPI Man icon to show that the system is in override requires that a dry contact on your controller be used to connect terminal EXT to ground.

Optional VOC Level Indicator:

-LED option; A three color LED shines through the front panel. Green for good, Yellow for fair and Red for poor. (Left in Figure 7)

-ARW option; The arrow icons light to indicate good, fair or poor. (Right in Figure 7)



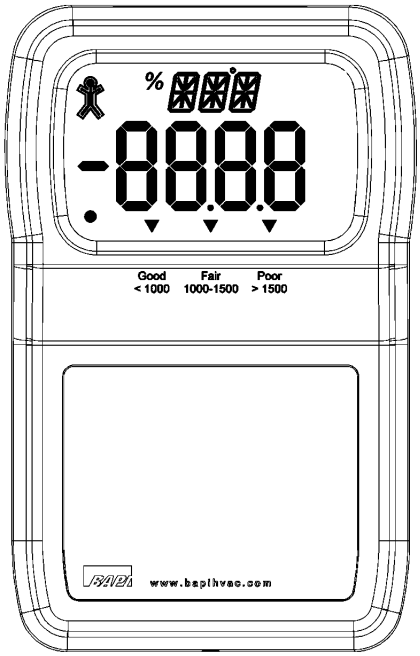


Figure 7: VOC Level Indication

Specifications subject to change without notice.

Optional Technician Adjustments

BAPI's VOC room sensor comes calibrated and ready to operate. In some installations the sensor may not match local instrumentation. The technician adjustment procedure allows °F or °C display units, temperature or humidity offsets or display information to be changed at any time, for display units only.

Removing Ground from Temperature Sensor

Some installations may experience erratic temperature readings. A possible remedy may be to float the temperature sensor as shown in figures 8 and 9. Run wires directly from TP+ and TP- to the controller's analog input. The VOC/CO2 and RH jumpers are omitted for clarity.

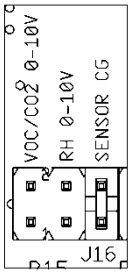


Figure 8: Temp sensor grounded

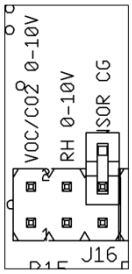


Figure 9: Temp Sensor Floating

°F or °C display units

Figure 10 and figure 11 show the jumper positions for displayed values of Celsius or Fahrenheit degrees. The jumpers on pins PRG and BNK are omitted for clarity.

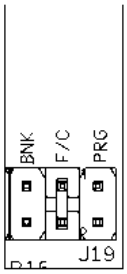


Figure 10: °F

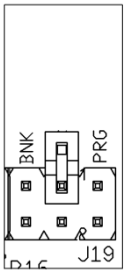


Figure 11: °C

Parameter Offsets & Display Information

Figure 12 and figure 13 show how to place the unit into field setup mode. Take the jumper from the BNK terminals and place it on the PRG terminals. The F/C jumper is omitted for clarity.

The major display should read P1 and the minor display should read DSP.

Use the UP/DN buttons (See Figure 14) to select the desired page.

Press and release the ENT button to select the desired page.

Use the UP/DN buttons to adjust the desired value

Press and release the ENT button to save the change and return to the page display.

Adjust another page or place the jumper into normal operation.

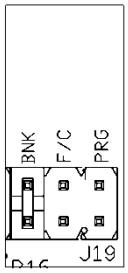


Figure 12: Normal Operation

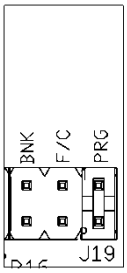


Figure 13: Programming Setup

Table 4: Parameter Offsets & Display Information

Parameter	Display		Adjustment	
	Main	Minor		
Display Options	P1	DSP	**Item**	**Display Action**
			1	Temperature Only
			2	% RH Only
			3	VOC Only
			4	Temperature and %RH (10 second rotation)
			5	Temperature and VOC (10 second rotation)
			6	%RH and VOC (10 second rotation)
			7	Temperature, %RH and VOC (10 second rotation)
Temperature Offset	P2	TMP	±5° in 0.1° increments	
%RH Offset	P3	%RH	±5% RH in 0.1% RH increment	
VOC Offset	P4	VOC	±100 ppm in 1 ppm increment	
Altitude	P5	ALT	Effective Pressure Altitude (display only, no adjustment)	

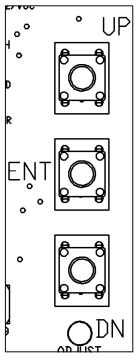


Figure 14: Calibration Buttons

Output Selection

The VOC outputs may be field configured for 0 to 5 VDC or 0 to 10 VDC outputs at any time. Set the jumpers on J16 as shown in figures 15 and 16. The humidity outputs may be field configured for 0 to 5 VDC or 0 to 10 VDC outputs at any time. Set the jumpers on J16 as shown in figures 17 and 18. **Note:** The sensor may be ordered with optional humidity outputs of 1 to 5 VDC or 2 to 10 VDC, figures 17 and 18 describe those options.

The jumpers on pins not being described are omitted for clarity

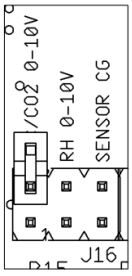


Figure 15: CO2 Output 0 – 5VDC

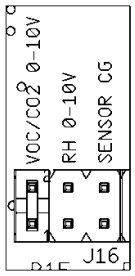


Figure 16: CO2 Output 0 – 10VDC

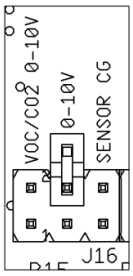


Figure 17: RH Output 0 – 5VDC or 1 to 5VDC

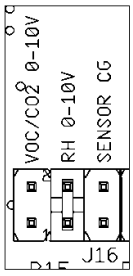


Figure 18: RH Output 0 – 10VDC or 2 to 10VDC

Sensor Start-up

At each power up, the sensor enters the start-up period for 15 minutes. The main display will show the current temperature and the minor display will show 123 for the first 15 seconds. The VOC output and display will follow the timing shown in figure 19. Start-up time for the humidity output is 30 seconds, while the outputs for temperature and temperature setpoint are available immediately.

During the start-up period an optional verification/commissioning test, described below, may be performed. This test is not mandatory, it is necessary only if building commissioning requires sensor verification or if verification of VOC output is required for later troubleshooting.

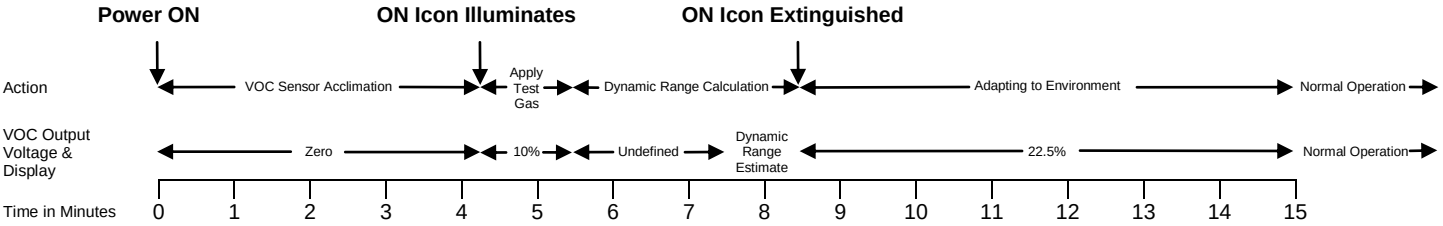


Figure 19: Sensor Start-up Timeline

Optional Sensor Performance Verification and Commissioning

BAPI's VOC sensor contains an adaptive, self adjusting, Volatile Organic Compound (VOC) sensor element that provides a CO_2 equivalent control signal output. When incorporated into a control strategy based on ASHRAE's Demand Control Ventilation algorithm, ventilation using this sensor will achieve true indoor air quality and not just CO_2 dilution.

The fundamental performance criterion of the VOC sensor element is its dynamic sensing range. The VOC sensor element requires a minimum dynamic range of 3 for proper operation. During BAPI's verification/commissioning test, the dynamic range is tested and displayed.

BAPI recommends installing the sensor and powering it for at least 48 hours before the first verification test is performed. BAPI further recommends ventilating the space such that the sensor reads 750 ppm CO_2 equivalent before any verification test is performed. Wait at least one hour before repeating the test.

1. Start Automatic Verification/Commissioning Test

A. Remove sensor power for at least one minute and reapply. The VOC sensor will set the VOC output to zero volts. Display models will indicate 0.0 on the main display and CMS, short for commissioning, on the minor display. (Power ON in figure 19)

B. Wait four minutes fifteen seconds.

C. The VOC sensor will set the VOC output voltage to 5% of full scale (0.25 VDC for 0 to 5 VDC, 0.5 VDC for 0 to 10 VDC or 2.4 VDC for 2 to 10 VDC outputs). Display units will illuminate the **ON** icon and set the main display to 1.0.

D. The visual indication and the 5% output voltage confirms that the VOC sensor is in its verification/commissioning test. (Apply Test Gas period in figure 19)

Optional Sensor Performance Verification and Commissioning Continued

2. Apply Verification Stimulus

A. Apply the stimulus gas during the first minute after the sensor illuminates the **ON** icon (*See Stimulus Preparation and Application)*.

B. Read and record the VOC output voltage or Main LCD display approximately 2 to 4 minutes following the stimulus gas application to determine the dynamic range measurement. (Dynamic Range Estimate period in figure 19)

C. When the dynamic range estimate period is complete the **ON** icon will be extinguished.

3. Termination of Verification Mode

A. For the last 7 minutes of the start-up period the sensor adapts to its ambient environment. The VOC sensor will maintain its output voltage at 450 ppm CO_2 equivalent. Display units will show 450 ppm equivalents.

B. At 15 minutes the VOC sensor will terminate the start-up period and begin normal operation.

C. The VOC output will now report the VOCs present as CO_2 equivalents.

4. Result Analysis and Recommendations

The VOC algorithm requires a minimum of 3.0 dynamic range for proper operation. Sensors reporting 3.0 or less dynamic range should be considered for replacement. (See Figure 21)

Stimulus Preparation and Application

Customer supplied – 70% minimum Isopropyl Alcohol.

Place 50ml of the Isopropyl Alcohol into a 200ml glass bottle (2oz in an 8oz glass bottle) with stopper and allow to reach room temperature (65° to 80°F, 18° to 27°C), a minimum of 15 minutes.

1. Using a medical grade syringe, remove the stopper from the alcohol bottle, place the tip of the syringe at least half-way into the bottle and withdraw a 60 ml sample of the **ALCOHOL VAPOR**. (**NO LIQUID**)
2. Replace the stopper on the alcohol bottle.
3. Place the end of the syringe -
   A. Over, or into the top ventilation slot of the VOC monitor's housing for room versions.
   B. Into a knockout opening or directly into the aspiration probe's top hole for duct mount versions.
4. Empty the syringe into the sensor using one continuous motion.

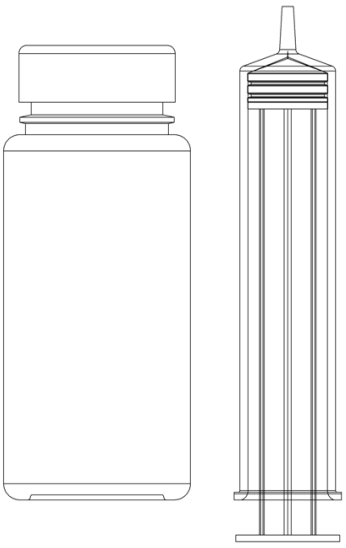


Figure 20: Alcohol Bottle and Syringe

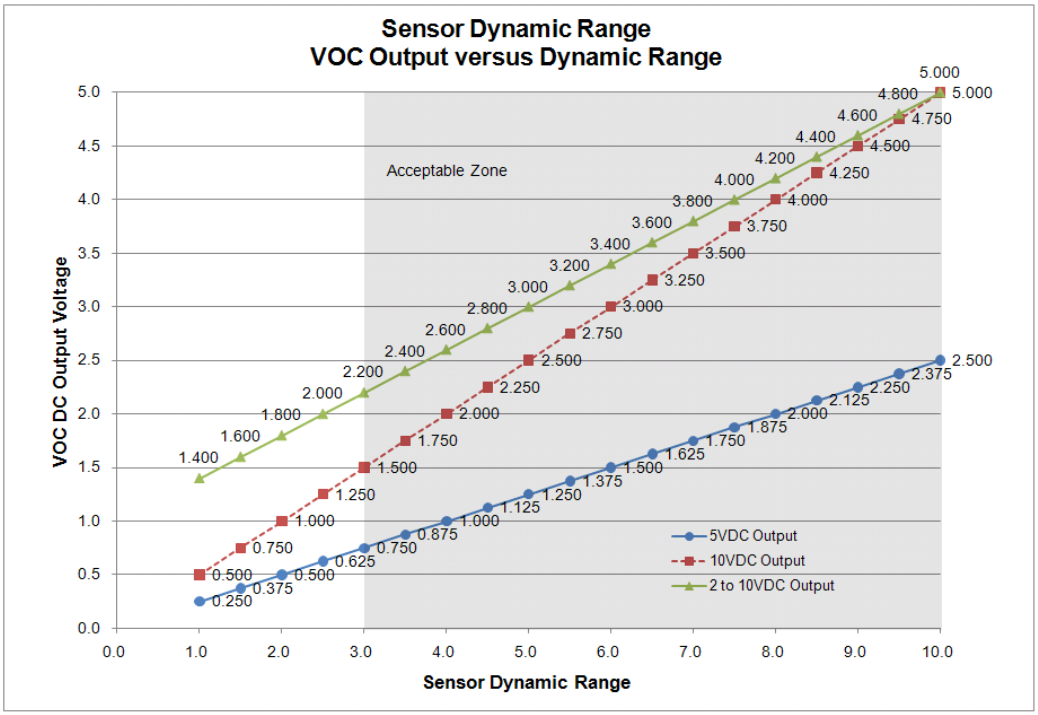


Figure 21: Acceptable Dynamic Range Output

Specifications subject to change without notice.

Diagnostics

Possible Problems:	Possible Solutions:
General troubleshooting	- Determine that the input is set up correctly in the controller's and building automation software. - Check wiring at the sensor and controller for proper connections. - Check for corrosion at either the controller or the sensor. Clean off the corrosion, re-strip the interconnecting wire and reapply the connection. In extreme cases, replace the controller, interconnecting wire and/or sensor. - Label the terminals that the interconnecting wires are connected to at the sensor end and the controller end. Disconnect the interconnecting wires from the controller and the sensor. With the interconnecting wires separated at both ends measure the resistance from wire-to-wire with a multimeter. The meter should read greater than 10 Meg-ohms, open or OL depending on the meter you have. Short the interconnecting wires together at one end. Go to the other end and measure the resistance from wire-to-wire with a multimeter. The meter should read less than 10 ohms (22 gauge or larger, 250 feet or less). If either test fails, replace the wire. - Check power supply/controller voltage supply - Disconnect sensor and check power wires for proper voltage (see specifications below)
Incorrect VOC	- Wait 15 minutes after a power interruption. - Check all software parameters - Determine if the sensor is exposed to an external environment different from the room (conduit draft)
Incorrect Humidity	- Check all software parameters - If available, check the sensor against a calibrated instrument such as a hygrometer - Determine if the sensor is exposed to an external environment different from the room (conduit draft)
Incorrect Temperature	- Determine that the temperature sensor's wires are connected to the correct controller input terminals and are not loose. - Check the wires at the sensor and controller for proper connections. - Measure the physical temperature at the temperature sensor's location using an accurate temperature standard. **Output to Controller** Disconnect the temperature sensor's wire (Terminals TP+ & TP-) and measure the temperature sensor's resistance across the sensor output pins with an ohmmeter. Put the ohmmeters black lead on Terminal TP- and the red lead on Terminal TP+. Compare the temperature sensor's resistance to the appropriate temperature sensor table on the BAPI web site (See below). If the measured resistance is different from the temperature table by more than 5% call BAPI technical support. Don't forget to reconnect the wires. **How to Find Temperature Sensor Resistance** Find BAPI's web site at www.bapihvac.com; click on the button labeled SENSORS on the left of the screen and then click on the sensor type you have. - Make sure that the sensor leads are not touching one another. - Determine if the sensor is exposed to an external environment different from the room (conduit or wall cavity draft)

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