VOLATILE ORGANIC COMPOUND PROBES
MODELS 984, 985, 986 AND 987

OPERATION AND SERVICE MANUAL

P/N 6007661, REVISION D
NOVEMBER 2018

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LIMITATION OF WARRANTY AND LIABILITY (effective February 2015)
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Seller warrants the goods, excluding software, sold hereunder, under normal use and service as described in the operator's manual, to be free from defects in workmanship and material for **24 months**, or if less, the length of time specified in the operator's manual, from the date of shipment to the customer. This warranty period is inclusive of any statutory warranty. **This limited warranty is subject to the following exclusions and exceptions**:

a. Hot-wire or hot-film sensors used with research anemometers, and certain other components when indicated in specifications, are warranted for 90 days from the date of shipment;

b. Pumps are warranted for hours of operation as set forth in product or operator's manuals;

c. Parts repaired or replaced as a result of repair services are warranted to be free from defects in workmanship and material, under normal use, for 90 days from the date of shipment;

d. Seller does not provide any warranty on finished goods manufactured by others or on any fuses, batteries or other consumable materials. Only the original manufacturer's warranty applies;

e. This warranty does not cover calibration requirements, and seller warrants only that the instrument or product is properly calibrated at the time of its manufacture. Instruments returned for calibration are not covered by this warranty;

f. This warranty is **VOID** if the instrument is opened by anyone other than a factory authorized service center with the one exception where requirements set forth in the manual allow an operator to replace consumables or perform recommended cleaning;

g. This warranty is **VOID** if the product has been misused, neglected, subjected to accidental or intentional damage, or is not properly installed, maintained, or cleaned according to the requirements of the manual. Unless specifically authorized in a separate writing by Seller, Seller makes no warranty with respect to, and shall have no liability in connection with, goods which are incorporated into other products or equipment, or which are modified by any person other than Seller.

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Service Policy

Knowing that inoperative or defective instruments are as detrimental to TSI as they are to our customers, our service policy is designed to give prompt attention to any problems. If any malfunction is discovered, please contact your nearest sales office or representative, or call TSI's Customer Service department at (800) 680-1220 (USA) or (001 651) 490-2860 (International) or visit www.tsi.com.

CONTENTS

Introduction

TSI measures Volatile Organic Compounds (VOCs) in air by using Photo-Ionization Detection (PID). A PID sensor uses an ultraviolet (UV) light source to break down VOCs in the air into positive and negative ions. The PID sensor then detects or measures the charge of the ionized gas, with the charge being a function of the concentration of VOCs in the air.

TSI VOC probes are designed for evaluating or investigating indoor air quality (IAQ) conditions and are best suited for ambient, non-hazardous conditions. Common passive sensor monitoring applications include evaluating off-gassing of new building construction materials, point source location, comparing complaint to non-complaint areas and sensitization investigations.

The potential for adverse health effects depends on the type of chemical, concentration in air, time of exposure, and personal sensitivity to any specific VOC.

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Chapter 1

Unpacking and Parts Identification

Carefully unpack the probe from the shipping container. Check the individual parts against the list of components below. If anything is missing or damaged, notify TSI immediately.

1. Probe
2. VOC calibration collar
3. CO_2 calibration collar (included with Models 986 and 987)
4. Calibration certificate
5. Manual

Model 984	Low concentration (ppb) VOC and temperature
Model 985	High concentration (ppm) VOC and temperature
Model 986	Low concentration (ppb) VOC, temperature, CO_2 and humidity
Model 987	High concentration (ppm) VOC, temperature, CO_2 and humidity

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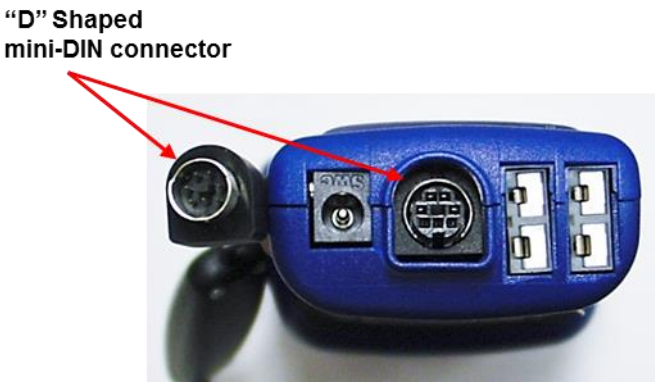
Chapter 2

Setting-up

Connecting the VOC Probe to Instrument

The VOC probes have a “D” shape over-molding on the mini-DIN connector which must align with the connector at the base of the multi-functional instrument models 9565-X, 9565-P, TA465-X, TA465-P and 7575-X. This will ensure the probe is properly connected and remains so during use.



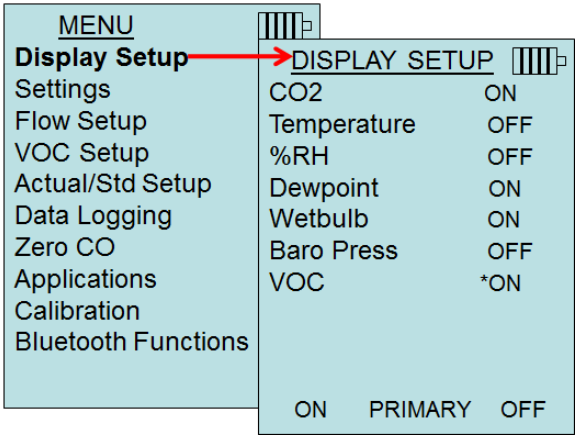
Using the Probe

The sensing probe relies on the diffusion of air. For best results, try to keep the sensing probe surrounded by moving air. Do ***not*** breathe on the probe.

Humans exhale CO_2 levels exceeding 10,000 ppm and it may take time for the probes that measure CO_2 to re-stabilize, and high humidity from your breath can cause condensation on the UV light source in the PID sensor.

DISPLAY SETUP

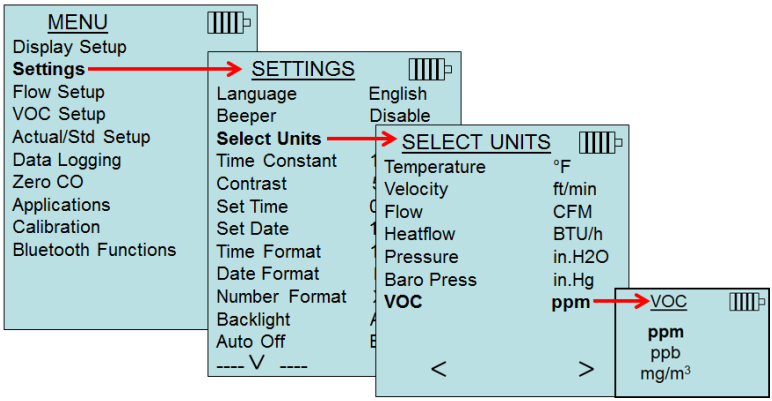
Display Setup menu is where you will setup the desired parameters to be displayed on the instrument screen. With a parameter highlighted you can then use the **ON** soft key to have it show up on the instrument screen or select the **OFF** soft key to turn off the parameter. Use **PRIMARY** soft key to have a parameter show up on the instrument screen in a larger display. A total of 5 parameters can be shown on the display, 1 primary (large font) and 4 secondary. Parameters shown in the Display Setup screen are dependent on the type of probe currently connected.



SETTINGS

Settings menu is where you can set the general settings. These include Language, Beeper, Select Units, Time Constant, Contrast, Set Time, Set Date, Time Format, Date Format, Number Format, Backlight, and Auto Off.

Use the ▲or ▼ keys to select an option, and the ➤ or ➤ soft keys to change the settings for each option. Press the ↵ key to accept settings.



VOC SETUP

The Response Factor and Molecular Weight of a specific gas can be inputted by the user.

- The Response Factor is used to calculate the actual concentration of a specific VOC.
- The displayed resolution will vary based on the programmed response factor as listed below:

When units are ppm		
Response Factor	**0–20,000 ppb Sensor Resolution**	**0–2,000 ppm Sensor Resolution**
0.1–0.3	0.001	0.1
0.3–3	0.01	1
3.0–30	0.1	10
30–200	1	100

When units are ppb		
Response Factor	**0–20,000 ppb Sensor Resolution**	**0–2,000 ppm Sensor Resolution**
0.1–0.3	1	100
0.3–3	10	1,000
3.0–30	100	10,000
30–200	1,000	100,000

- The Molecular Weight of a specific gas allows for converting concentration (PPM or PPB) to mass concentration (mg/m^3) and uses the following equation:

$$\text{Mass Concentration} = \frac{\text{ppm x MW x 273.15 x BP}}{\text{22.4136 x C x 29.92}}$$

Mass concentration = mg/m^3
MW = molecular weight of gas
BP = barometric pressure in in. Hg
C = temperature in °C

To convert ppm to ppb:
ppb = ppm * 1000

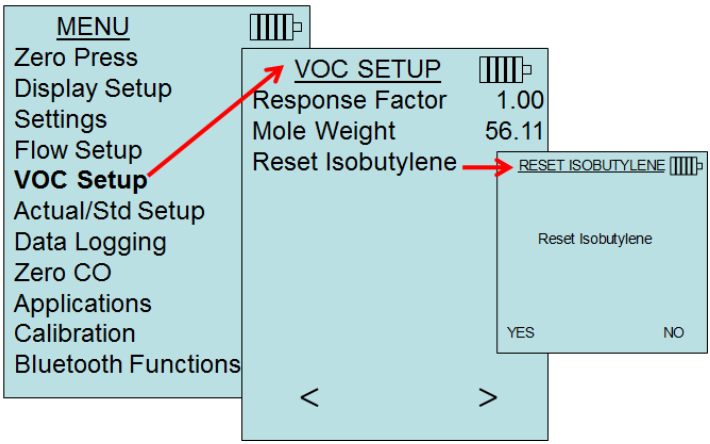
- The displayed resolution will vary based on the programmed response factor and mole weight as listed below:

When units are mg/m³		
Response Factor x Mole Weight	**0–20,000 ppb Sensor Resolution**	**0–2,000 ppm Sensor Resolution**
1.0–5	0.001	0.1
5.0–50	0.01	1
50–500	0.1	10
500–84,000	1	100

NOTE

This conversion calculation is most accurate when the composition of the gas is known and requires an instrument firmware of 3.08 or higher.

- Reset Isobutylene will restore the factor to factory conditions for Isobutylene (56.11).



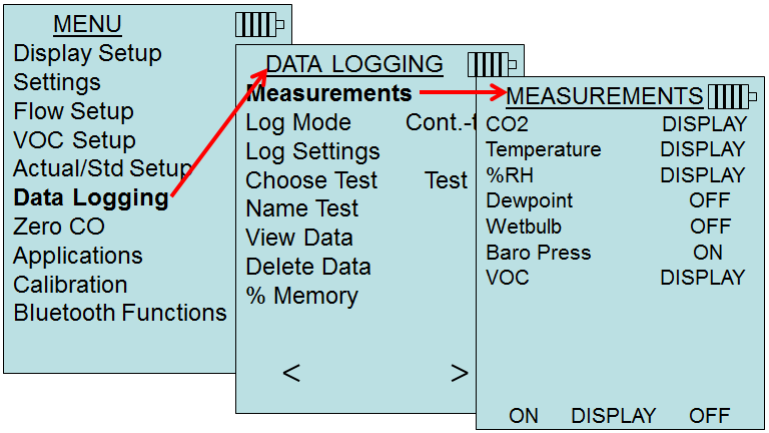
DATA LOGGING

Measurements

Measurements to be logged to memory are independent of measurements on the display, and must therefore be selected under **DATA LOGGING → Measurements**.

- When set to **ON**, measurement will be logged to memory.
- When set to **DISPLAY**, measurement will be logged to memory if it is visible on the main running screen.
- When set to **OFF**, measurement will not be logged to memory.

Refer to the instrument manual (Chapter 3: Data Logging → "LogMode/Log Settings") for information on the different logging formats available.



Chapter 3

Response Factors

TSI Volatile Organic Compound (VOC) probes are calibrated using isobutylene, but the sensor's Photo Ionization Detector (PID) is a broadband VOC detector with a sensitivity that differs for each VOC compound.

PID lamps can be created with a number of gasses, each of which has different photon energy. TSI's PID probes use Krypton gas, with photon energy of 10.6 eV (Electron Volt) that offers a long lamp life and responds to a wide range of gases.

If you know what VOC you are measuring, the table in this section will allow you to calculate the real concentration for your specific VOC that responds to a 10.6 eV lamp source.

NOTE

These are approximate values, so for best accuracy, you should calibrate with the relevant VOC.

NOTE

TSI PID sensors cannot measure all VOCs or gases. VOCs that have an electron-volt potential greater than or equal (≥) to 10.6 eV will give no response since they cannot be ionized by the 10.6 eV lamp source. Semi-Volatile Organic Compounds (SVOC) cannot be measured if the vapor pressure is too low (a few ppm at 20°C) to volatize the compound.

The table includes five columns:

Gas/ VOC	The most common name for the VOC.
CAS No.	Find the VOC using the CAS No.
Formula	To assist in identifying the VOC and to determine the VOC's molecular weight.
Response Factor (RF)	Multiply the displayed concentration by the Response Factor to calculate the actual concentration of the VOC. **NOTE:** The **Response Factor (RF)** can be programmed into the instrument via the **VOC SETUP** menu.
Molecular Weight	The molecular weight of the VOC is used to convert its number concentration (PPM or PPB) to mass concentration (mg/m^3).

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Acetaldehyde	75-07-0	C_2H_4O	4.9	44.05
Acetic Acid	64-17-7	$C_2H_4O_2$	36.2	60.05
Acetic Anhydride	108-24-7	$C_4H_6O_3$	4.0	102.1
Acetone	67-64-1	C_3H_6O	0.7	58.08
Acrolein	107-02-8	C_3H_4O	4.0	56.06
Acrylic Acid	79-10-7	$C_3H_4O_2$	2.7	72.06
Allyl alcohol	107-18-6	C_3H_6O	2.1	58.08
Allyl chloride	107-05-1	C_3H_5Cl	4.5	76.53
Ammonia	7664-41-7	H_3N	8.5	17.03
Amyl acetate, n-	628-63-7	$C_7H_{14}O_2$	1.8	130.2
Amyl alcohol	71-41-0	$C_5H_{12}O$	3.2	88.15
Aniline	62-53-3	C_6H_7N	0.5	93.13
Anisole	100-66-3	C_7H_8O	0.5	108.1
Arsine	7784-42-1	AsH_3	2.5	77.95
Asphalt, petroleum fumes	8052-42-4		1.0	
Benzaldehyde	100-52-7	C_7H_6O	0.9	106.1
Benzene	71-43-2	C_6H_6	0.5	78.11
Benzenethiol	108-98-5	C_6H_5SH	0.7	110.2
Benzonitrile	100-47-0	C_7H_5N	0.7	103.1
Benzyl alcohol	100-51-6	C_7H_8O	1.3	108.1
Benzyl chloride	100-44-7	C_7H_7Cl	0.6	126.6
Benzyl formate	104-57-4	$C_8H_8O_2$	0.8	136.1

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Biphenyl	92-52-4	$C_{12}H_{10}$	0.4	154.2
Bis(2,3-epoxypropyl) ether	2238-07-5	$C_6H_{10}O_3$	3.0	130.1
Bromine	7726-95-6	Br_2	20.0	159.8
Bromobenzene	108-86-1	C_6H_5Br	0.7	157.0
Bromoethane	74-96-4	C_2H_5Br	5.0	109.0
Bromoethyl methyl ether, 2-	6482-24-2	C_3H_7OBr	2.5	139.0
Bromoform	75-25-2	$CHBr_3$	2.8	252.7
Bromopropane, 1-	106-94-5	C_3H_7Br	1.3	123.0
Butadiene	106-99-0	C_4H_6	0.8	54.09
Butadiene diepoxide,1,3-	1464-53-5	$C_4H_6O_2$	4.0	86.09
Butane, n-	106-97-8	C_4H_{10}	46.3	58.12
Butanol, 1-	71-36-3	$C_4H_{10}O$	4.0	74.12
Buten-3-ol, 1-	598-32-3	C_4H_8O	1.2	72.11
Butene, 1-	106-98-9	C_4H_8	1.3	56.11
Butoxyethanol, 2-	111-76-2	$C_6H_{14}O_2$	1.1	118.2
Butyl acetate, n-	123-86-4	$C_6H_{12}O_2$	2.4	116.2
Butyl acrylate, n-	141-32-2	$C_7H_{12}O_2$	1.5	128.2
Butyl lactate	138-22-7	$C_7H_{14}O_3$	2.5	146.2
Butyl mercaptan	109-79-5	$C_4H_{10}S$	0.5	90.19
Butylamine, 2-	513-49-5	$C_4H_{11}N$	0.9	73.14
Butylamine, n-	109-73-9	$C_4H_{11}N$	1.0	73.14
Camphene	565-00-4	$C_{10}H_{16}$	0.5	136.2

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Carbon disulfide	75-15-0	CS_2	1.4	76.14
Carbon tetrabromide	558-13-4	CBr_4	3.0	331.6
Carvone, R-	6485-40-1	$C_{10}H_{14}O$	1.0	150.2
Chlorine dioxide	10049-04-4	ClO_2	1.0	67.45
Chloro-1,3-butadiene, 2-	126-99-8	C_4H_5Cl	3.2	88.54
Chlorobenzene	108-90-7	C_6H_5Cl	0.5	112.6
Chloroethanol, 2-	107-07-3	C_2H_5ClO	10.0	80.51
Chloroethyl methyl ether, 2-	627-42-9	C_3H_7ClO	2.6	94.54
Chlorotoluene, o-	95-49-8	C_7H_7Cl	0.5	126.6
Chlorotoluene, p-	108-41-8	C_7H_7Cl	0.5	126.6
Chlorotrifluoroethylene	79-38-9	C_2ClF_3	1.0	116.5
Citral	5392-40-5	$C_{10}H_{16}O$	1.0	152.2
Citronellol	26489-01-0	$C_{10}H_{20}O$	1.0	156.3
Cresol, m-	108-39-4	C_7H_8O	1.1	108.1
Cresol, o-	95-48-7	C_7H_8O	1.1	108.1
Cresol, p-	106-44-5	C_7H_8O	1.1	108.1
Crotonaldehyde	4170-30-3	C_4H_6O	1.0	70.09
Cumene	98-82-8	C_9H_{12}	0.6	120.2
Cyclohexane	110-82-7	C_6H_{12}	1.3	84.16
Cyclohexanol	108-93-0	$C_6H_{12}O$	2.9	100.2
Cyclohexanone	108-94-1	$C_6H_{10}O$	1.1	98.14
Cyclohexene	110-83-8	C_6H_{10}	0.8	82.15

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Cyclohexylamine	108-91-8	$C_6H_{13}N$	1.0	99.18
Cyclopentane	287-92-3	C_5H_{10}	4.0	70.13
Decane, n-	124-18-5	$C_{10}H_{22}$	1.0	142.3
Diacetone alcohol	123-42-2	$C_6H_{12}O_2$	0.8	116.2
Dibenzoyl peroxide	94-36-0	$C_{14}H_{10}O_4$	0.8	242.2
Dibromochloromethane	124-48-1	$CHBr_2Cl$	10.0	208.3
Dibromoethane 1,2-	106-93-4	$C_2H_4Br_2$	2.0	187.9
Dibutyl hydrogen phosphate	107-66-4	$HC_8H_{18}PO_4$	4.0	210.2
Dichloro-1-propene, 2,3-	78-88-6	$C_3H_4Cl_2$	1.4	111.0
Dichloroacetylene	7572-29-4	C_2Cl_2	5.0	94.93
Dichlorobenzene o-	95-50-1	$C_6H_4Cl_2$	0.5	147.0
Dichloroethene, 1,1-	75-35-4	$C_2H_2Cl_2$	1.0	96.94
Dichloroethene, cis-1,2-	156-59-2	$C_2H_2Cl_2$	0.8	96.94
Dichloroethene, trans-1,2-	540-59-0	$C_2H_2Cl_2$	0.7	96.94
Dichloroethylene 1,2-	540-59-0	$C_2H_2Cl_2$	0.8	96.94
Dichloromethane	75-09-2	CH_2Cl_2	39.0	84.93
Dicyclopentadiene	77-73-6	$C_{10}H_{12}$	0.9	132.2
Diesel Fuel	68334-30-5		0.8	
Diethyl ether	60-29-7	$C_4H_{10}O$	0.9	74.12
Diethyl maleate	141-05-9	$C_8H_{12}O_4$	2.0	172.2
Diethyl phthalate	84-66-2	$C_{12}H_{14}O_4$	1.0	222.2
Diethyl sulphate	64-67-5	$C_4H_{10}SO_4$	3.0	154.2

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Diethyl sulphide	352-93-2	$C_4H_{10}S$	0.6	90.19
Diethylamine	109-89-7	$C_4H_{11}N$	1.0	73.14
Diethylaminoethanol, 2-	100-37-8	$C_6H_{15}ON$	2.7	117.2
Diethylaminopropylamine, 3-	104-78-9	$C_7H_{18}N_2$	1.0	130.2
Dihydrogen selenide	7783-07-5	H_2Se	1.0	2.016
Dihydroxybenzene, 1,2	120-80-9	$C_6H_6O_2$	1.0	110.1
Dihydroxybenzene, 1,3	108-46-3	$C_6H_6O_2$	1.0	110.1
Diisobutylene	107-39-1	C_8H_{16}	0.6	112.2
Diisopropyl ether	108-20-3	$C_6H_{14}O$	0.7	102.2
Diisopropylamine	108-18-9	$C_6H_{15}N$	0.7	101.2
Diketene	674-82-8	$C_4H_4O_2$	2.2	84.07
Dimethoxymethane	109-87-5	$C_3H_8O_2$	1.4	76.09
Dimethyl cyclohexane, 1,2-	583-57-3	C_8H_{16}	1.1	112.2
Dimethyl disulphide	624-92-0	$C_2H_6S_2$	0.2	94.20
Dimethyl ether	115-10-6	C_2H_6O	1.3	46.07
Dimethyl phthalate	131-11-3	$C_{10}H_{10}O_4$	1.0	194.2
Dimethyl sulphide	75-18-3	C_2H_6S	0.5	62.13
Dimethylacetamide N,N-	127-19-5	C_4H_9NO	1.3	87.12
Dimethylamine	124-40-3	C_2H_7N	1.4	45.08
Dimethylaminoethanol	108-01-0	$C_4H_{11}NO$	1.5	89.14
Dimethylaniline, NN-	121-69-7	$C_8H_{11}N$	0.6	121.2
Dimethylbutyl acetate	108-84-9	$C_8H_{16}O_2$	1.6	144.2

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Dimethylethylamine, NN-	598-56-1	$C_4H_{11}N$	0.8	73.14
Dimethylformamide	68-12-2	C_3H_7NO	0.9	73.09
Dimethylheptan-4-one, 2,6-	108-83-8	$C_9H_{18}O$	0.8	142.2
Dimethylhydrazine, 1,1-	57-14-7	$C_2H_8N_2$	1.0	60.10
Dinitrobenzene, m-	99-65-0	$C_6H_4N_2O_4$	3.0	168.1
Dinitrobenzene, p-	100-25-4	$C_6H_4N_2O_4$	5.0	168.1
Dinonyl phthalate	84-76-4	$C_{26}H_{42}O_4$	1.0	418.6
Dioxane 1,2-		$C_4H_8O_2$	1.5	88.11
Dioxane 1,4-	123-91-1	$C_4H_8O_2$	1.5	88.11
Dipentene	138-86-3	$C_{10}H_{16}$	0.9	136.2
Diphenyl ether	101-84-8	$C_{12}H_{10}O$	0.8	170.2
Disulphur dichloride	10025-67-9	S_2Cl_2	3.0	135.0
Di-tert-butyl-p-cresol	2409-55-4	$C_{11}H_{16}O$	1.0	164.2
Divinylbenzene	1321-74-0	$C_{10}H_{10}$	0.4	130.2
Dodecanol	112-53-8	$C_{12}H_{26}O$	0.9	186.3
Epichlorohydrin	106-89-8	C_3H_5ClO	8.0	92.52
Epoxypropyl isopropyl ether, 2,3-	4016-14-2	$C_6H_{12}O_2$	1.1	116.2
Ethanol	64-17-5	C_2H_6O	8.7	46.07
Ethanolamine	141-43-5	C_2H_7NO	3.0	61.08
Ethoxy-2-propanol, 1-	1569-02-4	$C_5H_{10}O_2$	2.0	102.1
Ethoxyethanol, 2-	110-80-5	$C_4H_{10}O_2$	29.8	90.12
Ethoxyethyl acetate, 2-	111-15-9	$C_6H_{12}O_3$	3.0	132.2

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Ethyl(S)-(-)-lactate	97-64-3	$C_5H_{10}O_3$	3.0	118.1
Ethyl acetate	141-78-6	$C_4H_8O_2$	3.6	88.11
Ethyl acrylate	140-88-5	$C_5H_8O_2$	2.0	100.1
Ethyl amine	75-04-7	C_2H_7N	1.0	45.08
Ethyl benzene	100-41-4	C_8H_{10}	0.5	106.2
Ethyl butyrate	105-54-4	$C_6H_{12}O_2$	1.0	116.2
Ethyl chloroformate	541-41-3	$C_3H_5O_2Cl$	80.0	108.5
Ethyl cyanoacrylate	7085-85-0	$C_6H_7O_2N$	1.5	125.1
Ethyl decanoate	110-38-3	$C_{12}H_{24}O_2$	1.8	200.3
Ethyl formate	109-94-4	$C_3H_6O_2$	30.0	74.08
Ethyl hexanoate	123-66-0	$C_8H_{16}O_2$	2.6	144.2
Ethyl hexanol, 2-	105-76-7	$C_8H_{18}O$	1.5	130.2
Ethyl hexyl acrylate, 2-	103-11-7	$C_{11}H_{20}O_2$	1.0	184.3
Ethyl mercaptan	75-08-1	C_2H_6S	0.7	62.13
Ethyl octanoate	106-32-1	$C_{10}H_{20}O_2$	2.3	172.3
Ethylene	74-85-1	C_2H_4	8.0	28.05
Ethylene glycol	107-21-1	$C_2H_6O_2$	20.0	62.07
Ethylene oxide	75-21-8	C_2H_4O	15.0	44.05
Ferrocene	102-54-5	$C_{10}H_{10}Fe$	0.8	186.0
Formamide	75-12-7	CH_3ON	2.0	45.04
Furfural	98-01-1	$C_5H_4O_2$	1.4	96.08
Furfuryl alcohol	98-00-0	$C_5H_6O_2$	2.0	98.10

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Gasoline vapors	8006-61-9		1.1	
Gasoline vapors92 octane	8006-61-9		0.8	
Germane	7782-65-2	GeH_4	10.0	76.64
Glutaraldehyde	111-30-8	$C_5H_8O_2$	0.9	100.1
Heptan-2-one	110-43-0	$C_7H_{14}O$	0.7	114.2
Heptan-3-one	106-35-4	$C_7H_{14}O$	0.8	114.2
Heptane n-	142-82-5	C_7H_{16}	2.1	100.2
Hexamethyldisilazane, 1,1,1,3,3,3-	999-97-3	$C_6H_{19}NSi_2$	1.0	161.4
Hexamethyldisiloxane	107-46-0	$C_6H_{18}OSi_2$	0.3	162.4
Hexan-2-one	591-78-6	$C_6H_{12}O$	0.8	100.2
Hexane n-	110-54-3	C_6H_{14}	4.2	86.18
Hexene, 1-	592-41-6	C_6H_{12}	0.9	84.16
Hydrazine	302-01-2	H_4N_2	3.0	32.05
Hydrogen peroxide	7722-84-1	H_2O_2	4.0	34.01
Hydrogen sulfide	7783-06-4	H_2S	4.0	34.08
Hydroquinone	123-31-9	$C_6H_6O_2$	0.8	110.1
Hydroxypropyl acrylate 2-	999-61-1	$C_6H_{10}O_3$	1.5	130.1
Iminodi(ethylamine) 2,2-	111-40-0	$C_4H_{13}N_3$	0.9	103.2
Iminodiethanol 2,2'-	111-42-2	$C_4H_{11}NO_2$	1.6	105.1
Indene	95-13-6	C_9H_8	0.5	116.2
Iodine	7553-56-2	I_2	0.2	253.8
Iodoform	75-47-8	CHI_3	1.5	393.7

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Iodomethane	74-88-4	CH_3I	0.4	141.9
Isoamyl acetate	123-92-2	$C_7H_{14}O_2$	1.6	130.2
Isobutane	75-28-5	C_4H_{10}	8.0	58.12
Isobutanol	78-83-1	$C_4H_{10}O$	3.5	74.12
Isobutyl acetate	110-19-0	$C_6H_{12}O_2$	2.3	116.2
Isobutyl acrylate	106-63-8	$C_7H_{12}O_2$	1.3	128.2
Isobutylene	115-11-7	C_4H_8	1.0	56.11
Isobutyraldehyde	78-84-2	C_4H_8O	1.2	72.11
Isodecanol	25339-17-7	$C_{10}H_{22}O$	0.9	158.3
Isononanol	2452-97-9	$C_9H_{20}O$	1.5	144.3
Isooctane	565-75-3	C_8H_{18}	1.1	114.2
Isooctanol	26952-21-6	$C_8H_{18}O$	1.7	130.2
Isopentane	78-78-4	C_5H_{12}	6.0	72.15
Isophorone	78-59-1	$C_9H_{14}O$	0.8	138.2
Isoprene	78-79-5	C_5H_8	0.7	68.12
Isopropanol	67-63-0	C_3H_8O	4.4	60.10
Isopropyl acetate	108-21-4	$C_5H_{10}O_2$	2.2	102.1
Isopropyl chloroformate	108-23-6	$C_4H_7O_2Cl$	1.6	122.6
Jet Fuel JP-4			0.8	
Jet Fuel JP-5			0.7	
Jet Fuel JP-8			0.7	
Ketene	463-51-4	C_2H_2O	3.0	42.04

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Maleic anhydride	108-31-6	$C_4H_2O_3$	2.0	98.06
Mercaptoacetic acid	68-11-1	$C_2H_4O_2S$	1.0	92.12
Mesitylene	108-67-8	C_9H_{12}	0.3	120.2
Methacrylic acid	79-41-4	$C_4H_6O_2$	2.3	86.09
Methacrylonitrile	126-98-7	C_4H_5N	5.0	67.09
Methanol	67-56-1	CH_4O	200.0	32.04
Methoxyethanol, 2-	109-86-4	$C_3H_8O_2$	2.7	76.09
Methoxyethoxyethanol, 2-	111-77-3	$C_5H_{12}O_3$	1.4	120.1
Methoxymethylethoxy-2-propanol	34590-94-8	$C_7H_{16}O_3$	1.3	148.2
Methoxypropan-2-ol	107-98-2	$C_4H_{10}O_2$	3.0	90.12
Methoxypropyl acetate	108-65-6	$C_6H_{12}O_3$	1.2	132.2
Methyl acetate	79-20-9	$C_3H_6O_2$	5.2	74.08
Methyl acrylate	96-33-3	$C_4H_6O_2$	3.4	86.09
Methyl bromide	74-83-9	CH_3Br	1.9	94.94
Methyl cyanoacrylate	137-05-3	$C_5H_5O_2N$	5.0	111.1
Methyl ethyl ketone	78-93-3	C_4H_8O	0.8	72.11
Methyl ethyl ketone peroxides	1338-23-4	$C_8H_{18}O_2$	0.8	146.2
Methyl isobutyl ketone	108-10-1	$C_6H_{12}O$	0.8	100.2
Methyl isothiocyanate	556-61-6	C_2H_3NS	0.6	73.12
Methyl mercaptan	74-93-1	CH_4S	0.7	48.11
Methyl methacrylate	80-62-6	$C_5H_8O_2$	1.6	100.1
Methyl propyl ketone	107-87-9	$C_5H_{10}O$	0.8	86.13

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Methyl salicylate	119-36-8	$C_8H_8O_3$	1.2	152.1
Methyl sulphide	75-18-3	C_2H_6S	0.5	62.13
Methyl t-butyl ether	1634-04-4	$C_5H_{12}O$	0.8	88.15
Methyl-2-propen-1-ol, 2-	51-42-8	C_4H_8O	1.1	72.11
Methyl-2-pyrrolidinone, N-	872-50-4	C_5H_9NO	0.9	99.13
Methyl-4,6-dinitrophenol, 2-	534-52-1	$C_7H_6N_2O_5$	3.0	198.1
Methyl-5-hepten-2-one, 6-	110-93-0	$C_8H_{14}O$	0.8	126.2
Methylamine	74-89-5	CH_5N	1.4	31.06
Methylbutan-1-ol, 3-	123-51-3	$C_5H_{12}O$	3.4	88.15
Methylcyclohexane	108-87-2	C_7H_{14}	1.1	98.19
Methylcyclohexanol, 4-	589-91-3	$C_7H_{14}O$	2.4	114.2
Methylcyclohexanone 2-	583-60-8	$C_7H_{12}O$	1.0	112.2
Methylheptan-3-one, 5-	541-85-5	$C_8H_{16}O$	0.8	128.2
Methylhexan-2-one, 5-	110-12-3	$C_7H_{14}O$	0.8	114.2
Methylhydrazine	60-34-4	CH_6N_2	1.3	46.07
Methyl-N-2,4,6-tetranitroaniline, N-	479-45-8	$C_7H_5N_5O_8$	3.0	287.1
Methylpent-3-en-2-one, 4-	141-79-7	$C_6H_{10}O$	0.7	98.14
Methylpentan-2-ol, 4-	108-11-2	$C_6H_{14}O$	2.8	102.2
Methylpentane-2,4-diol, 2-	107-41-5	$C_6H_{14}O_2$	4.0	118.2
Methylpropan-2-ol, 2-	75-65-0	$C_4H_{10}O$	3.5	74.12
Methylstyrene	25013-15-4	C_9H_{10}	0.5	118.2
Mineral oil	8042-47-5		0.8	

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Mineral spirits	64475-85-0		0.8	
Naphthalene	91-20-3	$C_{10}H_8$	0.4	128.2
Nitric oxide	10102-43-9	NO	8.0	30.01
Nitroaniline 4-	100-01-6	$C_6H_6N_2O_2$	0.8	138.1
Nitrobenzene	98-95-3	$C_6H_5NO_2$	1.7	123.1
Nitrogen dioxide	10102-44-0	NO_2	10.0	46.01
Nitrogen trichloride	10025-85-1	NCl_3	1.0	120.4
Nonane, n-	111-84-2	C_9H_{20}	1.3	128.3
Norbornadiene, 2,5-	121-46-0	C_7H_8	0.6	92.14
Octachloronaphthalene	2234-13-1	$C_{10}Cl_8$	1.0	403.7
Octane, n-	111-65-9	C_8H_{18}	1.6	114.2
Octene, 1-	111-66-0	C_8H_{16}	0.7	112.2
Oxydiethanol 2,2-	111-46-6	$C_4H_{10}O_3$	4.0	106.1
Paraffin wax, fume	8002-74-2		1.0	
Paraffins, normal	64771-72-8		1.0	
Pentacarbonyl iron	13463-40-6	FeC_5O_5	1.0	195.9
Pentan-2-one	107-87-9	$C_5H_{10}O$	0.8	86.13
Pentan-3-one	96-22-0	$C_5H_{10}O$	0.8	86.13
Pentandione, 2,4-	123-54-6	$C_5H_8O_2$	0.8	100.1
Pentane, n-	109-66-0	C_5H_{12}	7.9	72.15
Peracetic acid	79-21-0	$C_2H_4O_3$	2.0	76.05
Petroleum ether			0.9	

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Phenol	108-95-2	C_6H_6O	1.2	94.11
Phenyl propene, 2-	98-83-9	C_9H_{10}	0.4	118.2
Phenyl-2,3-epoxypropyl ether	122-60-1	$C_9H_{10}O_2$	0.8	150.2
Phenylenediamine, p-	106-50-3	$C_6H_8N_2$	0.6	108.1
Phosphine	7803-51-2	PH_3	2.0	34.00
Picoline, 3-	108-99-6	C_6H_7N	0.9	93.13
Pinene, alpha	80-56-8	$C_{10}H_{16}$	0.3	136.2
Pinene, beta	127-91-3	$C_{10}H_{16}$	0.3	136.2
Piperidine	110-89-4	$C_5H_{11}N$	0.9	85.15
Piperylene	504-60-9	C_5H_8	0.7	68.12
Prop-2-yn-1-ol	107-19-7	C_3H_4O	1.3	56.06
Propan-1-ol	71-23-8	C_3H_8O	4.8	60.10
Propane-1,2-diol, total	57-55-6	$C_3H_8O_2$	10.0	76.09
Propene	115-07-1	C_3H_6	1.4	42.08
Propionaldehyde	123-38-6	C_3H_6O	1.7	58.08
Propionic acid	79-09-4	$C_3H_6O_2$	8.0	74.08
Propyl acetate, n-	109-60-4	$C_5H_{10}O_2$	2.5	102.1
Propylene dinitrate	6423-43-4	$C_3H_6N_2O_6$	ZR	166.1
Propylene oxide	75-56-9	C_3H_6O	7.0	58.08
Propyleneimine	75-55-8	C_3H_7N	1.3	57.10
Pyridine	110-86-1	C_5H_5N	0.8	79.10
Pyridylamine 2-	504-29-0	$C_5H_6N_2$	0.8	94.12

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Styrene	100-42-5	C_8H_8	0.4	104.2
Sulphur dioxide	7446-09-5	SO_2	ZR	64.06
Sulphur hexafluoride	2551-62-4	SF_6	ZR	146.1
Sulphur tetrafluoride	7783-60-0	SF_4	ZR	108.1
Sulphuric acid	7664-93-9	H_2SO_4	ZR	98.08
Sulphuryl fluoride	2699-79-8	SO_2F_2	ZR	102.1
Terphenyls		$C_{18}H_{14}$	0.6	230.3
Terpinolene	586-62-9	$C_{10}H_{16}$	0.5	136.2
Tert-butanol	75-65-0	$C_4H_{10}O$	2.6	74.12
Tetrabromoethane, 1,1,2,2-	79-27-6	$C_2H_2Br_4$	2.0	345.7
Tetracarbonylnickel	13463-39-3	NiC_4O_4	1.0	170.7
Tetrachloroethylene	127-18-4	C_2Cl_4	0.7	165.8
Tetrachloronaphthalenes,all isomers	20020-02-4	$C_{10}H_4Cl_4$	1.0	266.0
Tetraethyl orthosilicate	78-10-4	$C_8H_{20}O_4Si$	2.0	208.3
Tetrafluoroethylene	116-14-3	C_2F_4	1.0	100.0
Tetrahydrofuran	109-99-9	C_4H_8O	1.6	72.11
Tetramethyl succinonitrile	3333-52-6	$C_8H_{12}N_2$	1.0	136.2
Therminol			1.0	
Toluene	108-88-3	C_7H_8	0.5	92.14
Toluene-2,4-diisocyanate	584-84-9	$C_9H_6N_2O_2$	1.6	174.2
Toluenesulphonylchloride, p-	98-59-9	$C_7H_7SO_2Cl$	3.0	190.6
Toluidine, o-	95-53-4	C_7H_9N	0.5	107.2

Gas/VOC	CAS No.	Formula	Response Factor	Molecular Weight (g/mol)
Tributyl phosphate	126-73-8	$C_{12}H_{27}O_4P$	5.0	266.3
Tributylamine	102-82-9	$C_{12}H_{27}N$	1.0	185.4
Trichlorobenzene 1,2,4-	120-82-1	C6H3Cl3	0.6	181.4
Trichloroethylene	79-01-6	C2HCl3	0.7	131.4
Trichlorophenoxyacetic acid, 2,4,5-	93-76-5	$C_8H_5O_3Cl_3$	1.0	255.5
Triethylamine	121-44-8	$C_6H_{15}N$	0.9	101.2
Trimethylamine	53-50-3	C_3H_9N	0.5	59.11
Trimethylbenzene, 1,3,5-	108-67-8	C_9H_{12}	0.3	120.2
Turpentine	8006-64-2	$C_{10}H_{16}$	0.6	136.2
TVOC			1.0	
Undecane, n-	1120-21-4	$C_{11}H_{24}$	0.9	156.3
Vinyl acetate	108-05-2	$C_4H_6O_2$	1.1	86.09
Vinyl bromide	593-60-2	C_2H_3Br	1.0	106.9
Vinyl chloride	75-01-4	C_2H_3Cl	2.1	62.50
Vinyl-2-pyrrolidinone, 1-	88-12-0	C_6H_9NO	0.9	111.1
Xylene mixed isomers	1330-20-7	C_8H_{10}	0.4	106.2
Xylene, m-	108-38-3	C_8H_{10}	0.4	106.2
Xylene, o-	95-47-6	C_8H_{10}	0.6	106.2
Xylene, p-	106-42-3	C_8H_{10}	0.6	106.2
Xylidine, all	1300-73-8	$C_8H_{11}N$	0.7	121.2

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Chapter 4

Field Testing and Calibration

Overview

Due to the nature of the PID sensor and the presence of VOCs in air along with other environmental factors such as altitude, temperature and relative humidity, the zero value of the VOC probe will shift over time. **TSI recommends testing the probe performance each time the instrument is used to make measurements.** This is a common practice within the gas measurement community which includes IAQ consultants and industrial hygienists.

Probe Verification

Verifying the probe performance can easily be accomplished in the field by comparing it to certified zero and span calibration gases. To do this, attach the probe with the calibration collar to a bottle of Zero Gas and compare to the instrument readings (also referred to as a “Bump Test”). If the probe reads any number other than 0, the PID sensor has drifted and needs to be re-calibrated.

NOTE

With probe attached, power on the instrument for 10 minutes before verifying performance. This allows the instrument and probe electronics to stabilize to produce best results.

TSI Recommended Accessories for Testing or Calibrating PID Probes

- Zero Gas—80% Nitrogen/20% Oxygen
- Span Gas—1 ppm Isobutylene in balance Nitrogen—use with ppb probe
- Span Gas—10 ppm Isobutylene in balance Nitrogen—use with ppb probe
- Span Gas—20 ppm Isobutylene in balance Nitrogen—use with ppm probe
- Span Gas—100 ppm Isobutylene in balance Nitrogen—use with ppm probe
- 0.3 to 0.5 L/min flow rate Continuous Flow Regulator
- Tygon® tubing 0.250 in. (6.35 mm) OD, 0.125 in. (3.175 mm) ID
- VOC probe calibration collar (included with probe)

When spanning with an isobutylene gas, select a concentration value that is closest to the desired measurement range. This will result in maximum accuracy of the PID sensors readings.

Example 1 (ppb)

If you have a ppb PID probe and want to measure VOCs in the low ppb range, span calibrating with a 1 ppm isobutylene gas will give more accurate results than span calibrating with a 10 ppm isobutylene gas. If you would like to measure VOCs in the mid to upper range of the PID sensor, calibrating with 10 ppm isobutylene span gas would be appropriate.

Example 2 (ppm)

If you have a ppm PID probe and want to measure VOCs in the low ppm range, span calibration with a 20 ppm isobutylene gas will give more accurate results, than span calibrating with 100 ppm isobutylene gas will. If you would like to measure VOCs in the mid to upper range of the PID sensor, calibrating with 100 ppm isobutylene span gas would be appropriate.

Zero, Span gasses and regulators that meet TSI's requirements are available internationally from PortaGas at www.portagas.com in 103 liter bottle configurations.

PID Probe Calibration

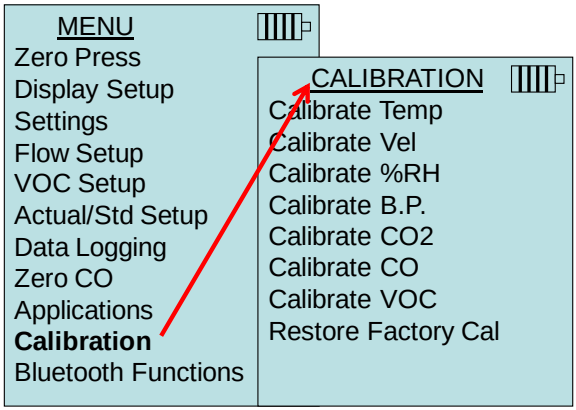
If the probe reads any number other than 0 when tested against a zero gas, the PID sensor has drifted and needs to be re-calibrated using the following instructions. These instructions are also applicable if the PID sensor has been replaced in the field.

NOTES

- With probe attached power on the instrument for 10 minutes before calibrating the probe. This allows the instrument and probe electronics to stabilize to produce best results.
- Field calibration is required if a new replacement PID sensor is installed on the probe.
- Restore to Factory Calibration before performing field calibration.
- After restoring Factory Calibration, try the “Bump Test” again at 0 ppm and/or at a known concentration of Isobutylene in balance Nitrogen gas. If readings are still out of tolerance, then proceed with field calibration procedure.

Accessing the Calibration Menu

To access the CALIBRATION menu, press the **MENU** key and scroll down to CALIBRATION and press **ENTER**. Highlight Calibrate VOC and then press **ENTER**.



NOTE

The measurement capabilities of the instrument and probe will determine what appears in the main MENU and CALIBRATION menu. Instrument models using detachable probes must have the probe attached to perform field calibrations. This screen display above is from the 9565-P VelociCalc® Multi-Function Ventilation Meter with VOC probe attached.

Calibrate VOC

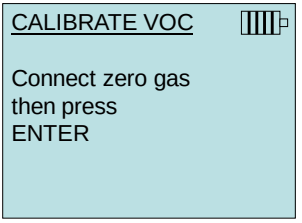
A probe calibration collar (included with probe), zero calibration gas, span calibration gas, gas regulator and tubing are required to perform the calibration. The gas regulator used to control the flow should be capable of providing 0.3 L/min. Follow the on-screen instructions to complete the calibration.

Step 1—Grasp probe handle and pull PID sensor protective cap off.

Step 2—Slide calibration collar onto probe and attach to gas cylinder using tubing.

Step 3—Zero Calibration.

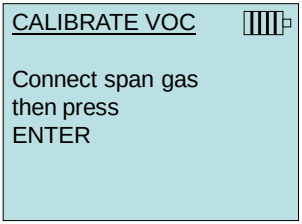
After pressing **ENTER** with the zero calibration gas connected, the instrument begins to take data. A bar graph will appear showing the time remaining. *The time allocated by the instruments firmware for zero is sufficient for zeroing.*



Step 4—Span Calibration.

For best results, *run the span gas with the probe attached for 60 seconds before pressing the **ENTER** button to conduct the span calibration.*

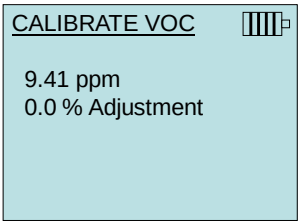
After pressing **ENTER** with the span calibration gas connected, the instrument begins to take data. A bar graph will appear showing the time remaining.



Step 5—Span Adjustment

Once the countdown is complete, the VOC concentration as measured by the probe is displayed along with the percent of adjustment.

In this example, the span gas is rated at 10 ppm. Use the UP or DOWN arrow keys to adjust offset to match the span gas concentration. Press **ENTER** to accept and to return to the CALIBRATION menu.



Calibrate CO_2

This calibration option applies to meters and probes capable of measuring CO_2. A probe calibration collar, zero calibration gas, span calibration gas, gas regulator and tubing are required to perform the calibration. The gas regulator used to control the flow should be capable of providing 0.3 L/min. Follow the on-screen instructions to complete the calibration.

Requirements

- Probe calibration collar (included with IAQ and VOC probes)
- Span calibration gas, 5000 ppm maximum
- Zero Gas – 80% Nitrogen / 20% Oxygen
- 0.3 L/min flow rate Continuous Flow Regulator
- Tygon tubing 0.250 in. (6.35 mm) OD, 0.125 in. (3.175 mm) ID

NOTE
If probe measures VOC gasses, remove VOC sensor first.

- Pull PID sensor protective cap off ①
- Remove PID sensor ②
- Unscrew collar ③
- Gently remove small PCB ④

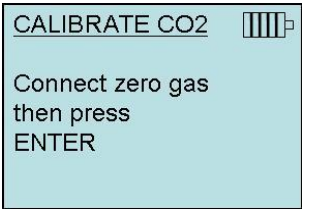
Step 1—Slide calibration collar onto probe and attach to gas cylinder using tubing.

Step 2— Bump Test

Measure concentration with 0 ppm calibration gas flowing through the calibration collar. Do the same with the Span Gas. If readings are out of tolerance, Restore CO_2 Factory Calibration (see RESTORE FACTORY CAL) and then perform the Bump Test again at 0 ppm and Span. If readings are still OOT, proceed with Field Calibration.

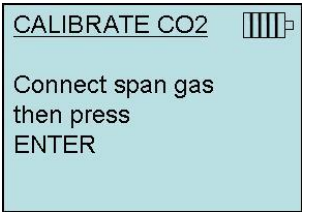
Step 3—Zero Calibration.

After pressing **ENTER** with the zero calibration gas connected, the instrument will begin to take data. A bar graph will appear showing the time remaining.



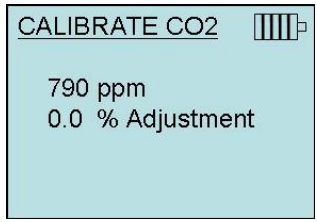
Step 4—Span Calibration.

After pressing **ENTER** with the span calibration gas connected, the instrument will begin to take data. A bar graph will appear showing the time remaining.

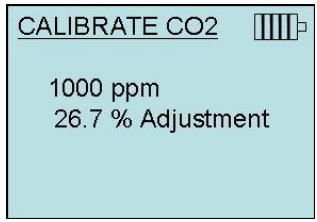


Step 5—Span Adjustment.

Once the countdown is complete, the CO_2 concentration as measured by the probe is displayed along with the percent of adjustment.



In this example, the span gas is rated at 1000 ppm. Use the UP or DOWN arrow keys to adjust offset to match the span gas concentration. Press **ENTER** to accept and to return to the CALIBRATION menu.

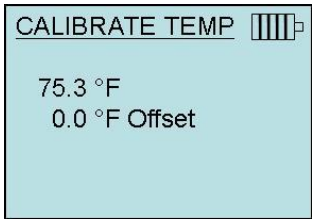


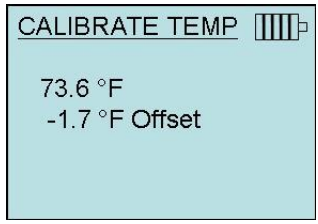
Calibrate Temp

This calibration option applies to all meters and probes capable of measuring temperature. The temperature calibration can be adjusted ±6.0°F (±3.3°C). Compare the instruments temperature reading to a reference standard and make changes as required.

Step 1—Use the UP or DOWN arrow keys to adjust offset.

Step 2—Press **ENTER** to accept and to return to CALIBRATION menu.





In this example, the temperature measured by the probe is 75.3°F and the reference temperature is 73.6°F. Adjusting the offset by -1.7°F allows the probe to match the reference standard.

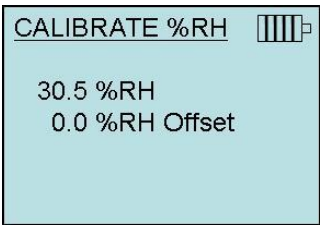
Calibrate %RH

This calibration option applies to meters and probes capable of measuring relative humidity. Compare the instruments relative humidity reading to a reference standard and make changes as required. The Offset can be adjusted ±12.0% RH.

Step 1—Use the UP or DOWN arrow keys to adjust offset.

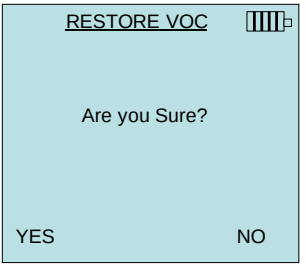
Step 2—Press **ENTER** to accept and to return to CALIBRATION menu.

In this example, the relative humidity measured by the probe is 30.5 %RH and the reference humidity is 31.6 %RH. Adjusting the offset by 1.1% allows the probe match the reference standard.



RESTORE FACTORY CAL

This option resets the field calibration for any measurement parameter back to the last factory calibration. To restore the last factory calibration for any measurement parameter, the probe must be attached to the meter on models with detachable probe.



Chapter 5

Probe Maintenance

The electronics in the PID sensor in the VOC probes are not accessible. However, periodic sensor maintenance of the electrode stack and lamp may be needed for optimal performance.

The PID lamp will need cleaning from time to time. How often depends on the environment you are measuring in. If you are measuring indoor air quality where the VOC concentrations are low and there are few particulates, then a monthly or even less frequent cleaning may be adequate. However, if you are measuring high VOC concentrations and particulates are present in high concentrations, check calibration frequently and clean the lamp. When the PID has lost sensitivity, change the stack as explained below in the sections entitled "Removing Electrode Stack and Lamp" and "Refitting Electrode Stack and Lamp".

The PID needs maintenance if:

Condition	Recommended Action
Sensitivity has dropped too much (note the change required when checking calibration)	Clean lamp
The baseline is climbing after you zero the PID	Replace electrode stack
The PID becomes sensitive to humidity	Replace electrode stack
The baseline is unstable or shifts when the PID is moved	Replace electrode stack

Removing the Electrode Stack and Lamp

CAUTION
Always use the Electrode Stack Removal Tool (included with replacement stack); any other tools may damage your PID and void the warranty.

1. Remove cap and PID sensor from VOC probe, as shown in Figure 1.
2. Gently pull the sensor from the probe.
3. Place the PID, top side down, onto a clean surface.
4. Insert electrode stack removal tool into the two slots on the sides of the PID (as shown in Figure 2) and squeeze together until electrode stack and lamp are released.

CAUTION
Electrode stack and lamp may jump off sensor and become lost if removed when the PID is right-side up.

5. Carefully lift the PID body away from the electrode stack and lamp.

Figure 1. Removing Cap and PID Sensor from VOC Probe

NOTES
• If the lamp lodges in the sensor, use tweezers to carefully remove it. • If the spring behind the lamp also comes out, replace it in the sensor housing.

Figure 2. Using Electrode Stack Removal Tool

Cleaning the PID Lamp

Cleaning the PID lamp is recommended as a first step for PIDs needing service. Use the procedure described below. Recalibrate the sensor after cleaning the lamp.

To check for a lamp that needs cleaning, hold it in front of a light source and look across the window surface as shown in Figure 3. A dirty lamp will have a “blue hue” on the detection window.

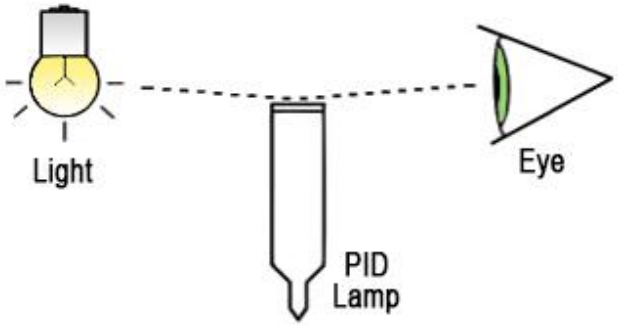


Figure 3. Checking Lamp for Contamination

Only clean the lamp using the lamp cleaning kit (P/N 801782) while following the instructions below. To avoid contaminating the sensor and affecting accuracy, **DO NOT** touch the lamp window with bare fingers. You may touch the body of the lamp with clean fingers.

1. Remove Electrode Stack and Lamp from sensor and probe.
2. Open the container of alumina polishing compound. With a clean cotton swab, collect a small amount of the powder.
3. Use this cotton swab to polish the PID lamp window. Use a circular action, applying light pressure to clean the lamp window, as shown in Figure 4. **DO NOT** touch the lamp window with fingers.
4. Continue polishing until an audible “squeaking” is made by the cotton swab moving over the window surface. Squeaking usually occurs within 15 seconds.

Remove the residual powder from the lamp window with a clean cotton swab. Care must be taken not to touch the tips of cotton swabs that are to be used to clean the lamps as this may contaminate them with finger oil.

Ensure the lamp is completely dry and any visible signs of contamination are removed before replacing.

Figure 4. Cleaning Lamp Window

PID Lamp Cleaning Kit P/N 801782

The vial of cleaning compound contains alumina (CAS Number 1344-28-1) as a very fine powder. Key safety issues are identified below.

Hazard identification:
May cause irritation of respiratory tract and eyes.
Storage:
Keep container closed to prevent water adsorption and contamination.
Handling:
• **DO NOT** breathe in the powder. Avoid contact with skin, eyes, and clothing. • Wear suitable protective clothing. • Follow industrial hygiene practices: Wash face and hands thoroughly with soap and water after use and before eating, drinking, smoking or applying cosmetics. • The powder carries a TVL (TWA) limit of 10 mg/m^3.

Replacing the Lamp

A PID lamp will last a long time, typically a few thousand hours. However, the sensitivity of the PID sensor is approximately proportional to the lamp light intensity. As the bulb ages and loses intensity, the response to a gas concentration decreases and may become noisier. If cleaning the window does not restore sensitivity, replace the lamp. Recalibrate the sensor after replacing the lamp.

Replacing the Electrode Stack

While the PID electrode stack can last the lifetime of the PID if used in clean environments, it may only last a month if used in heavily contaminated sites. Therefore, TSI recommends having a replacement electrode stack if you are working in dirty environments.

Replace the electrode stack if the sensor shows signs of contamination after the lamp window has been cleaned or is known to have been subjected to severe contamination. Recalibrate the sensor after replacing the electrode stack.

Discarding the Electrode Stack

Discard the contaminated electrode stack. The electrode stack does not have any toxic components unless contaminated in the field by toxic materials.

Refitting Electrode Stack and Lamp

WARNING:	**DO NOT** refit a damaged lamp.

1. Place the lamp inside the O-ring seal in the electrode stack as shown in Figure 5. Twisting the lamp slightly during insertion will help to ensure the lamp window is snug against the pellet's front electrode. The lamp should be freely supported by the O-ring.

Figure 5. Inserting Lamp into Electrode Stack

2. Continuing to hold the electrode stack between forefinger and thumb, carefully insert the lamp into recess in the sensor ensuring that the lamp remains in position. Press the electrode firmly, to ensure that the wing clips are engaged, and the top faces of the electrode stack and sensor housing are flush.
3. Refit the sensor into the VOC probe and replace the sensor cover.
4. Re-calibrate the gas detector.

Spare Components

If you need spare components, order the necessary parts listed below:

800706	10 ppm Cal Gas (for ppb probe)
800707	100 ppm Cal Gas (for ppm probe)
801716	Replacement Lamp and spring for revision 2 sensors only.  **NOTE**: Lamps for revision 1 sensors are no longer available and requires the purchase of new revision 2 replacement sensors listed below.
801781	Replacement Electrode Stack (for ppm Sensor) and Tool
801786	Replacement Electrode Stack (for ppb Sensor) and Tool
801782	Lamp Cleaning Kit with Spring
801783	Replacement ppm sensor
801784	Replacement ppb sensor

Recalibration

To maintain a high degree of accuracy in your measurements, TSI recommends that you return your VOC probe to TSI for annual recalibration. Please contact one of TSI's offices or your local distributor to make service arrangements and to receive a Return Material Authorization (RMA) number. To fill out an online RMA form, visit TSI's website at http://service.tsi.com.

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Chapter 6

Troubleshooting

Table 6-1 lists the symptoms, possible causes, and recommended solutions for common problems encountered with the instrumentation. If your symptom is not listed, or if none of the solutions solves your problem, please contact TSI.

Table 6-1: Troubleshooting instrument and VOC probes

Symptom	Possible Causes	Corrective Action
No Display	Unit not turned on	Switch unit on.
	Low or dead batteries	Replace batteries or plug in AC adapter.
	Dirty battery contacts	Clean the battery contacts.
No measurements shown on display	DISPLAY SETUP measurement parameters set to OFF	Set measurement parameters to ON.
No response to keypad	Keypad locked out	Unlock keypad by pressing ▲▼ keys simultaneously.
Instrument Error message appears	Memory is full	Download data if desired, then **DELETE ALL** memory.
	Fault in instrument	Factory service required on instrument.
Probe Error message appears	Fault in probe	Factory service required on probe.
Probe is plugged in, but the instrument does not recognize it	Probe was plugged in when the instrument was ON	Turn instrument OFF and then turn it back ON.

W A R N I N G !
Remove the probe from excessive temperature immediately: excessive heat can damage the sensor. Operating temperature limits can be found in Appendix A, Specifications.

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Appendix A

Specifications

Specifications are subject to change without notice.

Model 984 Low Concentration (ppb) VOC and Temperature

Range	10 to 20,000 ppb, 14 to 140°F (-10 to 60°C)
Accuracy	±1.0°F (±0.5°C)[1]
Resolution	0.1°F (0.1°C)

Model 985 High Concentration (ppm) VOC and Temperature

Range	1 to 2,000 ppm, 14 to 140°F (-10 to 60°C)
Accuracy	±1.0°F (±0.5°C)[1]
Resolution	0.1°F (0.1°C)

Model 986 Low Concentration (ppb) VOC, Temperature, CO_2, and Humidity

Range	10 to 20,000 ppb VOC, 0 to 5,000 ppm CO_2 14 to 140°F (-10 to 60°C), 5 to 95% RH
Accuracy	±3% of reading or 50 ppm CO2[2], whichever is greater ±1.0°F (±0.5°C)[1], ±3% RH[3]
Resolution	0.1 ppm CO_2[2], 0.1°F (0.1°C), 0.1% RH

Model 987 High Concentration (ppm) VOC, Temperature, CO_2, and Humidity

Range	1 to 2,000 ppm VOC, 0 to 5,000 ppm CO_2 14 to 140°F (-10 to 60°C), 5 to 95% RH
Accuracy	±3% of reading or 50 ppm CO_2[2], whichever is greater ±1.0°F (±0.5°C)[1], ±3% RH[3]
Resolution	0.1 ppm CO_2, 0.1°F (0.1°C), 0.1% RH

Temperature Range:

Operating (Electronics):	40 to 113°F (5 to 45°C)
Operating (Probe):	14 to 140°F (-10 to 60°C)
Storage:	-4 to 140°F (-20 to 60°C)

Probe Dimensions

Length (excluding handle)	7.0 in. (17.8 cm)
Base Diameter	0.75 in. (1.9 cm)
Tip Diameter	1.0 in. (2.54 cm)

NOTE: The 984 and 986 probes are designed to measure ppb concentrations of VOCs. The 10 to 20,000 ppb range corresponds to 0.01 to 20 ppm.

[1] Accuracy with instrument case at 77°F (25°C), add uncertainty of 0.05°F/°F (0.05°C/°C) for change in instrument temperature.
[2] Accuracy with probe at 77°F (25°C). Add uncertainty of ±0.2%/°F (±0.36%/°C) away from calibrated temperature
[3] Accuracy with probe at 77°F (25°C). Add uncertainty of 0.1% RH/°F (0.2% RH/°C) for change in probe temperature. Includes 1% hysteresis.

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