MRK-D-0199 Aeroqual's Volatile organic sensor types

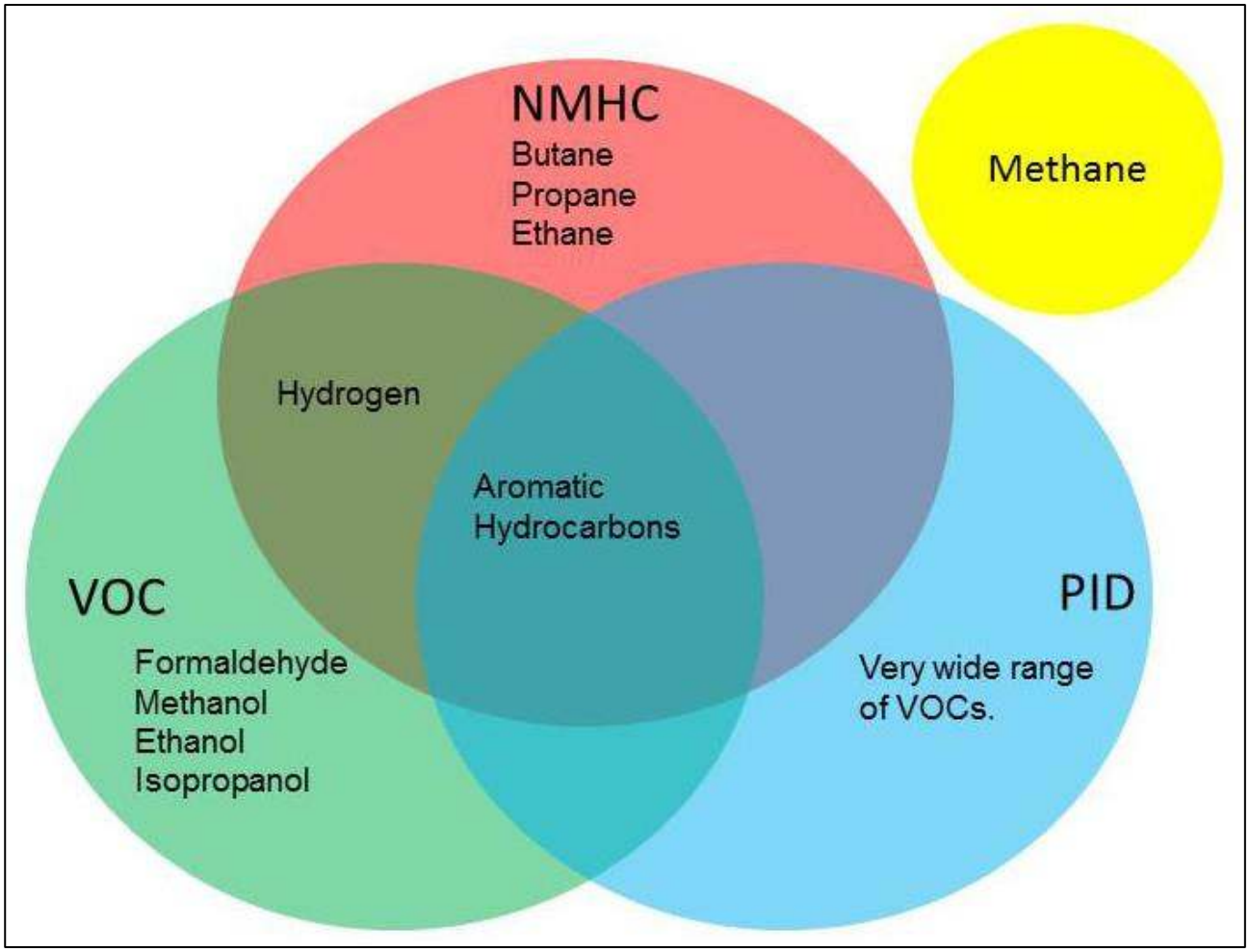
Aeroqual offers three different types of sensor for measurement of volatile organic compounds (VOCs): PID, GSS VOC and GSS NMHC.

Aeroqual VOC (Volatile Organic Carbon) sensors	
PID	Photoionization Detector 10.6 electron Volts.
GSS VOC	Gas Sensitive Semiconductor Volatile Organic Carbon
GSS NMHC	Gas Sensitive Semiconductor Non Methane Hydrocarbon

These sensors have been designed to respond to a broad range of VOCs although they each display a unique sensitivity to certain VOCs or classes of hydrocarbon, see **Diagram 1**.

- The three sensors are all sensitive towards aromatic hydrocarbons.
- None of the sensors respond to methane.
- The NMHC sensor, and VOC sensor show enhanced sensitivity towards certain organic compounds as shown below.
- The PID sensor does not respond to ethane or propane.

These differences and similarities in selectivity of the different compounds should be considered when choosing a sensor for a particular application.



The Aeroqual products which support the different types of VOC sensor are shown in the table below.

Sensor	Products
PID	AQM 65, Series 300, Series 500, Series 900
GSS VOC	Series 300, Series 500, Series 900
GSS NMHC	AQM 65, Series 300, Series 500, Series 900

Calibration, and correction factors for Aeroqual VOC sensors:

All VOC sensors are calibrated at the Aeroqual factory using **isobutylene**. This means in the presence of 1 ppm isobutylene all three sensors will report 1 ppm. However in the presence of other volatile organic compounds the response will very different for each sensor type. Correction factors for a range of different gases for the PID sensor are listed below.

Note: The isobutylene conversion factor from ppm to mg/m3: 1 ppm = 2.29 mg/m3

- If the GSS VOC or GSS NMHC sensor is being used to measure another organic compound Aeroqual advises to calibrate the VOC sensor towards that compound using a gas standard comprised of that compound.
- If the atmosphere being measured contains a mixture of hydrocarbons which is likely the case when measuring outdoor ambient air, then the measurement should be considered to be qualitative only.

Other related compounds can be measured using Aeroqual's specific sensors.

Gas Sensor	Code	Sensor	Range (ppm)	Minimum Detection Limit (ppm)	Accuracy of Calibration	Resolution (ppm)	Operational Range[2]	
							Temp.	RH
Methane (CH4)	MT	GSS	0- 10000	10	<±20 ppm +15%	1	0 to 40℃	10 to 90%
Formaldehyde (CH20)	EF	GSE	0-10	0.01	<±0.05 ppm @ 0-0.5 ppm <± 10% @ 0.5-10 ppm	0.1	0 to 40℃	10 to 90%
Perchloroethylene (C2Cl4)	PE	GSS	0 - 200	1	<±5 ppm @ 0-50 ppm <± 10% @ 50-200 ppm	1	0 to 40℃	10 to 90%
Hydrogen (H2)	HA	GSS	0- 5000	5	<±10 ppm +10%	1	0 to 40℃	10 to 90%

Aeroqual PID sensor response correction factors

The Aeroqual PID sensor response to a variety of gases is given in the table below. The Response Factor (RF) provides a sensitivity measure relative to isobutylene (RF=1). The PID sensor is more sensitive to compounds with lower RF values. Compounds not listed may also be detected by PID - please contact Aeroqual for information.

VOC (PID) Sensor Specifications

Gas Sensor	Code	Sensor	Range (ppm)	Minimum Detection Limit (ppm)	Accuracy of Calibration	Resolution (ppm)	Operational Range[2]	
							Temp.	RH
VOC	PDL	PID	0-20	0.01	<±10%	0.01	0 to 40°C	10 to 90%
VOC	PDH	PID	0-1000	0.2	<±10%	0.1	0 to 40°C	10 to 90%

Response Factors (RF)

- The default sensor concentration reading is in units of ppm of Isobutylene.
- The user can convert this into ppm of another gas by multiplying the reading by the response factor (RF) listed below.
- For example, the PID sensor head is calibrated against Isobutylene and is being used to measure the concentration of heptane. The reading in ppm of Isobutylene is 10ppm. Therefore the concentration of heptane is 10 ppm x 2.5 = 25 ppm.
- The VOC sensor can also be used to qualitatively indicate the total VOC level. The units of measurement are ppm Isobutylene equivalent.

Compound	Response Factor (RF) (a smaller RF means the PID is more sensitive to the compound)
1,2,3-trimethylbenzene	0.49
1,2,4-trimethylbenzene	0.43
1,2-dibromoethane	11.7
1,2-dichlorobenzene	0.50
1,3,5-trimethylbenzene	0.34
1,4-dioxane	1.4
1-butanol	3.4
1-methoxy-2-propanol	1.4
1-propanol	5.7
2-butoxyethanol	1.3
2-methoxyethanol	2.5
2-pentanone	0.78
2-picoline	0.57
3-picoline	0.90
4-hydroxy-4-methyl-2-pentanone	0.55
acetaldehyde	10.8
acetic acid	11.0
acetone	1.2
acetophenone	0.59
acrolein	3.9
allyl alcohol	2.5
ammonia	9.4
amylacetate	3.5
arsine	2.6
benzene	0.53
bromoform	2.3
bromomethane	1.8
butadiene	0.69

butyl acetate	2.4
carbon disulfide	1.2
chlorobenzene	0.4
cumene (isopropylbenzene)	0.54
cyclohexane	1.5
cyclohexanone	0.82
decane	1.6
diethylamine	1.0
dimethoxymethane	11.3
dimethyl disulfide	0.3
diesel fuel #1	0.9
diesel fuel #2	0.75
epichlorhydrin	7.6
ethanol	10.0
ethyl acetate	4.2
ethyl acetoacetate	0.9
ethyl acrylate	2.3
diethyl ether	1.2
ethyl mercaptan	0.6
ethylbenzene	0.51
ethylene	10.1
gasoline	1.1
heptane	2.5
hydrazine	2.6
hydrogen sulfide	3.2
isoamyl acetate	1.8
isobutanol	4.7
isobutyl acetate	2.6
isobutylene	1.0
isooctane	1.3
isopentane	8.0
isophorone	0.74
isoprene (2-methyl-1,3-butadiene)	0.6
isopropanol	5.6
isopropyl acetate	2.6
isopropyl ether	0.8
isopropylamine	0.90
Jet A Fuel	0.4
JP-5 Fuel	0.48
JP-8 Fuel	0.48
mesityl oxide	0.47
methyl acetate	7
methyl acetoacetate	1.1
methyl acrylate	3.4
methyl benzoate	0.93
methyl ethyl ketone	0.9
methyl isobutyl ketone	1.1
ketone	1.1
methyl mercaptan	0.6
methyl methacrylate	1.5
methyl tert-butyl ether	0.86
ether	0.86
methylamine	1.2
methylbenzil alcohol	0.8

m-xylene	0.53
naphtalene	0.37
n,n-dimethylacetamide	0.73

n,n-dimethylformamide	0.80
n-hexane	4.5
nitric oxide	7.2
n-nonane	1.6
n-pentane	9.7
n-propyl acetate	3.1
octane	2.2
o-xylene	0.54
phenol	1.0
phosphine	2.8
pinene, alpha	0.4
pinene, beta	0.4
propylene	1.3
propylene oxide	6.5
p-xylene	0.50
pyridine	0.79
quinoline	0.72
styrene	0.40
tert-butyl alcohol	3.4
tert-butyl mercaptan	0.55
tert-butylamine	0.71
tetrachloroethylene	0.56
tetrahydrofuran	1.6
thiophene	0.47
toluene	0.53
trans-1,2-Dichloroethene	0.45
trichloroethylene	0.50
trimethylamine	0.83
turpentine crude sulfite	1.0
turpentine pure gum	0.45
vinyl acetate	1.3
vinyl bromide	0.4
vinyl chloride	1.8
vinylcyclohexane (VCH)	0.54
vinylidene chloride (1,1-DCE)	0.8

Table 1 This list of PID correction factors is reproduced from: http://www.alphasense.com/WEB1213/wp-content/uploads/2014/06/AAN-305-05.pdf

Aeroqual GSS sensor response correction factors

The Aeroqual GSS sensor response to a selection of gases is given in the table below. The Response Factor (RF) provides a sensitivity measure relative to isobutylene (RF=1). The GSS sensor is more sensitive to compounds with lower RF values. Compounds not listed may also be detected by GSS - please contact Aeroqual for information.

VOC (GSS) Sensor Specifications

Gas Sensor	Code	Sensor	Range (ppm)	Minimum Detection Limit (ppm)	Accuracy of Calibration	Resolution (ppm)	Operational Range[2]	
							Temp.	RH
VOC	VM	GSS	0-25	0.1	<±0.1 ppm + 10 %	0.01	0 to 40°C	10 to 90%
VOC	VP	GSS	0-500	1	<± 5ppm + 10 %	0.1	0 to 40°C	10 to 90%

Compound	Response Factor (RF) (a smaller RF means the GSS is more sensitive to the compound)
CO	10
propane	80
toluene	1
butane	20
ethanol	0.15
ethyl acetate	0.2
isopropanol (IPA)	0.07
SO2	0.2
H2S	0.02
heptane	3
hydrogen	10
dodecane	2.5