

Introduction

Photoionization Detectors (PIDs) respond to a broad range of chemicals including many volatile organic compounds (VOCs) like alcohols and solvents, and some inorganic compounds, like ammonia and hydrogen sulfide. If the compound to be measured is also used to calibrate the PID, then the display will show directly the concentration of that compound. However, it is often difficult or costly to obtain a gas standard of the compound to be measured, and therefore a surrogate standard gas, typically isobutylene (IBE) is commonly used to calibrate the PID. This Tech/App Note lists the correction factors used to allow accurate measurement of hundreds of VOCs with different sensitivity using only isobutylene to calibrate. Isobutylene has the advantages that it is low cost, readily available, has low toxicity, and is not prone to adsorption losses on tubing connections.



Correction Factor Definition

With a PID calibrated to isobutylene and used to measure another compound, the reading is multiplied by the correction factor to obtain the true concentration:

$$\text{True Concentration} = \text{Reading} \times \text{CF}$$

For example, if the unit is calibrated with IBE but used to measure acrolein with a CF of 3.9 and the reading is 10 ppm, then the true concentration of acrolein is $10 \times 3.9 = 39$ ppm. The mPower NEO series PID has about 200 correction factors in a built-in library. When the appropriate factor is called up, the unit displays the corrected reading directly as the true concentration of the compound. A compound with $\text{CF} < 1$ is more sensitive than IBE while one with $\text{CF} > 1$ is less sensitive than IBE.

Unknown Compounds or Compound Mixtures

If the nature of the VOC is unknown, then the PID cannot apply a proper factor or calculate a true concentration. In such cases the response is deemed to be an "Isobutylene-equivalent" response. For known compound mixtures (such as paint solvents), an overall CF for the mixture can be calculated as:

$$\text{CF}_{\text{mix}} = 1 / [X1/\text{CF1} + X2/\text{CF2} + \dots Xn/\text{CFn}]$$

Where X_n and CF_n are the mole fraction and correction factor for component n , respectively (In the case of a paint solvent the mole fractions can be obtained from the MSDS). However, if the mixture is variable over time, then it is again not possible to calculate an accurate CF or concentration.

Matrix Gas Effects

These CFs apply to measurements in air, unless noted. In most cases, matrix gas effects can be ignored, but for unusual situations corrections may be needed.

- Oxygen at 100% reduces the VOC response by roughly 60% compared to pure nitrogen. Thus readings in pure N₂ are about 20% higher than in air (78% N₂/21% O₂).
- Hydrogen/Helium/Argon have little effect other than removing the oxygen quenching, and thus they cause about 20% increase in VOC response compared to air.
- Methane/Propane cause significant quenching at concentrations above about 1% by volume. Therefore, PID measurements cannot be made in pure natural gas or liquid petroleum gas. In some cases, it is possible to dilute the fuel gas 100-fold to avoid the quenching and still have a measurable response to the minor component of interest.
- Water Vapor. Humidity near 100% at room temperature can reduce the PID response to VOCs by about 40%. Below 50% RH corrections are generally not needed. Contact mPower for more details on how to make measurements in high-humidity environments.
- Carbon Dioxide at 100% reduces the VOC response by about 20% compared to air.

Concentration Limits

The CFs in Table 1 were typically measured at 100 ppm or less and apply to concentration ranges from low ppb to a few thousand ppm. At higher concentrations, the factors are less accurate because curve-fitting is required to linearize the VOC response, and such curve fits are slightly different for each compound. For best accuracy, we recommend calibrating at concentrations in the general range of the expected VOC readings.

Compound Formula and CAS No.

In Table 1, the chemical formula together with the Chemical Abstracts Service Number (CAS No.) provide a means of uniquely identifying the compound.

Compound Boiling Point

Chemicals with low boiling points below about 100°C give a very fast response time of just a few seconds on the NEO series PIDs. Those with higher boiling points have increasingly slower response so that compounds boiling at 200°C may take up to a minute to obtain a steady reading. At even higher

boiling points, accuracy begins to be impaired, as the compound vapors tend to be lost by deposition onto filters and inlet tubing and connections. For compounds like Therminol VP-1 with a b.p. of 257°C, the PID acts primarily as a leak detector without providing a precise concentration reading. A boiling point of 300°C is the upper limit for detectable compounds.

TWA

The Time-Weighted Average (TWA) is a dose limit for worker exposure. This is included in the table to give an estimate of the toxicity of the compound and the concentration range that typically needs to be measured when the PID is used for industrial hygiene purposes.

Table 1. Correction Factors for Measuring Various Compounds by PID

Compound Name	Formula	CAS No.	TWA* (ppm)	b.p. (°C)	CF @ 10.6 eV
Acetaldehyde	C ₂ H ₄ O	75-07-0	C25	21	6
Acetic Acid	C ₂ H ₄ O ₂	64-19-7	10	118	22
Acetone	C ₃ H ₆ O	67-64-1	250	56	1.1
Acetylene	C ₂ H ₂	74-86-2	NA	-84	NR
Acrolein	C ₃ H ₄ O	107-02-8	0.1	53	3.9
Acrylic Acid	C ₃ H ₄ O ₂	79-10-7	2	141	12
Ammonia	NH ₃	7664-41-7	25	-33	9.7
Aniline	C ₇ H ₇ N	62-53-3	2	184	0.48
Arsine	AsH ₃	7784-42-1	0.005	-63	1.9
Benzene	C ₆ H ₆	71-43-2	0.5	80	0.53
Benzyl Alcohol	C ₇ H ₈ O	100-51-6	10	205	1.1
Bromine	Br ₂	7726-95-3	0.1	59	1.3
Bromoform	CHBr ₃	75-25-2	0.5	149	2.5
Bromopropane, 1-	C ₃ H ₇ Br	106-94-5	10	71	1.5
Butadiene	C ₄ H ₆	106-99-0	2	-4	0.85
Butane, n-	C ₄ H ₁₀	106-97-8	1000	-1	NR
Butanol, 1-	C ₄ H ₁₀ O	71-36-3	20	118	4.7
Butanol, t-	C ₄ H ₁₀ O	75-65-0	100	82	2.9
Butoxyethanol, 2-	C ₆ H ₁₄ O ₂	111-76-2	20	171	1.2
Butyl Acetate, n-	C ₆ H ₁₂ O ₂	123-86-4	150	126	2.6
Butyl Acrylate, n-	C ₇ H ₁₂ O ₂	141-32-2	2	145	1.6
Butylamine, n-	C ₄ H ₁₁ N	109-73-9	C5	78	1.1
Carbon Dioxide	CO ₂	124-38-9	5000	-79	NR
Carbon Disulfide	CS ₂	75-15-0	1	46	1.2
Carbon Monoxide	CO	630-08-0	25	-192	NR
Chlorine	Cl ₂	7782-50-5	0.1	-34	NR
Chlorine Dioxide	ClO ₂	10049-04-4	C0.1	10	NR
Chlorobenzene	C ₆ H ₅ Cl	108-90-7	10	131	0.4
Cresol, m-	C ₇ H ₈ O	108-39-4	5	202	0.5
Cumene	C ₉ H ₁₂	98-82-8	50	152	0.54
Cyclohexane	C ₆ H ₁₂	110-82-7	100	81	1.4
Cyclohexanone	C ₆ H ₁₀ O	108-94-1	20	156	0.9
Decane	C ₁₀ H ₂₂	124-18-5	NA	174	1.4
Dibromo-3-chloro- propane, 1, 2-	C ₃ H ₅ Br ₂ Cl	96-12-8	0.001	198	1.7
Dibromoethane, 1, 2-	C ₂ H ₄ Br ₂	106-93-4	0.045	131	1.7
Dichlorobenzene, o-	C ₆ H ₄ Cl ₂	95-50-1	25	180	0.47
Diesel Fuel #2	-----	68334-30-5	14	200-350	0.7
Dimethylformamide, N, N-	C ₃ H ₇ NO	68-12-2	5	153	0.7
Dimethylhydrazine, 1, 1-	C ₂ H ₈ N ₂	57-14-7	0.01	63	0.78
Epichlorohydrin	C ₂ H ₅ ClO	106-89-8	0.5	118	8.5
Ethane	C ₂ H ₆	74-84-0	1000	-89	NR
Ethanol	C ₂ H ₆ O	64-17-5	1000	78	10

Ethylene (Ethene)	C ₂ H ₄	74-85-1	200	-128	9
Ethyl Acetate	C ₄ H ₈ O ₂	141-78-6	400	77	4.6
Ethyl Acrylate	C ₅ H ₈ O ₂	140-88-5	5	99	2.4
Ethyl Ether	C ₄ H ₁₀ O	60-29-7	400	35	1.1
Ethyl Mercaptan	C ₂ H ₆ S	75-08-1	0.5	35	0.56
Ethylbenzene	C ₈ H ₁₀	100-41-4	20	136	0.52
Ethylene Glycol	C ₂ H ₆ O ₂	107-21-1	MAK 10	197	16
Ethylene Oxide	C ₂ H ₄ O	75-21-8	1	11	13
Gasoline	-----	8006-61-9	300	35-200	1
Glutaraldehyde	C ₅ H ₈ O ₂	111-30-8	C0.05	187	0.8
Heptane,n-	C ₇ H ₁₆	142-82-5	400	98	2.8
Hexane,n-	C ₆ H ₁₄	110-54-3	50	68	4.3
Hexanol,1-	C ₆ H ₁₄ O	111-27-3	NA	157	2.5
Hydrazine	H ₄ N ₂	302-01-2	0.01	114	3
Hydrogen	H ₂	1333-74-0	Asphyxiant	-253	NR
Hydrogen Chloride	HCl	7647-01-0	C2	-85	NR
Hydrogen Cyanide	HCN	74-90-8	C4.7	26	NR
Hydrogen Fluoride	HF	7664-39-3	0.5	20	NR
Hydrogen Iodide	HI	10034-85-2	NA	-35	0.6
Hydrogen Sulfide	H ₂ S	7783-06-4	1	-60	3.3
Iodine	I ₂	7553-56-2	0.01	184	0.1
Iodomethane	CH ₃ I	74-88-4	2	42	0.22
Isobutane	C ₄ H ₁₀	75-28-5	1000	-12	NR
Isobutanol	C ₄ H ₁₀ O	78-83-1	50	108	3.8
Isobutylene	C ₄ H ₈	115-11-7	250	-7	1
Isoprene	C ₅ H ₈	78-79-5	2	34	0.63
Isopropanol	C ₃ H ₈ O	67-63-0	200	83	6
Jet fuel JP-4	-----	-----	NA	70-240	1
Jet fuel JP-5	-----	-----	29	180-270	0.6
Jet fuel JP-8	-----	-----	30	170-270	0.6
Limonene,D-	C ₁₀ H ₁₆	5989-27-5	30	176	0.33
Mesitylene	C ₉ H ₁₂	108-67-8	25	165	0.35
Methane	CH ₄	74-82-8	1000	-162	NR
Methanol	CH ₄ O	67-56-1	200	65	NR
Methoxyethoxyethanol,2-	C ₇ H ₁₆ O ₃	111-77-3	NA	194	1.2
Methyl Acetate	C ₃ H ₆ O ₂	79-20-9	200	57	6.6
Methyl Bromide	CH ₃ Br	74-83-9	1	4	1.7
Methyl Ether	C ₂ H ₆ O	115-10-6	1000	-24	3.1
Methyl Ethyl Ketone	C ₄ H ₈ O	78-93-3	200	80	0.86
Methyl Isobutyl Ketone	C ₆ H ₁₂ O	108-10-1	20	117	0.8
Methyl Isocyanate	C ₂ H ₃ NO	624-83-9	0.02	40	4.6
Methyl Isothiocyanate	C ₂ H ₃ NS	551-61-6	IDLH 3	119	0.45
Methyl Mercaptan	CH ₃ SH	74-93-1	0.5	6	0.54
Methyl Methacrylate	C ₅ H ₈ O ₂	80-62-6	50	101	1.5
Methyl Sulfide	C ₂ H ₆ S	75-18-3	10	37	0.44
Methyl t-Butyl Ether	C ₅ H ₁₂ O	1634-04-4	50	55	0.91

Methyl-2-Pyrrolidinone,N-	C ₅ H ₉ NO	872-50-4	10	202	0.8
Methylhydrazine	C ₂ H ₆ N ₂	60-34-4	0.01	87	1.2
Mineral spirits	-----	8020-83-5	100	130-200	0.71
Naphthalene	C ₁₀ H ₈	91-20-3	10	218	0.42
Nitric Oxide	NO	10102-43-9	25	-152	5.2
Nitrogen Dioxide	NO ₂	10102-44-0	0.2	21	16
Octane,n-	C ₈ H ₁₈	111-65-9	300	125	1.8
Oxygen	O ₂	7782-44-7	NA	-186	NR
Ozone	O ₃	10028-15-6	0.05	-112	NR
Pentane	C ₅ H ₁₂	109-66-0	1000	36	8.4
Perchloroethene	C ₂ Cl ₄	127-18-4	25	121	0.57
PGMEA	C ₆ H ₁₂ O ₃	108-65-6	50	146	1
Phenol	C ₆ H ₆ O	108-95-2	5	182	1
Phosphine	PH ₃	7803-51-2	0.05	-88	3.9
Pinene,b-	C ₁₀ H ₁₆	18172-67-3	20	166	0.37
Piperylene, Isomer Mix	C ₅ H ₈	504-60-9	NA	43	0.69
Propane	C ₃ H ₈	74-98-6	1000	-42	NR
Propene	C ₃ H ₆	115-07-1	500	-48	1.4
Propylene Oxide	C ₃ H ₆ O	16088-62-3	2	34	6.6
Pyridine	C ₅ H ₅ N	110-86-1	1	115	0.68
Styrene	C ₈ H ₈	100-42-5	20	145	0.4
Sulfur Dioxide	SO ₂	7446-09-5	STEL 0.25	-10	NR
Tetrahydrofuran	C ₄ H ₈ O	109-99-9	50	66	1.7
Tetramethyl Orthosilicate	C ₄ H ₁₂ O ₄ Si	681-84-5	1	121	1.9
Therminol VP-1	C ₁₂ H ₁₀ O & C ₁₂ H ₁₀	101-84-8 & 92-52-4	1	257	0.4
Toluene	C ₇ H ₈	108-88-3	20	111	0.5
Tolylene-2,4-Diisocyanate	C ₉ H ₆ N ₂ O ₂	584-84-9	0.001	251	1.4
Trichloroethene	C ₂ HCl ₃	79-01-6	10	87	0.54
Triethylamine	C ₆ H ₁₅ N	121-44-8	0.5	89	0.9
Turpentine	C ₁₀ H ₁₆	8006-64-2	20	90-115	0.3
Vinyl Chloride	C ₂ H ₃ Cl	75-01-4	1	-13	2
Vinyl-1-Cyclohexene,4-	C ₈ H ₁₂	100-40-3	0.1	129	0.56
Vinyl-2-Pyrrolidinone,1-	C ₆ H ₉ NO	88-12-0	0.05	94	0.8
Xylene,m-	C ₈ H ₁₀	108-38-3	100	139	0.44
Xylene,o-	C ₈ H ₁₀	95-47-6	100	144	0.46
Xylene,p-	C ₈ H ₁₀	106-42-3	100	138	0.39

* TWA taken as ACGIH 8-hr value wherever available. A few of these are AIHA WEELS or NIOSH RELs. C = Ceiling, STEL = Short Term Exposure Limit

MAK = German Maximum Allowable Concentration

For more information

www.watchgas.eu
info@watchgas.eu



WatchGas B.V.
Sextantstraat 61
2901 ZZ - Capelle aan den
IJssel+31 (0)85 01 87 709
The Netherlands