PID Correction Factors

Introduction

Photo-ionization 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.

PPM BENZ PPB

NEO Series PIDs

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:

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

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 x 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 CF<1 is more sensitive than IBE while one with 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:

$$CF_{mix} = 1 / [X_1/CF_1 + X_2/CF_2 + \ldots X_n/CF_n]$$

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 N_2 are about 20% higher than in air (78% N_2/21% O_2).
- *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_2H_4O	75-07-0	C25	21	6
Acetic Acid	$C_2H_4O_2$	64-19-7	10	118	22
Acetone	C_3H_6O	67-64-1	250	56	1.1
Acetylene	C_2H_2	74-86-2	NA	-84	NR
Acrolein	C_3H_4O	107-02-8	0.1	53	3.9
Acrylic Acid	$C_3H_4O_2$	79-10-7	2	141	12
Ammonia	NH_3	7664-41-7	25	-33	9.7
Aniline	C_7H_7N	62-53-3	2	184	0.48
Arsine	AsH_3	7784-42-1	0.005	-63	1.9
Benzene	C_6H_6	71-43-2	0.5	80	0.53
Benzyl Alcohol	C_7H_8O	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_3H_7Br	106-94-5	10	71	1.5
Butadiene	C_4H_6	106-99-0	2	-4	0.85
Butane, n-	C_4H_{10}	106-97-8	1000	-1	NR
Butanol, 1-	$C_4H_{10}O$	71-36-3	20	118	4.7

Compound Name	Formula	CAS No.	TWA* (ppm)	b.p. (°C)	CF @ 10.6 eV
Butanol, t-	$C_4H_{10}O$	75-65-0	100	82	2.9
Butoxyethanol, 2-	$C_6H_{14}O_2$	111-76-2	20	171	1.2
Butyl Acetate, n-	$C_6H_{12}O_2$	123-86-4	150	126	2.6
Butyl Acrylate, n-	$C_7H_{12}O_2$	141-32-2	2	145	1.6
Butylamine, n-	$C_4H_{11}N$	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_6H_5Cl	108-90-7	10	131	0.4
Cresol, m-	C_7H_8O	108-39-4	5	202	0.5
Cumene	C_9H_{12}	98-82-8	50	152	0.54
Cyclohexane	C_6H_{12}	110-82-7	100	81	1.4
Cyclohexanone	$C_6H_{10}O$	108-94-1	20	156	0.9
Decane	$C_{10}H_{22}$	124-18-5	NA	174	1.4
Dibromo-3-chloropropane, 1, 2-	$C_3H_5Br_2Cl$	96-12-8	0.001	198	1.7
Dibromoethane, 1, 2-	$C_2H_4Br_2$	106-93-4	0.045	131	1.7
Dichlorobenzene, o-	$C_6H_4Cl_2$	95-50-1	25	180	0.47
Dichloroethene, 1, 1-	$C_2H_2Cl_2$	75-35-4	5	32	0.82
Dichloroethene, t-1, 2-	$C_2H_2Cl_2$	156-60-5	200	49	0.45
Dicyclopentadiene	$C_{10}H_{12}$	77-73-6	5	170	0.48
Diesel Fuel #2	------	68334-30-5	14	200-350	0.7
Dimethylformamide, N, N-	C_3H_7NO	68-12-2	5	153	0.7
Dimethylhydrazine, 1, 1-	$C_2H_8N_2$	57-14-7	0.01	63	0.78
Epichlorohydrin	C_2H_5ClO	106-89-8	0.5	118	8.5
Ethane	C_2H_6	74-84-0	1000	-89	NR
Ethanol	C_2H_6O	64-17-5	1000	78	10
Ethylene (Ethene)	C_2H_4	74-85-1	200	-128	9
Ethyl Acetate	$C_4H_8O_2$	141-78-6	400	77	4.6
Ethyl Acrylate	$C_5H_8O_2$	140-88-5	5	99	2.4
Ethyl Ether	$C_4H_{10}O$	60-29-7	400	35	1.1
Ethyl Mercaptan	C2H6S	75-08-1	0.5	35	0.56
Ethylbenzene	C_8H_{10}	100-41-4	20	136	0.52
Ethylene Glycol	$C_2H_6O_2$	107-21-1	MAK 10	197	16
Ethylene Oxide	C_2H_4O	75-21-8	1	11	13
Gasoline	------	8006-61-9	300	35-200	1
Glutaraldehyde	$C_5H_8O_2$	111-30-8	C0.05	187	0.8
Heptane,n-	C_7H_{16}	142-82-5	400	98	2.8
Hexane,n-	C_6H_{14}	110-54-3	50	68	4.3
Hexanol,1-	$C_6H_{14}O$	111-27-3	NA	157	2.5
Hydrazine	H_4N_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_2S	7783-06-4	1	-60	3.3
Iodine	I_2	7553-56-2	0.01	184	0.1
Iodomethane	CH_3I	74-88-4	2	42	0.22

Compound Name	Formula	CAS No.	TWA* (ppm)	b.p. (°C)	CF @ 10.6 eV
Isobutane	C_4H_{10}	75-28-5	1000	-12	NR
Isobutanol	$C_4H_{10}O$	78-83-1	50	108	3.8
Isobutylene	C_4H_8	115-11-7	250	-7	1
Isoprene	C_5H_8	78-79-5	2	34	0.63
Isopropanol	C_3H_8O	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_9H_{12}	108-67-8	25	165	0.35
Methane	CH_4	74-82-8	1000	-162	NR
Methanol	CH_4O	67-56-1	200	65	NR
Methoxyethoxyethanol,2-	$C_7H_{16}O_3$	111-77-3	NA	194	1.2
Methyl Acetate	$C_3H_6O_2$	79-20-9	200	57	6.6
Methyl Bromide	CH_3Br	74-83-9	1	4	1.7
Methyl Ether	C_2H_6O	115-10-6	1000	-24	3.1
Methyl Ethyl Ketone	C_4H_8O	78-93-3	200	80	0.86
Methyl Isobutyl Ketone	$C_6H_{12}O$	108-10-1	20	117	0.8
Methyl Isocyanate	C_2H_3NO	624-83-9	0.02	40	4.6
Methyl Isothiocyanate	C_2H_3NS	551-61-6	IDLH 3	119	0.45
Methyl Mercaptan	CH_3SH	74-93-1	0.5	6	0.54
Methyl Methacrylate	$C_5H_8O_2$	80-62-6	50	101	1.5
Methyl Sulfide	C_2H_6S	75-18-3	10	37	0.44
Methyl t-Butyl Ether	$C_5H_{12}O$	1634-04-4	50	55	0.91
Methyl-2-Pyrrolidinone,N-	C_5H_9NO	872-50-4	10	202	0.8
Methylhydrazine	$C_2H_6N_2$	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_8H_{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_5H_{12}	109-66-0	1000	36	8.4
Perchloroethene	C_2Cl_4	127-18-4	25	121	0.57
PGMEA	$C_6H_{12}O_3$	108-65-6	50	146	1
Phenol	C_6H_6O	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_5H_8	504-60-9	NA	43	0.69
Propane	C_3H_8	74-98-6	1000	-42	NR
Propene	C_3H_6	115-07-1	500	-48	1.4
Propylene Oxide	C_3H_6O	16088-62-3	2	34	6.6
Pyridine	C_5H_5N	110-86-1	1	115	0.68
Styrene	C_8H_8	100-42-5	20	145	0.4
Sulfur Dioxide	SO_2	7446-09-5	STEL 0.25	-10	NR
Tetrahydrofuran	C_4H_8O	109-99-9	50	66	1.7
Tetramethyl Orthosilicate	$C_4H_{12}O_4Si$	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

Compound Name	Formula	CAS No.	TWA* (ppm)	b.p. (°C)	CF @ 10.6 eV
Toluene	C_7H_8	108-88-3	20	111	0.5
Tolylene-2,4-Diisocyanate	$C_9H_6N_2O_2$	584-84-9	0.001	251	1.4
Trichloroethene	C_2HCl_3	79-01-6	10	87	0.54
Triethylamine	$C_6H_{15}N$	121-44-8	0.5	89	0.9
Turpentine	$C_{10}H_{16}$	8006-64-2	20	90-115	0.3
Vinyl Chloride	C_2H_3Cl	75-01-4	1	-13	2
Vinyl-1-Cyclohexene,4-	C_8H_{12}	100-40-3	0.1	129	0.56
Vinyl-2-Pyrrolidinone,1-	C_6H_9NO	88-12-0	0.05	94	0.8
Xylene,m-	C_8H_{10}	108-38-3	100	139	0.44
Xylene,o-	C_8H_{10}	95-47-6	100	144	0.46
Xylene,p-	C_8H_{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