Response Factors

In the ideal case, a Flame Ionization Detector (FID) is a carbon ion counter, whose response is directly proportional to the carbon count of the material being analyzed. The response is generally output as a concentration of carbon atoms in the medium being sampled, such as "parts per million carbon as vapor" or, for example ppm C (carbon).However physical detector cell design limitations, the physics of the ion stream in the hydrogen flame and the molecular structure and composition of the gas will affect the response. The FID output in many cases will NOT be equal to the actual carbon count. It will however be repeatable and proportional. For example, a FID calibrated with 1000 ppm propane (C_3H_8) will read 3000 ppm C_1. If 3000 ppm methane is sampled, the response should be the same, i.e. 3000 ppm C1. In actual practice the reading is higher, but will always be higher by the same factor. This factor is called the Response Factor (RF). The RF phenomenon is well known. There can be RF for every compound. In some cases it will be unity ("1"). Ideally, one should know the RF for all compounds being measured, so that the necessary corrections may be applied. If possible, one should calibrate the analyzer (FID) with a known gas of the material being sampled. This is usually not practical, especially in cases where there are many gas constituents, or the species are unknown, as in combustion products or other emissions.

In practice, most Total Hydorcarbon Analyzers with FID's are calibrated with propane span gases, and the results are reported as ppm C_3, (propane equivalent). If the response factor is known, the results may be converted to true concentrations, or the Total Hydrocarbon Analyzer (THA) may be initially calibrated with the response factor built in.

The following formula defines the calibration in mgC/m^3 :

$$f_{RCx} = \frac{A_{Cx}}{C_{Cx}}$$

f_{RCx} : carbon responsefactor of the component x, propane equivalent

A_{Cx} : measured (displayed) value of the component x in mgC/m^3 ; FID calibrated with propane, with 1ppm C_3H_8 = 1,61 mgC/m^3 under standard conditions (273 K, 1013 hPa)

C_{Cx} : carbon conzentration in mgC/m^3 of the measured component x

To convert the measured (displayed) value into the actual concentration:

$$C_{Cx} = \frac{A_{Cx}}{f_{RCx}}$$

For the calibration in ppm the numerical values of f_{RCx} are the same but the formula has to be changed as follows:

$$f_{RCx} = \frac{[A_{Vx} \cdot n_{Ref}]}{[C_{Vx} \cdot n_x]}$$

f_{RCx} : carbon responsefactor of the component x, propane equivalent

A_{Vx} : measured (displayed) value of the component x in ppm; FID calibrated in ppm propane

C_{Vx} : volume concentration of the measured component x in ppm

n_{Ref} : carbon number of the reference molecule; for propane: C_3H_8, 3 C-atoms: $n_{Ref} = 3$

n_x : carbon number of the substance x

To convert the measured (displayed) value into the actual concentration:

$$C_{Vx} = \frac{[A_{Vx} \cdot n_{Ref}]}{[f_{RCx} \cdot n_x]}$$

J.U.M. Engineering Ges.m.b.H.
Gauss-Str. 5, 85757 Karlsfeld, Tel: 08131-50416, Fax: 08131-98894

The following response factors (propane equivalent) were determined by TÜV-Nord using two J.U.M. FID´s, Model VE 7, the FID 2 was tested 9 months after the FID 1

Component	Total Formula	f_{RCx} FID 1	f_{RCx} FID 2
Acetone	C_3H_6	0,72	0,73
Acetylene	C_2H_2	0,92	0,94
Benzene	C_6H_6	1,05	1,05
n-Butane	C_4H_{10}	0,98	0,98
Chlorbenzene	$C_6H_5\_Cl$	1,01	1,04
Chloroform	$HCCl_3$	0,82	0,78
Cyclohexane	C_6H_{12}	0,93	0,94
Methylene Chloride	CH_2Cl_2	1,09	1,06
Diethyl Ether	$C_4H_{10}O$	0,75	0,77
Acetic Acid	$C_2H_4O_2$	0,58	0,55
Ethyl Acetate	$C_4H_8O_2$ ($H_3C\_COOC_2H_5$)	0,70	0,72
Isobutyl Acetate		0,88	0,89
Ethanol	C_2H_6O	0,65	0,67
4-Ethyl Toluene		0,88	0,89
n-Heptane	C_7H_{16}	0,91	0,95
n-Hexane	C_6H_{14}	0,85	0,86
Methane	CH_4	1,26	1,25
Methanol	CH_4O	0,69	0,68
iso-Octane		0,99	0,98
Propane	C_3H_8	1,00	1,00
iso-Propanol	C_3H_8O	0,82	0,81
Tetrachlorethylene	C_2Cl_4	1,22	1,20
Toluene	C_7H_8	1,02	1,03
Trichlorethene	C_2HCl_3	1,03	1,01
1,1,1-Trichlorethane	$C_2H_3Cl_3$	1,06	1,02
p-Xyloene	C_8H_{10}	0,91	0,90

Other C3H8 equiv. Response factors found with J.U.M. FID´s VE7, 3-300A and 3-200

Component	Total Formula	f_{RCx}
Acetonitrile	C_2H_3N	0,7
2-Butanol	$C_4H_{10}O$	0,83
2-Butanone	C_4H_8O	0,78
Chlorpropionsäuremethylester		0,69
Dichlormethane		1,06
Diisopropylether	$C_6H_{14}O$	0,84
Dimethylformamide	C_3H_7NO	0,50
Dioxane	$C_4H_8O_2$	0,51
Ethylbenzene	$C_6H_5\_C_2H_5$	1,04
Ethan	C_2H_6	1,01
Ethin		1,07
Etylenglykolmonoethylester		0,58
Iso-Octane		0,98
Isopropylalcohol (Isopropanol)		0,79
Methanol	CH_3OH, CH_4O	0,79
Methylcyclohexane	C_7H_{14}	0,96
Methylenechloride	CH_2Cl_2	1,1
4-Methyl-2-Pentanone	$C_6H_{12}O$	0,83
Pentane	C_5H_{12}	0,98
i-Propanol	C_3H_8O	0,74
n-Propanol	C_3H_8O	0,80
Propylchloride	C_3H_7Cl	1,05
o-Xyloene	C_8H_{10}	1,01
Trichlormethane (Chloroform)		0,8
Trichloethene		1,07