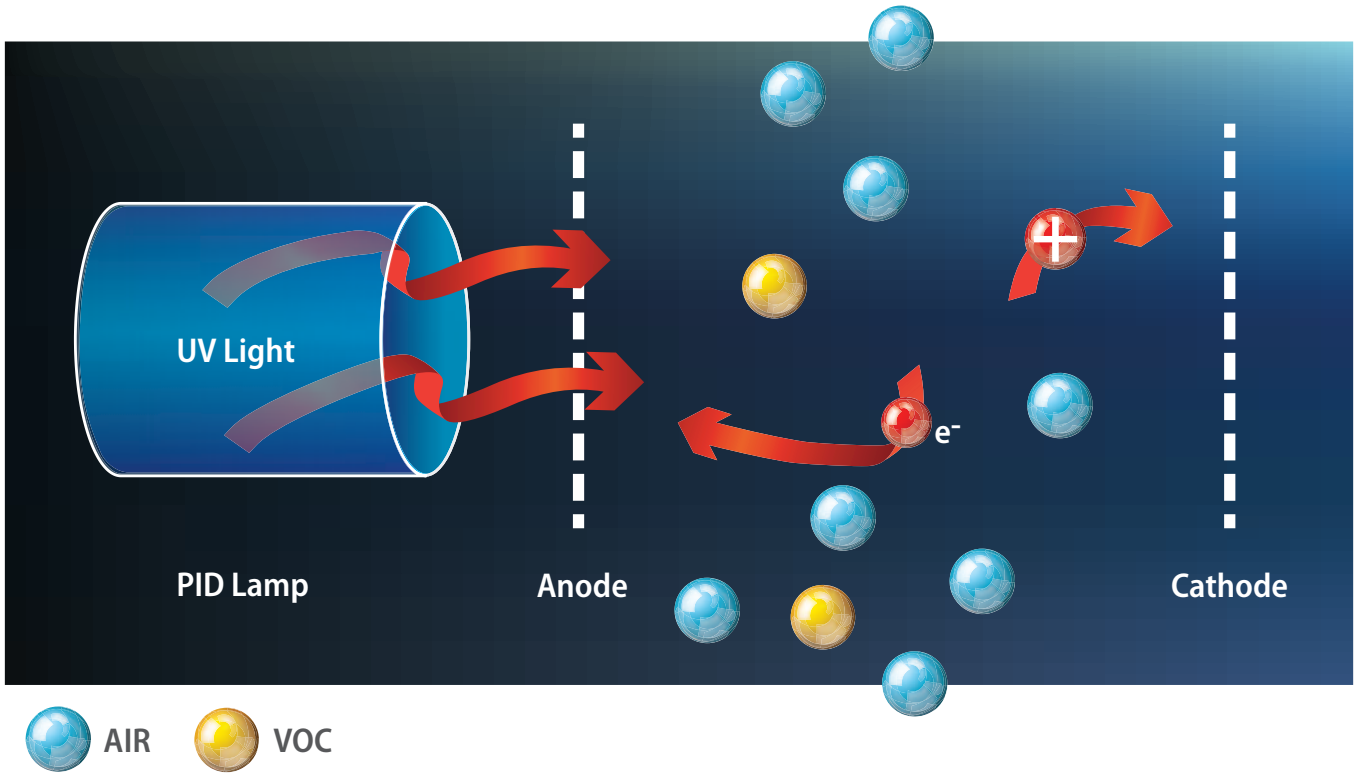
Photoionization Detectors (PIDs)
Theory, Uses and Applications

MSA
The Safety Company

Photoionization Technology and Operation

PIDs effectively detect and monitor for numerous hazardous substances, providing maximum benefit and safety to users. While many hazardous gas detection methods are available, photoionization detectors offer the combination of speed of response, ease of use and maintenance, small size, and ability to detect low levels, including most volatile organic compounds (VOCs).

PIDs rely upon *ionization* as the basis of detection. When sampled gas absorbs energy from a PID lamp, the gas becomes excited and its molecular content is altered. The compound loses an electron (e-) and becomes a positively charged ion. Once this process occurs, the substance is considered to be *ionized*. Here we see an illustration of photoionization.



Most substances can be ionized, some more easily than others. The ability of a substance to be ionized is measured as ionization potential (IP) using an electron volt (eV) energy scale. This scale generally runs from a value of 7 to a value of approximately 16. Substances with an eV rating of 7 are very easy to ionize; substances with an eV rating of between 12 and 16 are extremely difficult to ionize. IP ratings of some common substances include:

SUBSTANCE	IP
BENZENE	9.25
HEXANE	10.13
TOLUENE	8.82
STYRENE	8.47
METHYL ETHYL KETONE (MEK)	9.51
XYLENE	8.56
PHOSPHINE	9.87

When monitored chemicals are ionized using a PID instrument, current is produced and compound concentration displays as parts-per-million (ppm). PIDs use an ultraviolet (UV) lamp to ionize the compound to be monitored. The lamp, often the size of a common flashlight bulb, emits enough ultraviolet energy to ionize the compound. A 10.6 eV lamp puts out enough energy to ionize any compound with an eV rating of less than 10.6 including everything that can be ionized with a 9.8 eV lamp. While there are a limited number of compounds that require an 11.7 eV lamp, there is an inherent instability of available lamps that results in a very short operating life and many customers seek alternative detection methods for these compounds.

- Propyl alcohol 10.22 eV
- Phosphine 9.87 eV
- Vinyl chloride 9.99 eV
- Toluene 8.82 eV
- Benzene 9.25 eV
- Styrene 8.47 eV
- Vinyl acetate 9.19 eV

SUBSTANCE TYPES THAT PIDS CAN DETECT

PIDs measure organic compounds such as benzene, toluene and xylene, and also certain inorganics such as ammonia and hydrogen sulfide. As a general rule, if compounds measured or detected contain a carbon (C) atom, a PID can be used. However, such is not always the case, as methane (CH4) and carbon monoxide (CO) cannot be detect with a PID. Listed here are some common substances that a PID can detect and monitor:

- Benzene
- Toluene
- Vinyl chloride
- Hexane
- Isobutylene
- Jet fuel
- Styrene
- Allyl alcohol
- Mercaptans
- Trichloroethylene
- Perchloroethylene
- Propylene oxide
- Phosphine

SUBSTANCES THAT PIDS CANNOT DETECT

PIDs *cannot* be used to measure the following common substances:

- Oxygen
- Nitrogen
- Carbon dioxide
- Sulfur dioxide
- Carbon monoxide
- Methane
- Hydrogen fluoride
- Hydrogen chloride
- Fluorine
- Sulfur hexafluoride
- Ozone

RESPONSE FACTORS

The optimal method of calibrating a PID to different compounds is through use of a standard of the gas of interest. However, such is not always practical, as doing so requires that an assortment of sometimes hazardous gases be kept on hand for this purpose. To address this issue, *response factors* are used. A response factor is a measure of PID sensitivity to a particular gas. Using response factors, users can measure a large number of compounds via a single calibration gas – typically *isobutylene*. Isobutylene is used because it is near the midpoint ionization point of most VOCs and is not flammable or toxic at low concentrations used in calibration. Users simply multiply the instrument reading (calibrated for isobutylene) by the response factor to obtain the corrected value for the compound of interest.

Instruction manuals for most PIDs list response factors; some PIDs have response factors for common gases programmed into the instrument's

software, enabling all response factor calculations to be performed automatically. If the compound at a test site is known, the instrument can be set to indicate a direct reading for the target compound.

THRESHOLD LIMIT VALUES (TLV) AND PERMISSIBLE EXPOSURE LIMITS (PEL)

Default low and high alarm values are typically set for isobutylene. If users must monitor a different gas, they must determine TLVs for the gas of interest and change the instrument's alarm level accordingly. Instrument manuals should be referenced to ensure that correct instructions are followed. Chemical limit values can be found by referencing ACGIH, NIOSH, OSHA, or local regulations.

INDICATOR VERSUS ANALYZER

A common misconception about PIDs is that they are *analyzers*. Many expect that a PID will provide exactly the vapor present at a spill site; such is not the case. While PIDs are extremely sensitive and effective tools, they are not analyzers and cannot determine if a spill is benzene or jet fuel, for example. A PID can detect that a substance is present and can alert you as to potentially hazardous situations, but additional steps are necessary to properly identify the substance's exact composition and quantities present. Listed here is a sample procedure to identify a substance's concentration at a spill site:

1. Set the PID to isobutylene.
2. Detect and record a reading.
3. Identify, via placard or MSDS, the specific substance.

If the placard or MSDS reads that the substance is vinyl chloride, set the PID response factor to vinyl chloride to enable direct reading of actual vinyl chloride level.

INDUSTRIAL HYGIENE PID APPLICATIONS

PIDs are great for use as screening tools in hazard assessments due to their ability to detect multiple risks at very low concentrations. While PIDs do not identify specific compounds, they are widely used to identify sources and compound types. Potential chemical attacks may employ industrial chemicals; first responders can use PIDs to confidently determine if a chemical is present and, if so, to accurately measure its concentration using a reference factor.

CONFINED SPACE

Industrial activity produces many toxic gases and vapors as components or byproducts. Using a PID for assessment and continuous monitoring within confined space allows for a more comprehensive evaluation and greater protection than when used to supplement standard 4-gas instrument configuration.

Three Methods in which Response Factors are used with PIDs

METHOD	EXAMPLE
Method #1: Preprogrammed Response Factors Typically, PID detectors are calibrated with 100 ppm isobutylene. Other gases, for which there are hundreds, have corresponding correction values known as response factors. Numerous corresponding response factors are preprogrammed into PID instruments. After users select the desired gas to measure from the instrument menu, units will automatically calculate the corrected gas concentration reading for the gas of interest. The direct reading now measures the selected gas concentration.	The instrument is calibrated to read in isobutylene equivalents for a reading of 100 ppm with 10.6 eV lamp. Ethylbenzene is the target gas, with response factor of 0.51. Select the pre-programmed response factor; the instrument now reads approximately 51 ppm when exposed to the same gas, reading directly in ethylbenzene concentration values.
Method #2: Customized Response Factors Typically, PID detectors are calibrated with 100 ppm isobutylene. If users do not find a desired gas in the preprogrammed instrument menu list, users can program a custom gas and response factor. If users do not know the corresponding response factor, they may call MSA and request that a customized response factor be calculated that is specific to their application.	Tetrahydrofuran is the target gas. The response factor for tetrahydrofuran is 1.6 using a 10.6 eV lamp. Program a custom gas for tetrahydrofuran with RF 1.6 and select this RF for use. The instrument now reads directly in tetrahydrofuran concentration values.
Method #3 Manually Calculated Response Factors Typically, PID detectors are calibrated with 100 ppm isobutylene. If users choose to read isobutylene's direct reading for a different gas and do not want to use the preprogrammed or customized response factors, users may manually calculate the desired gas' direct reading. If users know the response factor of the desired gas, they can manually multiply the isobutylene reading by the known response factor. The result of this equation can be recorded externally to the instrument.	The instrument is calibrated with isobutylene to isobutylene equivalents for a reading of 10 ppm with 10.6 eV lamp. Cyclohexanone is the target gas, with a correction factor of 0.82. Multiply 10 by 0.82 to produce an adjusted cyclohexanone concentration of 8.2.

LEAK DETECTION

Often, leak concentration is too low to be smelled by humans. PIDs are often used to detect low-level leaks in order to detect compounds at levels of less than 1 ppm.

PIDs can be used for leak detection to detect leak sources. Higher concentrations of gases are found at or near the source of a leak. When a substance is detected, users wearing adequate personal protective equipment should move in the direction of higher concentrations when trying to identify the leak source.

PERIMETER MONITORING

At HazMat sites, perimeters are set to contain hazardous areas. PIDs can be used to set and, if necessary due to changing environmental conditions, change perimeter lines. For example, toluene concentration reads 5 ppm at Perimeter Line A at 10:50 a.m. At 11:05 a.m., the Line A reading rises to 10 ppm due to wind direction, telling HazMat workers that the perimeter line may need to be extended.

SPILL DELINEATION

As water and foam are often used at HazMat sites, a variety of liquids may be present on the ground in addition to any material inadvertently spilled. A PID is effective in locating hazardous substances while ignoring foam and water, as PIDs will not respond to foam or water.

REMEDIATION

HazMat spills can contaminate bodies of water or soil, potentially posing long-term environmental concerns. PIDs are extremely useful in taking samples from soil to determine if remediation is necessary in conjunction with applicable environmental regulations.

ARSON INVESTIGATION

PIDs are often used to detect accelerants at post-fire scenes. When a PID reading is detected, a sample from that specific area can be taken to a laboratory for analysis. For this application, it is recommended that PIDs be set to the isobutylene response factor for general purpose indications.

DIESEL FUEL TLV MONITORING

Marine chemists follow diesel fuel TLV limits that are determined by the American Conference of Governmental Industrial Hygienists (ACGIH). The presence of diesel fuel in the workplace and associated exhaust has long been connected with carcinogens, and particulate pollution associated with lung disease. Diesel vapor TLV is 15 ppm; sampling for diesel fuel vapors and recording results are significant aspects of inspections. Surveys are conducted in fuel tanks, cargo spaces and engine rooms.

CONCLUSION

PIDs are extremely valuable tools for industrial, homeland security, law enforcement, fire service, and HazMat applications. PID sensitivity, low level detection and ability to detect many different compounds enable PIDs to make accomplishing these difficult jobs easier and more efficient.

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ID 0803-11-MC / June 2015

10 PID Response Factor Table

WARNING

VOC Response factors apply in the 0-500 ppm range. The values in this table were obtained using dry bottled gases at room temperature. The response factors may change at higher concentrations, different temperature and humidity conditions, or with cleanliness of lamp. For increased accuracy at different ambient conditions or concentrations, determine a custom response factor and enter it via the Custom Gas page; see Chapter XX, Custom Gas Setup. These response factors are specific to the energy of the lamp designated in the table. They are not valid for devices using PID lamps at any other energy. Using these response factors with a lamp at any other energy may critically compromise the device's ability to detect volatile organic compounds which can result in serious personal injury or death.

WARNING

Use of Altair5X PID for detection of extremely toxic gases:

The system resolution limit of the Altair5X PID in normal mode (with a new, clean lamp) is approximately 0.1 ppm isobutylene equivalent. Users must be aware of exposure limit guidelines, such as TLV, for the target compound. Do not use the Altair5X PID Detector if the exposure limit for the target compound is below 0.1 ppm. Failure to follow this warning can cause over-exposure, which can result in serious personal injury or death.

For any compound, its exposure limit guideline can be recalculated in terms of equivalent ppm isobutylene by dividing the exposure limit guideline by the appropriate response factor. Example: For butyl acetate (CAS 123-86-4), the recommended threshold limit value (as TWA) is 150 ppm. Its response factor (10.6 eV lamp) is 2.4. The TLV for butyl acetate, in terms of equivalent ppm isobutylene is: 150 ppm ÷ 2.4 = 62.5 ppm isobutylene equivalent.

WARNING

The ALTAIR 5X PID Detector has a reproducibility of ±2 ppm(± 2000 ppb) or 10%, whichever is greater (see table in chapter 6.2).The user must account for this potential variation between the displayed value and the actual concentration when setting alarms and interpreting readings. Failure to comply with this warning can cause over-exposure and result in serious personal injury or death.

Gases with very high response Factors (RF):

The Altair5X PID is a very versatile solution for monitoring many different gases and vapors. In addition to the pre-programmed list provided in the Altair5X PID device, users can determine response factors for many other compounds (see Section X). The maximum response factor value that will be accepted by the Altair5X PID device is 39.99.

WARNING

Use the correct lamp when determining the response factor. Failure to apply the appropriate response factors can result in inaccurate readings, and serious injury or death can occur.

Contact MSA Customer Service at 1-800-MSA-2222 with any question regarding the above information.

COMPOUND NAME	Display Name	Synonym(s)	CAS Number[1]	Chemical Formula	Ionization Potential	RF 10.6eV lamp
acetaldehyde	ETHANAL		75-07-0	C2H4O	10.23	10.8
acetone	ACETONE	2-Propanone	67-64-1	C3H6O	9.71	1.2
acetophenone	ACETPHEN		98-86-2	C8H8O	9.28	0.59

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COMPOUND NAME	Display Name	Synonym(s)	CAS Number[1]	Chemical Formula	Ioniza-tion Potential	RF 10.6eV lamp
acrolein	ACROLEIN		107-02-8	C3H4O	10.1	3.9
allyl alcohol	PROPENOL		107-18-6	C3H6O	9.67	2.5
ammonia	AMMONIA		7664-41-7	NH3	10.16	9.4
amyl acetate	AMYLACET	mix of n-Pentyl acetate & 2-Methylbutyl acetate	628-63-7	C7H14O2		3.5
arsine	ARSINE	Arsenic trihydride	7784-42-1	AsH3	9.89	2.6
benzene	BENZENE		71-43-2	C6H6	9.25	0.53
bromoform	BRFORM	Tribromomethane	75-25-2	CHBr3	10.48	2.3
bromomethane	MEBR	Methyl bromide	74-83-9	CH3Br	10.54	1.8
butadiene	BUTADIEN	1,3-Butadiene, Vinyl ethylene	106-99-0	C4H6	9.07	0.69
butanol, 1-	BUTANOL	Butyl alcohol, n-Butanol	71-36-3	C4H10O	9.99	3.4
butoxyethanol, 2-	BTOXETOH	Butyl Cellosolve, Ethylene glycol monobutyl ether	111-76-2	C6H14O2	<10	1.3
butyl acetate	BTYLACET		123-86-4	C6H12O2	10	2.4
butyl alcohol, tert-	TBUOH	tert-Butanol, t-Butyl alcohol, t-butanol	75-65-0	C4H10O	9.9	3.4
butyl mercaptan, tert-	TBUMRCAP	1-Butanethiol	109-79-5	C4H10S	9.14	0.55
butylamine, tert-	TBUAMINE	Butylamine, t-	75-64-9	C4H11N	8.5	0.71
carbon disulfide	CS2		75-15-0	CS2	10.07	1.2
chlorobenzene	CLBNZ	Monochloroben-zene	108-90-7	C6H5Cl	9.06	0.4
cumene	CUMENE	Isopropylbenzene	98-82-8	C9H12	8.73	0.54
cyclohexane	CYCHEXAN		110-82-7	C6H12	9.86	1.5
cyclohexanone	CYCHEXON		108-94-1	C6H10O	9.14	0.82
decane	DECANE		124-18-5	C10H22	9.65	1.6
Diacetone alcohol	PYRATON	4-Methyl-4-hydroxy-2-pentanone	123-42-2	C6H12O2	9.50	0.55
dibromoethane, 1,2-	EDB	EDB, Ethylene dibromide, Ethylene bromide	106-93-4	C2H4Br2	10.37	11.7
dichlorobenzene, 1,2-	O-DCLBNZ	dichlorobenzene, o-	95-50-1	C6H4Cl2	9.08	0.5

COMPOUND NAME	Display Name	Synonym(s)	CAS Number[1]	Chemical Formula	Ioniza-tion Potential	RF 10.6eV lamp
Dichloroethene, trans-1,2-	DCETHENE	t-1,2-DCE, trans-Dichloroethylene	156-60-5	C2H2Cl2	9.65	0.45
diesel fuel #1	DIESEL		68334-30-5	m.w. 226		0.9
diesel fuel #2	DIESEL		68334-30-5	m.w. 216		0.75
diethylamine	DEA		109-89-7	C4H11N	8.01	1
dimethoxymethane	METHYLAL	Methlylal	109-87-5	C3H8O2	10	11.3
dimethyl disulfide	DMDS	DMDS	624-92-0	C2H6S2	7.4	0.3
dimethylacetamide, n,n-	DMA	DMA	127-19-5	C4H9NO	8.81	0.73
dimethylformamide, n,n-	DMF	DMF	68-12-2	C3H7NO	9.13	0.8
dioxane, 1,4-	DIOXANE		123-91-1	C4H8O2	9.19	1.4
epichlorhydrin	EPCLHYD	ECH Chloromethy-loxirane, 1-chloro2,3-epoxy-propane	106-89-8	C2H5ClO	10.2	7.6
ethanol	ETHANOL	Ethyl alcohol	64-17-5	C2H6O	10.47	10
ethyl acetate	ETACET	Acetic ether; Ethyl acetic ester; Ethyl ethanoate	141-78-6	C4H8O2	10.01	4.2
ethyl acetoacetate	EAA		141-97-9	C6H10O3		0.9
ethyl acrylate	ETHYLACR		140-88-5		<10.3	2.3
ethyl ether	ETETHER	Diethyl ether	60-29-7	C4H10O	9.51	1.2
ethyl mercaptan	ETMERCAP	Ethanethiol	75-08-1	C2H6S	9.31	0.6
ethylbenzene	ETBNZE		100-41-4	C8H10	8.77	0.51
ethylene	ETHYLENE	ethene	74-85-1	C2H4	10.51	10.1
ethylene glycol	ETGLYCOL	1,2-Ethanediol	107-21-1	C2H6O2	10.16	15.7
ethylene oxide	ETOXIDE	Oxirane, Epox-yethane	75-21-8	C2H4O	10.57	19.5
gasoline (summary hydrocarbons)	GASOLINE		8006-61-9	m.w. 72		1.1
heptane	HEPTANE		142-82-5	C7H16	9.92	2.5
hexane, n-	HEXANE		110-54-3	C6H14	10.13	4.5
hydrazine	HYDRAZINE		302-01-2	H4N2	8.1	2.6
hydrogen sulfide	H2S		7783-06-04	H2S	10.45	3.2
isoamyl acetate	IAMYACET	Isopentyl acetate	123-92-2	C7H14O2	<10	1.8
isobutanol	IBUTANOL	2-Methyl-1-propanol	78-83-1	C4H10O	10.02	4.7

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COMPOUND NAME	Display Name	Synonym(s)	CAS Number[1]	Chemical Formula	Ioniza-tion Potential	RF 10.6eV lamp
isobutene	ISOBUTYL	Isobutylene, Methyl butene	115-11-7	C4H8	9.22	1
isobutyl acetate	IBUACET	2-methylpropyl acetate, β-methylpropyl ethanoate	110-19-0	C6H12O2	9.97	2.6
isooctane	IOCTANE	2,2,4-Trimethyl-pentane	540-84-1	C8H18	9.86	1.3
isopentane	ISOPENT	2-Methylbutane	78-78-4	C5H12	10.32	8
isophorone	IPHORNE		78-59-1	C9H14O	9.07	0.74
isoprene	ISOPRENE	2-Methyl-1,3-buta-diene	78-79-5	C5H8	8.86	0.6
isopropanol	IPA	Isopropyl alcohol, 2-propanol, IPA	67-63-0	C3H8O	10.12	5.6
isopropyl acetate	ISOPRACE		108-21-4		9.99	2.6
isopropyl ether	IPROETHR	Diisopropyl ether	108-20-3	C6H14O	9.2	0.8
isopropylamine	2PRAMINE		75-31-0	C3H9N	8.6	0.9
Jet A fuel	JETA(A1)	F-34, Kerosene type aviation fuel	8008-20-6	m.w. 145		0.4
JP-5 fuel	JP5	Jet 5, F-4 4, Kero-sene type aviation fuel	8008-20-6	m.w. 167		0.48
JP-8 fuel	JP8	F-34, Kerosene type aviation fuel	8008-20-6	m.w. 165		0.48
mesityl oxide	MSTYLOXD		141-79-7	C6H10O	9.1	0.47
methoxyethanol, 2-	MEOXETOH	Methyl cellosolve, Ethylene glycol monomethyl ether	109-86-4	C3H8O2	10.1	2.5
methyl acetate	MEACET		79-20-9	C3H6O2	10.27	7
methyl acetoacetate	MEACACET		105-45-3	C5H8O3	9.82	1.1
methyl acrylate	MEACRYLT	Methyl 2-propenoate, Acrylic acid methyl ester	96-33-3	C4H6O2	9.9	3.4
methyl benzoate	MEBNZOTE		93-58-3	C8H8O2	9.32	0.93
methyl ethyl ketone	MEK	MEK, 2-Butanone	78-93-3	C4H8O	9.51	0.9
methyl isobutyl ketone	MIBK	MIBK, 4-Methyl-2-pentanone	108-10-1	C6H12O	9.3	1.1
methyl mercaptan	METHMERC	Methanethiol	74-93-1	CH4 S	9.44	0.6
methyl methacrylate	MEMEACRY		80-62-6	C5H8O2	9.7	1.5

COMPOUND NAME	Display Name	Synonym(s)	CAS Number[1]	Chemical Formula	Ioniza-tion Potential	RF 10.6eV lamp
methyl tert-butyl ether	MTBE	MTBE, tert-Butyl methyl ether	1634-04-4	C5H12O	9.24	0.86
methylamine	MEAMINE	Aminomethane	74-89-5	CH5N	8.97	1.2
methylbenzyl alcohol, 4-	MEBNZOL		589-18-4	C8H10O		0.8
naphthalene	NAPHTH	Mothballs	91-20-3	C10H8	8.13	0.37
nitric oxide	NO		10102-43-9	NO	9.26	7.2
nitrogen dioxide	NO2		10102-44-0	NO2	9.59	10
nonane, n-	NONANE		111-84-2	C9H20	9.71	1.6
octane	OCTANE		111-65-9	C8H18	9.82	2.2
pentane, n-	PENTANE		109-66-0	C5H12	10.35	9.7
pentanone, 2-	PENT2ONE	MPK, 2-Pentanone, Methyl propyl ketone	107-87-9	C5H10O	9.38	0.78
phenol	PHENOL	Hydroxybenzene	108-95-2	C6H6O	8.51	1
phosphine	PHOSPHIN		7803-51-2	PH3	9.87	2.8
picoline, 2-	2PICOLIN		109-06-8	C6H7N	9.23	0.57
picoline, 3-	3PICOLIN	3-Methylpyridine	108-99-6	C6H7N	9.04	0.9
pinene, alpha	PINENEA		80-56-8		8.07	0.4
pinene, beta	PINENEB		127-91-3			0.4
propanol, 1-	PROPANOL		71-23-8	C3H8O	10.22	5.7
propionaldehyde	PROPANAL	Propanal	123-38-6	C3H6O	9.96	14.8
propyl acetate, n-	PRACETAT		109-60-4		9.98	3.1
propylene	PROPENE	Propene	115-07-1	C3H6	9.73	1.3
Propylene glycol methyl ether	MEOXPROP	PGME, 1-methoxy-2-propanol	107-98-2	C4H10O2	9.54	1.4
propylene oxide	PROPLYOX	Methyloxirane	75-56-9	C3H6O	10.22	6.5
pyridine	PYRIDINE		110-86-1	C5H5N	9.25	0.79
quinoline	QUNOLINE		91-22-5		8.63	0.72
styrene	STYRENE		100-42-5	C8H8	8.47	0.4
tetrachloroethylene	PERC	PCE, Perchlo-roethylene, Tetra-chloroethylene, Perchloroethene	127-18-4	C2Cl4	9.32	0.56
tetrahydrofuran	THF	THF	109-99-9	C4H8O	9.41	1.6
thiophene	THIOLE		110-02-1		8.86	0.47
toluene	TOLUENE	Methylbenzene	108-88-3	C7H8	8.82	0.53

COMPOUND NAME	Display Name	Synonym(s)	CAS Number[1]	Chemical Formula	Ioniza-tion Potential	RF 10.6eV lamp
trichloroethylene	TCE		79-01-6		9.47	0.5
trimethylamine	TEN	TEN	121-44-8	C6H15N	7.53	0.83
trimethylbenzene, 1,2,3-	123MEBNZ		526-73-8	C9H12	8.42	0.49
trimethylbenzene, 1,2,4-	124MEBNZ		95-63-6	C9H12	8.27	0.43
trimethylbenzene, 1,3,5-	135MEBNZ		108-67-8	C9H12	8.4	0.34
turpentine - crude sulfite	TURPS-CS	Pinenes (85%) + other diisoprenes	8006-64-2	C10H16		1
turpentine - pure gum	TURPS-PG	Pinenes (85%) + other diisoprenes	8006-64-2	C10H16		0.45
vinyl acetate	VNYLACET		108-05-4	C4H6O2	9.19	1.3
vinyl bromide	VBRM	Bromoethylene	593-60-2	C2H3Br	9.8	0.4
vinyl chloride	VCM	Chloroethylene, VCM	75-01-4	C2H3Cl	9.99	1.8
vinylcyclohexane	VYLCYHEX	VCH	695-12-5	C8H14	9.51	0.54
vinylidene chloride	VDC	1,1-DCE, dichlo-roethene, 1,1-	75-35-4	C2H2Cl2	9.81	0.8
xylene, m-	M-XYLENE	1,3-Dimethylben-zene	108-38-3	C8H10	8.56	0.53
xylene, o-	O-XYLENE	1,2-Dimethylben-zene	95-47-6	C8H10	8.56	0.54
xylene, p-	P-XYLENE	1,4-Dimethylben-zene	106-42-3	C8H10	8.44	0.5

[1] The CAS Number is a unique numerical identifier created and assigned to a chemical substance by the American Chemical Society.