Operation & Maintenance Manual

GDS-PID
Photoionization Detector
Gas Sensor

For Detection of Organic & Inorganic Gases

Important: Read and understand contents prior to first use. Improper use or operation could result in instrument malfunction or serious injury.

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SECTION 1 – SAFETY INFORMATION

1.1 Safety Information – Read Before Installation & Applying Power

IMPORTANT

Users should have a detailed understanding of GDS-PID operating and maintenance instructions. Use the GDS-PID only as specified in this manual or detection of gases and the resulting protection provided may be impaired. Read the following **WARNINGS** prior to use.

WARNINGS

- Do not paint the sensor assembly.
- Do not use the GDS-PID if its enclosure is damaged or cracked or has missing components.
- Make sure the cover and field wiring are securely in place before operation.
- Periodically test for correct operation of the system's alarm events by exposing the monitor / sensor system to a targeted gas concentration above the High Alarm set point.
- Do not expose the GDS-PID to electrical shock or continuous severe mechanical shock.
- Protect the GDS-PID from dripping liquids and high power sprays.
- Use only for applications described within this manual.

CAUTION: FOR SAFETY REASONS THIS EQUIPMENT MUST BE OPERATED AND SERVICED BY QUALIFIED PERSONNEL ONLY. READ AND UNDERSTAND INSTRUCTION MANUAL COMPLETELY BEFORE OPERATING OR SERVICING.

ATTENTION: POUR DES RAISONS DE SÉCURITÉ, CET ÉQUIPEMENT DOIT ÊTRE UTILISÉ, ENTRETENU ET RÉPARÉ UNIQUEMENT PAR UN PERSONNEL QUALIFIÉ. ÉTUDIER LE MANUE D'INSTRUCTIONS EN ENTIER AVANT D'UTILISER, D'ENTRETENIR OU DE RÉPARER L'ÉQUIPEMENT.

1.2 Contacting Global Detection Systems Corp.

To contact Global Detection Systems Corp, please call 409-927-2980, FAX 409-927-4180 or visit us on the web at www.gdscorp.com For sales information, send email to sales@gdscorp.com or for technical support email us at tech@gdscorp.com Our headquarters are located at 2513 Hwy 6 in Santa Fe, Texas 77510.

SECTION 2 – PID SPECIFICATIONS

Model:	Global Detection Systems Corp. PID Photoionization Detector for Organic & Inorganic Compounds
Available gases:	Volatile Organic Compounds and other gases with an Ionization Potential (IP) of 10.6eV or less (See Appendix A)
Detection Method:	Diffusion
Output (analog):	Installed in GDS-48 Universal Sensor Head: Bridge output similar to traditional catalytic bead sensor Installed in GASMAX II Gas Monitor: 4-20 mA (Source type) max. 600 Ohm load at 24 VDC supply voltage
Linear Range:	Low Range: 0-20 ppm (Isobutylene equivalent) High Range: 0-2000 ppm (Isobutylene equivalent)
Response Time:	T90 < 20 Seconds (diffusion mode)
Operating Temperature Rating:	Remote installation using GDS-48 Universal Sensor: 0°C to +50°C Local installation with GASMAX II Gas Monitor (Arctic Monitor option): -40°C to +50°C
Operating Voltage:	Installed in GDS-48 Universal Sensor Head: 3.3 to 5.0V DC measured at the detector head Installed in GASMAX II Gas Monitor: 10-30 VDC measured at the detector head
Hazardous Environment Certification	Installed in GDS-48 Universal Sensor Head: CSA Certified Class 1, Division 1, Groups B, C, D Installed in GASMAX II Gas Monitor: CSA Certified Class 1, Division 1 Groups B, C, D
Warranty:	Electronics (GASMAX II) – Two years from date of purchase Sensor: (PID) – One year from date of purchase

SECTION 2 - GENERAL DESCRIPTION

3.1 GDS Photoionization (PID) Gas Detector for Organic & Inorganic Gases

The GDS-PID photoionization gas detector is a permanently-mounted microprocessor based smart sensor that continuously monitors for a wide range of organic and inorganic gases. With an output similar to a traditional catalytic bead combustible gas sensor, the GDS PID can be connected to a GDS Corp **C1** ***Protector*** sixteen-channel controller, a GDS Corp **C2** ***Protector*** two-channel controller, a single or dual channel **GASMAX II** Gas Monitor, or other instrumentation device that supports a standard Whetstone bridge input that can provide 3.5 - 5VDC excitation voltage. When used locally with the GASMAX II monitor, a standard 4-20mA output, an isolated 4-20mA output, a MODBUS digital output and local alarm relay contacts are available.

3.2 Features (Installed in GDS-48 Remote Sensor Housing)

- Output compatible with standard 3-wire catalytic bead bridge-type circuit (3.5 – 5 VDC excitation)
- Complete PID sensor, containing detector cell, photoionization lamp, lamp driver, amplifier and filter
- 10.6 eV lamp detects common VOCs while remaining insensitive to humidity, O_2 or CO_2 changes
- Replaceable lamp assembly
- High range (0 – 2000 ppm) and Low Range (0 – 20 ppm) versions available
- Can be installed Intrinsically Safe in hazardous areas (requires IS barrier) – contact factory for details

3.3 Features (Installed with GASMAX II Gas Monitor, C1 Controller or C2 Controller)

- All above features plus the following
- Smart Sensor records serial number, born-on date and other information (GASMAX only)
- Graphic alphanumeric display in engineering units with alarm LEDs
- Optional isolated 4-20mA output, MODBUS digital serial output
- Optional alarm relay contact closure (3 separate levels + Fault)
- Magnetic interface allows setup without declassifying hazardous area
- Second GASMAX channel supports simultaneous monitoring of toxic gas using electrochemical sensor

3.4 Photoionization Detection Technology

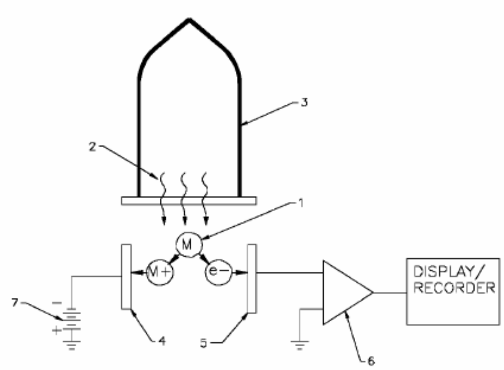
The Photoionization Detector (PID) detects a wide variety of organic compounds and some inorganic gases in ambient air. Whether or not a compound can be detected by a PID depends on the lamp energy and the energy required to remove an electron from the target compound molecule (its *ionization potential*). If the lamp energy is greater than the compounds ionization potential, the PID will detect it.

Due to its sensitivity, a PID is not recommended for high concentrations of target gases. However, a PID does not require oxygen to operate and so would be the detector of choice in conditions where O2 levels are unpredictable. A PID can also react to a number of inorganic substances, including Ammonia, Carbon Disulfide, Carbon Tetrachloride, Chloroform, Ethylamine, Formaldehyde and Hydrogen Sulfide.

A typical PID block diagram is shown below. Molecules of interest (1) are being exposed to high-energy ultra-violet radiation (2), generated by the gas discharge lamp (3). Some percentage of these molecules are ionized, i.e. converted into positively charged ions and negatively charged electrons:

To be ionized, the molecule M should have its Ionization Potential (IP) smaller than the energy of UV lamp photons (E). As a rule, the bigger the difference is between E and IP, the bigger the detector's response. Both E and IP are usually measured in electron-volts (eV). For the Ionization Potentials of various chemicals, refer to Appendix 2.

The pair of electrodes (4, 5) is located in the ionization volume near the lamp window. One of them (polarizing electrode, 4) is connected to the High Voltage DC source (7), the other (signal electrode, 5) is attached to the amplifier (6) input. The electric field, created by these two electrodes, forces both electrons and ions to drift towards their respective electrode, by which they are being collected. The resulting small current is being amplified by the amplifier chip and then the output analog signal is recorded and/or displayed in digital or analog format. The output signal is proportional to the concentration of ionizable molecules in detector's chamber and thus serves as a measure of concentration. Major air components (N2, O2, CO2) are not ionized by typical lamp's radiation and therefore do not generate any detector's response. For this reason, PID is very useful for detection of a wide range of VOCs (Volatile Organic Compounds) in ambient air, down to the low-ppb concentrations, without interference from air components.



SECTION 4 - OPERATION

4.1 Installation and Startup

Warning: The user shall be made aware that if the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

The first step in the installation process is to establish a mounting location for the GDS PID. Select a location that is typical of the atmosphere to be monitored or close to the anticipated source of a target gas.

It is very important that the GDS PID be properly located to enable it to provide maximum protection. The most effective number and placement of sensors vary depending on the conditions of the application. When determining where to locate sensors the following factors should be considered.

- What are the characteristics of the gas that is to be detected? Is it lighter or heavier than air? If it is lighter than air the sensor should be placed above the potential gas leak. Place the sensor close to the floor for gases that are heavier than air or for vapors resulting from flammable liquid spills. Note that air currents can cause a gas that is heavier than air to rise. In addition, if the temperature of the gas is hotter than ambient air or mixed with gases that are lighter than air, it could also rise.
- How rapidly will the gas diffuse into the ambient air? Select a location for the sensor that is close to the anticipated source of a gas leak.
- Wind or ventilation characteristics of the immediate area must also be considered. Movement of air may cause gas to accumulate more heavily in one area than in another. The detector should be placed in the areas where the most concentrated accumulation of gas is anticipated. For outdoor applications with strong wind conditions, it may require the sensors to be mounted closer together and on the down wind side, to the anticipated area of a gas leak. Also take into consideration for indoor applications, the fact that many ventilation systems do not operate continuously.
- The sensor should be accessible for maintenance.
- Excessive heat or vibration can cause premature failure of any electronic device and should be avoided if possible.
- Follow all national and local installation codes and practices**.**

Both the GDS-48 Universal Sensor housing and GASMAX II Gas Monitor provide a ¾" NPT threaded connector for installation with conduit or shielded cable. **Shielded cable is recommended.** Wiring should be installed in metal conduit with no other cabling in the same conduit.

4.2 Warm-up

The GDS PID gas detector is a very sensitive device, and if the sensor has been stored for a significant amount of time, it may become contaminated with trace amounts of ambient detectable compounds. This in turn may cause excessive drift of the background signal during warm-up. Therefore, it is highly recommended to run the sensor for some period of time after prolonged storage, especially if it going to be used for the low level applications. An overnight burn-in period should be sufficient in most cases. During this time, the detector will clean itself and the baseline signal will drop and stabilize. If the sensor is used on a daily basis, it should be allowed to stabilize for 10-20 minutes before use. If high accuracy is not important (for example, in leak detection application) or in the case of measuring relatively high concentrations (> 100 ppm), this stabilization procedure can be skipped.

4.3 Normal Operation

The operation of any gas sensor should be checked periodically to ensure proper operation. When first installed, the GDS PID should be challenged with a calibration gas (Isobutylene recommended) to make certain that the detector and any associated alarm systems are functional. Periodically thereafter, the GDS PID should be tested and/or recalibrated as necessary. Normally, initial calibration tests should be done at least monthly, and may be done on a more extended basis once some experience with the sensor and surrounding environment is obtained.

The GDS PID responds to a wide range of organic and inorganic molecules. To determine if a particular gas generate a detector response, consult Appendix A and compare the Ionization Potential listed with the GDS PID lamp energy rating (10.6 eV). For example, the GDS PID will detect Ammonia (IP = 10.2), whereas it will not detect Acetylene (IP = 11.41). In general, the lower the IP value, the more sensitive the reading and the lower the Minimum Detectible Quantity (MDQ).

Depending on the IP of the compound and some other properties, the sensor's sensitivity varies significantly from one compound to another. If, for example, the sensor generates double the response to some compound as to Isobutylene, one should expect two times better MDQ, and vice versa – compounds to which the sensor has lesser sensitivity, it will have proportionally higher MDQ.

The high range sensor linear range is at least 0 to 2000 ppm of Isobutylene, based on a maximum of 20% non-linearity. The calibration point in this case is 100 ppm. However, the sensor's signal continues to increase uniformly as concentration increases all the way to 5000 ppm. As a result, the sensor can be used beyond the normal linear range for certain applications, including alarm triggering at high concentrations

(4000 ppm, for example). In this case the sensor must be calibrated at this concentration with actual gas samples.

Another way to extend the linear range of the GDS PID is to use software linearization. Since the sensor has reproducible characteristics from unit to unit, an appropriate software algorithm can be applied for this purpose. The GASMAX II provides an easy way to enter a specific ten-point piecewise approximation response curve.

The overall linearity of the sensor may vary slightly, depending on the target compound. As a rule, if the GDS PID is very sensitive to a given compound, the available linear range will be relatively narrow, and vice versa. Therefore, if some application requires high accuracy, the linearity characteristic of the sensor should be experimentally measured for this particular application's target compound.

A sample's balance gas affects the sensor's response to the target gas, mainly as a result of the difference in UV transparency for different balance gases. In a less UV-transparent environment (ex: O_2, CH_4) the GDS-PID will have a lower response to a target gas than it would in a more UV-transparent environment (ex: N_2, H_2). Therefore, for best accuracy calibration should be done in an environment that is as close as possible to the actual operating conditions, especially with respect to humidity and the presence of low levels of non-VOC compounds.

SECTION 5 - CALIBRATION

5.1 Calibration

It is important to understand that the GDS PID is a broadband detector capable of responding to a wide range of organic and inorganic substances, and will respond to any individual gas or combination of gases with IP values less than the lamp UV energy level (10.6 eV).

In general, if an actual sample of the expected target compound (between 40% and 80% of the desired full scale value) is available, it is recommended that the GDS PID be calibrated using the target gas in place of Isobutylene. This technique will ensure maximum accuracy.

After installation, allow the GDS-PID to stabilize for a period of 8 hours or more, preferably overnight. After stabilization, calibrate the unit as described below. During the first several weeks of operation, periodically calibrate the unit to ensure there are no localized sources of contamination that may block the sensors window. It is recommended that the period between calibrations be no longer than 30 days.

5.2 Calibration with Known Target Gas

If a known concentration sample of the desired target gas is available, the GDS PID sensor can be calibrated like any typical sensor. In the case of a GDS PID installed remotely using a GDS-48, the calibration procedure associated with the assigned controller should be used. For example, the C1 *Protector* sixteen-channel controller provides an option for “Local Calibration” that allows the necessary zero and span adjustments to be performed. See the C1 *Protector* Controller manual for further details.

If the GDS PID is connected to a GASMAX II gas monitor, the standard built-in GASMAX II calibration should be used. See the GASMAX family manual for further details on sensor calibration procedures.

IMPORTANT: *Calibrating the GDS-PID for a specific gas does not make it selective to that gas. A PID is a wideband detector and will always indicate the total concentration of ionizable VOCs present in the ambient air sample.*

5.3 Response Factor

In many cases, calibrating the detector with actual target gas is impractical due to toxicity, cost or availability constraints. In these situations, the GDS PID sensor can be calibrated using Isobutylene in place of the target gas and a Response Factor can be applied to the output. The Response Factor is unique for each desired target gas (see Appendix B for a list of GDS-PID Response Factors).

The Response Factor measures the ratio between the sensitivity to a standard gas (isobutylene) and that of a target compound. For example, if the GDS PID low range sensor has a typical sensitivity of 1mV/ppm for Isobutylene and 2 mV/ppm for Benzene that means that Benzene Response Factor is equal to ~0.5. The Response Factor is calculated by dividing the actual concentration of a compound introduced into the sensor by the measured detector response:

$$\text{Response Factor} = \frac{\text{Actual Concentration}}{\text{Measured Response}}$$

In general, if the Response Factor is less than 1.0, the GDS PID is *more* sensitive to the target compound that it is to Isobutylene; if greater than 1.0, the GDS PID is *less* sensitive to the target compound than it is to Isobutylene.

5.4 Calibration with Isobutylene

When the desired target gas is unavailable or excessively dangerous, the GDS-PID can be calibrated using isobutylene and the output value adjusted to determine the actual target gas concentration.

Manual Conversion: One way to calculate the actual concentration of a target gas is to calibrate the GDSPID using Isobutylene, apply the target gas and manually multiply the detector reading by the target gas Response Factor. This technique is useful if more than one type of gas may be present, or if several different gases may be introduced into the detector, and it is not practical to recalibrate for a specific gas.

For example, if a sample of Ammonia (RF = 9.4) in air is applied to a GDS-PID / GASMAX II (Low Range sensor, calibrated for 0-20ppm Isobutylene) monitor and the GASMAX II reads 10ppm, the actual Ammonia concentration would be 94 ppm.

$$10\text{ppm (Reading)} \bullet 9.4 \text{ (Ammonia RF)} = 94 \text{ ppm Ammonia}$$

Like any photoionization detector, the GDS PID will respond to many different compounds simultaneously. If a single gas is present, a single Response Factor can be used to determine the final reading. In the event that the gas present is a mixture of several compounds, each having a different Response Factor, the process to calculate the actual concentrations is more difficult. In general, Response Factors for various mixtures of gases are not available. However, if the composition of the mixture is known with some accuracy, a corrected Response Factor can be obtained by adding weighted fractions of the different Response Factors of the mixture components. For example, if the mixture contains 60% Benzene and 40%

Toluene, multiply the Benzene factor by 0.6, the Toluene factor by 0.4 and add the result to obtain the new factor.

Direct readout in PPM: An alternative procedure to calibrate the GDS PID can provide a direct readout on the GASMAX II monitor for a specific compound. *NOTE: This procedure does not make the GDS-PID selective to the target compound.*

RF = Response Factor for specific compound
CG = PPM value of isobutylene calibration gas

LOW RANGE SENSOR

1. Set the GASMAX II SPAN value [20 * RF]
2. Set the GASMAX II CAL SPAN value to [CG * RF]
3. Make sure no VOCs are present in the ambient air surrounding the GASMAX II. If unable to guarantee no VOCs present, apply a steady flow of 0.5 L/min of ZERO AIR.
4. Perform a ZERO CALIBRATION on the GASMAX II gas monitor.
5. Apply a steady flow of 0.5 L/min of isobutylene calibration gas (8 - 16 ppm recommended)
6. Perform a SPAN CALIBRATION on the GASMAX II gas monitor.
7. The GASMAX II will now display the target gas concentration in PPM.

HIGH RANGE SENSOR

8. Set the GASMAX II SPAN value [2000 * RF]
9. Set the GASMAX II CAL SPAN value to [CG * RF]
10. Make sure no VOCs are present in the ambient air surrounding the GASMAX II. If unable to guarantee no VOCs present, apply a steady flow of 0.5 L/min of ZERO AIR.
11. Perform a ZERO CALIBRATION on the GASMAX II gas monitor.
12. Apply a steady flow of 0.5 L/min of isobutylene calibration gas (800 - 1600 ppm recommended)
13. Perform a SPAN CALIBRATION on the GASMAX II gas monitor.
14. The GASMAX II will now display the target gas concentration in PPM.

Note: Response factor values are **approximate** and are only given as a general guide to the response which may be expected from other gases. For accurate readings, it is always better to calibrate the unit with the actual target gas whenever possible.

SECTION 6 – SENSOR MAINTENANCE

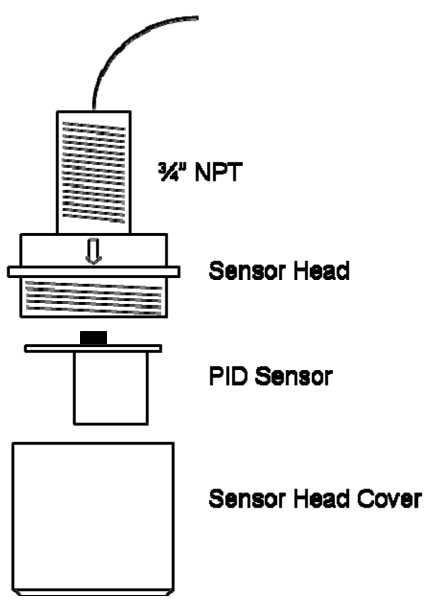
6.1 GDS-PID Maintenance

The GDS-PID sensor is a highly reliable, self-contained photoionization detector that requires very little maintenance other than periodic calibration and lamp replacement. There are no user-serviceable parts.

Cleaning – During the course of normal operation, contaminants in the ambient air can cause a reduction in sensitivity due to a build-up of film on the sensor's UV window. Periodic calibration will compensate for this effect. In the event that the sensor's sensitivity drops excessively, the sensor should be returned to the factory for cleaning.

Lamp Replacement – The sensor's life span is determined by the life of the UV lamp, typically > 5000 hours of continuous operation. Over the lamp's lifetime, the output will gradually decline, but the effect will be insignificant until well after 5000 hours of operation. Normal re-calibration will compensate for this effect. The lamp is replaceable. Contact GDS Corp for more information regarding PID sensor refurbishment options.

SECTION 7 – PARTS LIST & DRAWINGS



Part Number	Description
10-9060	Photoionization Detector for VOC (0-2000ppm)
10-9061	Photoionization Detector for VOC (0-20ppm)
10-906XR	PID Sensor Refurbishment
10-0247	Remote Stainless Steel Sensor Head w/ Cover
10-0198	Sensor splash guard
10-0205	Sensor flow cell for process monitoring
10-0187	Sensor replacement tool
1000-0078	Large black magnet for GASMAX II

Appendix 1: Ionization Potentials

Chemical Name	IP (eV)
A	
2-Amino pyridine	8
Acetaldehyde	10.21
Acetamide	9.77
Acetic acid	10.69
Acetic anhydride	10
Acetone	9.69
Acetonitrile	12.2
Acetophenone	9.27
Acetyl bromide	10.55
Acetyl chloride	11.02
Acetylene	11.41
Acrolein	10.1
Acrylamide	9.5
Acrylonitrile	10.91
Allyl alcohol	9.67
Allyl chloride	9.9
Ammonia	10.2
Aniline	7.7
Anisidine	7.44
Anisole	8.22
Arsine	9.89
B	
1,3-Butadiene (butadiene)	9.07
1-Bromo-2-chloroethane	10.63
1-Bromo-2-methylpropane	10.09
1-Bromo-4-fluorobenzene	8.99
1-Bromobutane	10.13
1-Bromopentane	10.1
1-Bromopropane	10.18
1-Bromopropene	9.3
1-Butanethiol	9.14
1-Butene	9.58
1-Butyne	10.18
2,3-Butadione	9.23
2-Bromo-2-methylpropane	9.89
2-Bromobutane	9.98
2-Bromopropane	10.08
2-Bromothiophene	8.63
2-Butanone (MEK)	9.54
3-Bromopropene	9.7
3-Butene nitrile	10.39
Benzaldehyde	9.53
Benzene	9.25
Benzenethiol	8.33
Benzonitrile	9.71
Benzotrifluoride	9.68
Biphenyl	8.27
Boron oxide	13.5
Boron trifluoride	15.56
Bromine	10.54
Bromobenzene	8.98
Bromochloromethane	10.77
Bromoform	10.48
Butane	10.63
Butyl mercaptan	9.15
cis-2-Butene	9.13
m-Bromotoluene	8.81
n-Butyl acetate	10.01
n-Butyl alcohol	10.04
n-Butyl amine	8.71
n-Butyl benzene	8.69
n-Butyl formate	10.5
n-Butyraldehyde	9.86
n-Butyric acid	10.16
n-Butyronitrile	11.67
o-Bromotoluene	8.79
p-Bromotoluene	8.67
p-tert-Butyltoluene	8.28
s-Butyl amine	8.7
s-Butyl benzene	8.68
sec-Butyl acetate	9.91
t-Butyl amine	8.64
t-Butyl benzene	8.68
trans-2-Butene	9.13
C	
1-Chloro-2-methylpropane	10.66
1-Chloro-3-fluorobenzene	9.21
1-Chlorobutane	10.67
1-Chloropropane	10.82
2-Chloro-2-methylpropane	10.61
2-Chlorobutane	10.65
2-Chloropropane	10.78
2-Chlorothiophene	8.68
3-Chloropropene	10.04
Camphor	8.76
Carbon dioxide	13.79
Carbon disulfide	10.07
Carbon monoxide	14.01
Carbon tetrachloride	11.47
Chlorine	11.48
Chlorine dioxide	10.36
Chlorine trifluoride	12.65
Chloroacetaldehyde	10.61

á -Chloroacetophenone	9.44
Chlorobenzene	9.07
Chlorobromomethane	10.77
Chlorofluoromethane (Freon 22)	12.45
Chloroform	11.37
Chlorotrifluoromethane (Freon 13)	12.91
Chrysene	7.59
Cresol	8.14
Crotonaldehyde	9.73
Cumene (isopropyl benzene)	8.75
Cyanogen	13.8
Cyclohexane	9.8
Cyclohexanol	9.75
Cyclohexanone	9.14
Cyclohexene	8.95
Cyclo-octatetraene	7.99
Cyclopentadiene	8.56
Cyclopentane	10.53
Cyclopentanone	9.26
Cyclopentene	9.01
Cyclopropane	10.06
m-Chlorotoluene	8.83
o-Chlorotoluene	8.83
p-Chlorotoluene	8.7

D

1,1-Dibromoethane	10.19
1,1-Dichloroethane	11.12
1,1-Dimethoxyethane	9.65
1,1-Dimethylhydrazine	7.28
1,2-Dibromoethene	9.45
1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon 114)	12.2
1,2-Dichloroethane	11.12
1,2-Dichloropropane	10.87
1,3-Dibromopropane	10.07
1,3-Dichloropropane	10.85
2,2-Dimethyl butane	10.06
2,2-Dimethyl propane	10.35
2,3-Dichloropropene	9.82
2,3-Dimethyl butane	10.02
3,3-Dimethyl butanone	9.17
cis-Dichloroethene	9.65
Decaborane	9.88
Diazomethane	9
Diborane	12
Dibromochloromethane	10.59
Dibromodifluoromethane	11.07
Dibromomethane	10.49
Dibutylamine	7.69
Dichlorodifluoromethane (Freon 12)	12.31
Dichlorofluoromethane	12.39
Dichloromethane	11.35
Diethoxymethane	9.7
Diethyl amine	8.01
Diethyl ether	9.53
Diethyl ketone	9.32
Diethyl sulfide	8.43
Diethyl sulfite	9.68
Difluorodibromomethane	11.07
Dihydropyran	8.34
Diiodomethane	9.34
Diisopropylamine	7.73
Dimethoxymethane (methylal)	10
Dimethyl amine	8.24
Dimethyl ether	10
Dimethyl sulfide	8.69
Dimethylaniline	7.13
Dimethylformamide	9.18
Dimethylphthalate	9.64
Dinitrobenzene	10.71
Dioxane	9.19
Diphenyl	7.95
Dipropyl amine	7.84
Dipropyl sulfide	8.3
Durene	8.03
m-Dichlorobenzene	9.12
N,N-Diethyl acetamide	8.6
N,N-Diethyl formamide	8.89
N,N-Dimethyl acetamide	8.81
N,N-Dimethyl formamide	9.12
o-Dichlorobenzene	9.06
p-Dichlorobenzene	8.95
p-Dioxane	9.13
trans-Dichloroethene	9.66

E

Epichlorohydrin	10.2
Ethane	11.65
Ethanethiol (ethyl mercaptan)	9.29
Ethanolamine	8.96
Ethene	10.52
Ethyl acetate	10.11
Ethyl alcohol	10.48
Ethyl amine	8.86
Ethyl benzene	8.76
Ethyl bromide	10.29
Ethyl chloride (chloroethane)	10.98
Ethyl disulfide	8.27
Ethylene	10.5
Ethyl ether	9.51

Ethyl formate	10.61
Ethyl iodide	9.33
Ethyl isothiocyanate	9.14
Ethyl mercaptan	9.29
Ethyl methyl sulfide	8.55
Ethyl nitrate	11.22
Ethyl propionate	10
Ethyl thiocyanate	9.89
Ethylene chlorohydrin	10.52
Ethylene diamine	8.6
Ethylene dibromide	10.37
Ethylene dichloride	11.05
Ethylene oxide	10.57
Ethylenelmine	9.2
Ethynylbenzene	8.82

F

2-Furaldehyde	9.21
Fluorine	15.7
Fluorobenzene	9.2
Formaldehyde	10.87
Formamide	10.25
Formic acid	11.05
Freon 11 (trichlorofluoromethane)	11.77
Freon 112 (1,1,2,2-tetrachloro-1,2-difluoroethane)	11.3
Freon 113 (1,1,2-trichloro-1,2,2-trifluororethane)	11.78
Freon 114 (1,2-dichloro-1,1,2,2-tetrafluoroethane)	12.2
Freon 12 (dichlorodifluoromethane)	12.31
Freon 13 (chlorotrifluoromethane)	12.91
Freon 22 (chlorofluoromethane)	12.45
Furan	8.89
Furfural	9.21
m-Fluorotoluene	8.92
o-Fluorophenol	8.66
o-Fluorotoluene	8.92
p-Fluorotoluene	8.79

H

1-Hexene	9.46
2-Heptanone	9.33
2-Hexanone	9.35
Heptane	10.08
Hexachloroethane	11.1
Hexane	10.18
Hydrazine	8.1
Hydrogen	15.43
Hydrogen bromide	11.62
Hydrogen chloride	12.74
Hydrogen cyanide	13.91
Hydrogen fluoride	15.77
Hydrogen iodide	10.38
Hydrogen selenide	9.88
Hydrogen sulfide	10.46
Hydrogen telluride	9.14
Hydroquinone	7.95

I

1-Iodo-2-methylpropane	9.18
1-Iodobutane	9.21
1-Iodopentane	9.19
1-Iodopropane	9.26
2-Iodobutane	9.09
2-Iodopropane	9.17
Iodine	9.28
Iodobenzene	8.73
Isobutane (Isobutylene)	9.4
Isobutyl acetate	9.97
Isobutyl alcohol	10.12
Isobutyl amine	8.7
Isobutyl formate	10.46
Isobutyraldehyde	9.74
Isobutyric acid	10.02
Isopentane	10.32
Isophorone	9.07
Isoprene	8.85
Isopropyl acetate	9.99
Isopropyl alcohol	10.16
Isopropyl amine	8.72
Isopropyl benzene	8.69
Isopropyl ether	9.2
Isovaleraldehyde	9.71
m-Iodotoluene	8.61
o-Iodotoluene	8.62
p-Iodotoluene	8.5

K

Ketene	9.61

L

2,3-Lutidine	8.85
2,4-Lutidine	8.85
2,6-Lutidine	8.85

M

2-Methyl furan	8.39
2-Methyl naphthalene	7.96
1-Methyl naphthalene	7.96
2-Methyl propene	9.23
2-Methyl-1-butene	9.12
2-Methylpentane	10.12
3-Methyl-1-butene	9.51
3-Methyl-2-butene	8.67
3-Methylpentane	10.08

4-Methylcyclohexene	8.91
Maleic anhydride	10.8
Mesityl oxide	9.08
Mesitylene	8.4
Methane	12.98
Methanethiol (methyl mercaptan)	9.44
Methyl acetate	10.27
Methyl acetylene	10.37
Methyl acrylate	9.9
Methyl alcohol	10.85
Methyl amine	8.97
Methyl bromide	10.54
Methyl butyl ketone	9.34
Methyl butyrate	10.07
Methyl cellosolve	9.6
Methyl chloride	11.28
Methyl chloroform (1,1,1-trichloroethane)	11
Methyl disulfide	8.46
Methyl ethyl ketone	9.53
Methyl formate	10.82
Methyl iodide	9.54
Methyl isobutyl ketone	9.3
Methyl isobutyrate	9.98
Methyl isocyanate	10.67
Methyl isopropyl ketone	9.32
Methyl isothiocyanate	9.25
Methyl mercaptan	9.44
Methyl methacrylate	9.7
Methyl propionate	10.15
Methyl propyl ketone	9.39
á -Methyl styrene	8.35
Methyl thiocyanate	10.07
Methylal (dimethoxymethane)	10
Methylcyclohexane	9.85
Methylene chloride	11.32
Methyl-n-amyl ketone	9.3
Monomethyl aniline	7.32
Monomethyl hydrazine	7.67
Morpholine	8.2
n-Methyl acetamide	8.9

N

1-Nitropropane	10.88
2-Nitropropane	10.71
Naphthalene	8.12
Nickel carbonyl	8.27
Nitric oxide, (NO)	9.25
Nitrobenzene	9.92
Nitroethane	10.88
Nitrogen	15.58
Nitrogen dioxide	9.78
Nitrogen trifluoride	12.97
Nitromethane	11.08
Nitrotoluene	9.45
p-Nitrochloro benzene	9.96

O

Octane	9.82
Oxygen	12.08
Ozone	12.08

P

1-Pentene	9.5
1-Propanethiol	9.2
2,4-Pentanedione	8.87
2-Pentanone	9.38
2-Picoline	9.02
3-Picoline	9.02
4-Picoline	9.04
n-Propyl nitrate	11.07
Pentaborane	10.4
Pentane	10.35
Perchloroethylene	9.32
Pheneloic	8.18
Phenol	8.5
Phenyl ether (diphenyl oxide)	8.82
Phenyl hydrazine	7.64
Phenyl isocyanate	8.77
Phenyl isothiocyanate	8.52
Phenylene diamine	6.89
Phosgene	11.77
Phosphine	9.87
Phosphorus trichloride	9.91
Phthalic anhydride	10
Propane	11.07
Propargyl alcohol	10.51
Propiolactone	9.7
Propionaldehyde	9.98
Propionic acid	10.24
Propionitrile	11.84
Propyl acetate	10.04
Propyl alcohol	10.2
Propyl amine	8.78
Propyl benzene	8.72
Propyl ether	9.27
Propyl formate	10.54
Propylene	9.73
Propylene dichloride	10.87
Propylene imine	9
Propylene oxide	10.22
Propyne	10.36

Pyridine	9.32
Pyrrole	8.2

Q

Quinone	10.04

S

Stibine	9.51
Styrene	8.47
Sulfur dioxide	12.3
Sulfur hexafluoride	15.33
Sulfur monochloride	9.66
Sulfuryl fluoride	13

T

o-Terphenyls	7.78
1,1,2,2-Tetrachloro-1,2-difluoroethane (Freon 112)	11.3
1,1,1-Trichloroethane	11
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	11.78
2,2,4-Trimethyl pentane	9.86
o-Toluidine	7.44
Tetrachloroethane	11.62
Tetrachloroethene	9.32
Tetrachloromethane	11.47
Tetrahydrofuran	9.54
Tetrahydropyran	9.25
Thiolacetic acid	10
Thiophene	8.86
Toluene	8.82
Tribromoethene	9.27
Tribromofluoromethane	10.67
Tribromomethane	10.51
Trichloroethene	9.45
Trichloroethylene	9.47
Trichlorofluoromethane (Freon 11)	11.77
Trichloromethane	11.42
Triethylamine	7.5
Trifluoromonobromo-methane	11.4
Trimethyl amine	7.82
Tripropyl amine	7.23

V

o-Vinyl toluene	8.2
Valeraldehyde	9.82
Valeric acid	10.12
Vinyl acetate	9.19
Vinyl bromide	9.8
Vinyl chloride	10
Vinyl methyl ether	8.93

W

Water 1	2.59

X

2,4-Xylidine	7.65
m-Xylene	8.56
o-Xylene	8.56
p-Xylene	8.45

Appendix 2: Response Factors

Chemical Name	RF
1,2,3-trimethylbenzene	0.49
1,2,4-trimethylbenzene	0.43
1,2-dibromoethane	11.70
1,2-dichlorobenzene	0.50
1,2-dichloroethane (11.7 lamp)	0.50
1,3,5-trimethylbenzene	0.34
1,4-dioxane	1.40
1-butanol	3.40
1-methoxy-2-propanol	1.40
1-propanol	5.70
2-butoxyethanol	1.30
2-methoxyethanol	2.50
2-pentanone	0.78
2-picoline	0.57
3-picoline	0.90
4-hydroxy-4-methyl-2-pentanone	0.55
acetaldehyde	10.80
acetic acid	11.00
acetone	1.20
acetophenone	0.59
acrolein	3.90
allyl alcohol	2.50
ammonia	9.40
amylacetate	3.50
arsine	2.60
benzene	0.53
bromoform	2.30
bromomethane	1.80
butadiene	0.69
butyl acetate	2.40
carbon disulfide	1.20
chlorobenzene	0.40
cumene (isopropylbenzene)	0.54
cyclohexane	1.50
cyclohexanone	0.82
decane	1.60
diethylamine	1.00
dimethoxymethane	11.30
dimethyl disulfide	0.30
diesel fuel #1	0.90
diesel fuel #2	0.75
epichlorhydrin	7.60
ethanol	10.00
ethyl acetate	4.20
ethyl acetoacetate	0.90
ethyl acrylate	2.30
ethyl ether (diethyl ether)	1.20
ethyl mercaptan	0.60
ethylbenzene	0.51
ethylene	10.10
ethylene glycol	15.70
ethylene oxide	19.50
gasoline	1.10
heptane	2.50
hydrazine	2.60
hydrogen sulfide	3.20
isoamyl acetate	1.80
isobutanol	4.70
isobutyl acetate	2.60
isobutylene	1.00
isooctane	1.30
isopentane	8.00
isophorone	0.74
isoprene (2-methyl-1,3-butadiene)	0.60
isopropanol	5.60
isopropyl acetate	2.60
isopropyl ether	0.80
isopropylamine	0.90
Jet A fuel	0.40
JP-5 fuel	0.48
JP-8 fuel	0.48
mesityl oxide	0.47
methanol (11.7 lamp)	2.50
methyl acetate	7.00
methyl acetoacetate	1.10
methyl acrylate	3.40
methyl benzoate	0.93
methyl ethyl ketone	0.90
methyl isobutyl ketone	1.10
methyl mercaptan	0.60
methyl methacrylate	1.50
methyl tert-butyl ether	0.86
methylamine	1.20
methylbenzil alcohol	0.80
methylene chloride (11.7 lamp)	0.85
m-xylene	0.53
naphtalene	0.37

n,n-dimethylacetamide	0.73
n,n-dimethylformamide	0.80
n-hexane	4.50
nitric oxide	7.20
n-nonane	1.60
nitrogen dioxide (11.7 lamp)	10.00
n-pentane	9.70
n-propyl acetate	3.10
octane	2.20
o-xylene	0.54
phenol	1.00
phosphine	2.80
pinene, alpha	0.40
pinene, beta	0.40
propionaldehyde (propanal)	14.80
propylene	1.30
propylene oxide	6.50
p-xylene	0.50
pyridine	0.79
quinoline	0.72
styrene	0.40
tert-butyl alcohol	3.40
tert-butyl mercaptan	0.55
tert-butylamine	0.71
tetrachloroethylene	0.56
tetrahydrofuran	1.60
thiophene	0.47
toluene	0.53
trans-1,2-Dichloroethene	0.45
trichloroethylene	0.50
trimethylamine	0.83
turpentine - crude sulfite	1.00
turpentine - pure gum	0.45
vinyl acetate	1.30
vinyl bromide	0.40
vinyl chloride	1.80
vinylcyclohexane (VCH)	0.54
vinylidene chloride (1,1-DCE)	0.80

Note: Data extracted from industry literature; actual data has not been independently validated by GDS Corp. Response factor values are **approximate** and are only given as a general guide to the response which may be expected from other gases. For accurate readings, it is always better to calibrate the unit with the actual target gas whenever possible.