



## GC Detector Series Information

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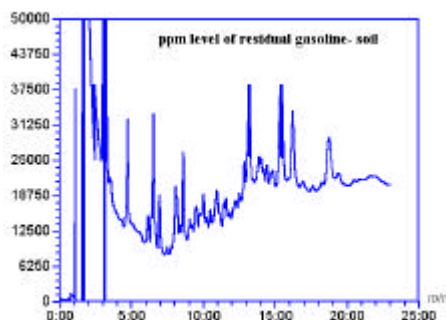


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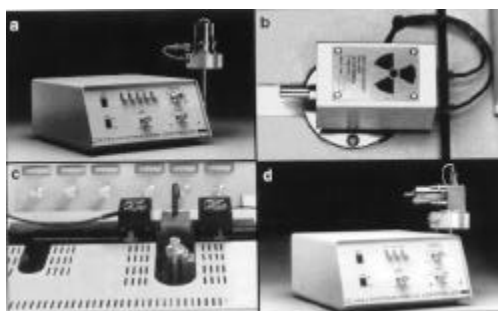
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## Detectors for Gas Chromatography

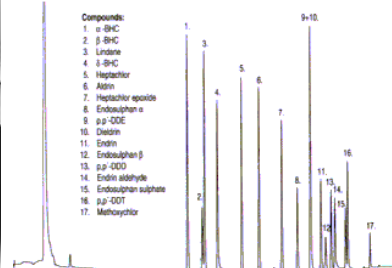


*PID chromatogram*



*GC Detectors: a. PID, b. HWX, c. FPD, d. FUV*

**Chlorinated Pesticides (EPA 608)**



*ECD chromatogram*

**HNU Systems, Inc. developed the first PID (photoionization detector) for gas chromatography (GC). This PID (Model PI51) was introduced at the Pittsburgh Conference in Cleveland, Ohio in 1976. The PID was found to be 50 times more sensitive than the FID making it an ideal detector for environmental measurements.** Over the past twenty plus years, the PID has become one of the most important detectors for environmental analysis all over the world. The novel Far UV Absorbance detector was introduced in 1985. The flame photometric detector (S or P) has novel rare earth filters instead of interference filters to improve the detection limits (2-5 fold) and a quartz jet to minimize decomposition of pesticides before they enter the flame region. The electron capture detector has a unique axial design that provides improved detection limits. Both detectors were added in the early nineties.

**Why upgrade?** To improve sensitivity, selectivity or even time of analysis (elimination of a derivatization step, for example). Add years to the lifetime of your capital equipment (GC) with an upgrade. **Extend your lab budget by spending \$5K for a detector instead of \$20 K for a new GC.**

### ► Features

#### Easy to Install

The detectors should be mounted firmly to the GC. This simply requires two mounting holes or a clamp. The detector inlets are long enough so that the column can be connected directly to the detector inlet inside the oven.

#### Four Detectors to choose from

PID, ECD, FUV, & I J; Operate any two at one time; **HNU detectors have the Widest Range & are the Best in the Industry**

## Run Detectors In-Series

Non destructive detectors such as the PID, or FUV can be placed upstream and a second detector (FID, FPD, PID) can be run in-series downstream for additional information or confirmation of a component

## Upgradability

HNU's detectors have been designed to be easy to upgrade. They contain their own proportional temperature controller and have an analog output that provides an input for the auxiliary ADC found on many modern GC's. The analog output can be used with any integrator or recorder.

## PID

Most sensitive PID available; axial geometry, inert chamber and ultrastable UV lamp combine to produce the best PID available. This detector is a carbon counter like the FID but it also responds to inorganic species such as hydrogen sulfide, ammonia, phosphine, arsine, iodine since the response depends on the ionization potential of the molecule. The most common lamp is the 10.2 eV but a more selective (9.5 or 8.3 eV) or more universal lamp (11.7 eV- carbon tetrachloride, ethane, chloroform, methanol) is also available. As a result, the selectivity of the PID can be varied.

## FUV

Novel photodiode and ultra stable UV lamp provides nearly universal response and low or sub ppm detection limits. the detection limit of the FUV for methane is approximately the same as the FID. At the same time, this detector will respond to oxygen and water at low or sub ppm levels.

**ECD** - not available

## FPD

Rare earth filters eliminate temperature effects of interference filters and provide a 2-5 fold improvement in sensitivity because of their sharp bands. This detector is selective for S or P compounds depending upon the filter employed. A dual S/P detector is also available.

Comparison of GC Detector Characteristics			
Detector	Model #	Dynamic Range	Concentration Range
PID	52	$10^7$	pg-ug
FID	54	10 <sup>7</sup>	pg-ug
ECD	58	$>10^4$	pg-ng

FPD (S)	56S	10 <sup>4</sup>	pg-ng
FPD (P)	56P	10 <sup>4</sup>	pg-ng

## ▶ GC Products

### GC322 Compact GC

Compact lab GC for quality control, dedicated applications, mobile labs, ... six detectors available (two at a time), packed and capillary injectors...

### GC Detectors

Upgrade your laboratory GC by adding one of our high performance GC Detectors such as: PID, FUV, FPD (S or P) or ECD

### PeakWorks™ for Windows® Chromatography Software

A new version of PeakWorks Chromatography Software was introduced at the 1999 Pittsburgh Conference in Orlando, Florida. This version will operate the 300 series GC's from HNU or other manufacturers GC's.

### Model GC312 Portable Gas Chromatograph

The Portable GC is a combined the GC, gases, and integrator in a single unit. It has battery, line and cigarette lighter operation with one or two detectors -PID, FID, FUV, STCD, FPD & CCD. Comes with Win XP, PeakWorks for Windows® Chromatography, Software control of the GC. Embedded Pentium PC is included.





## GC Detectors to upgrade the performance of Lab GC's

### PRODUCT NOTE

The PROCESS ANALYZERS GC Detectors are the same high performance detectors offered on our Model 301-B or 501-B Automatic GC's. We are offering standalone- **PID, FPD, ECD and Far UV** detectors that can be adapted to any lab GC's to significantly upgrade their performance. We also can offer a standalone version of Peakworks for Windows software for chromatographic integration. These detectors are ideal for a wide range of environmental, laboratory, and field applications.

#### INTRODUCTION

Process Analyzers offers six detector options; photoionization (PID), far ultraviolet (FUV), flame ionization (FID), flame photometric (FPD), thermal conductivity (TCD) and electron capture (ECD). These are the same detectors that are offered on a standalone basis. Thus, it is easy to upgrade your GC with these high performance HNU GC detectors.

#### COLUMNS

The columns can be any type of packed (1/8", or 1/16") or capillary (0.18-32 mm I.D. or 0.53 mm I.D.) columns (Fig.1 below) suitable for the application. Packed columns must be coiled with a diameter no greater than 6".

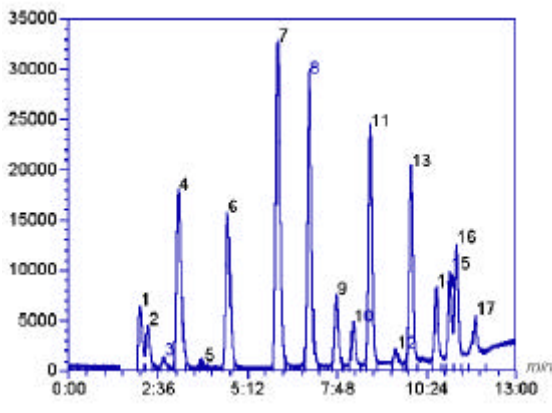


Fig.1 Capillary chromatogram TO14 Compounds via PID (ppb levels)

#### INJECTORS

A heated, on-column injector allows manual syringe injections of either gas or liquid samples onto packed or capillary columns. *Capillary injectors* allow direct syringe injections onto 0.10, 0.32 mm I.D. or 0.53 mm I.D. capillary columns.

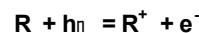
#### DETECTORS

The detectors quantitatively measure the concentration of the components in the sample. Six detectors are available with the Model 311-D; PID, FUV, FID, FPD, TCD and ECD. The instrument's *dual-detector* capability allows any two of the three interchangeable detectors to be run separately or in series. Teflon tubing is supplied with the GC for use as the gas lines with any of the detectors. Nylon or metal (copper or stainless steel) may be preferred when using the ECD.

#### PID

The PID provides a response to a wide range of organic and some inorganic compounds at part per billion (ppb) levels. The HNU PID consists of an ultraviolet lamp and an ion chamber. The detector measures the concentration of gases present in a sample using the method of *photoionization*.

Photoionization occurs when a molecule absorbs a photon (light energy) of sufficient energy, creating a positive ion and an electron as shown below:



The sample drawn into the ion chamber is exposed to photons generated by the ultraviolet lamp. Molecules in the sample with ionization

potentials less than or equal to the energy level of the lamp are ionized. The ionization potential is that energy in electron volts (eV) needed to free an electron from a molecule. A positively biased accelerator electrode repels these ions, causing them to travel to the collecting electrode, where an analog signal proportional to the concentration of the sample is generated. The signal is amplified to provide an analog output for graphic recording or electronic integration. Ultraviolet lamps are available in four energies; 8.3, 9.5, 10.2, and 11.7 electron volts (eV). *Note That the PROCESS ANALYZERS 10.2 eV lamp has exactly the same emission lines (10.0 and 10.6 eV) as lamps offered by other manufacturers under the 10.6 eV label.*

Detector selectivity (and sensitivity) varies with each lamp. The PID becomes *more selective* as the lamp energy decreases since it is capable of ionizing fewer compounds. The detector becomes *less selective* as the lamp energy increases. It is capable of ionizing a larger number of compounds. The best lamp for an application is typically one with an energy level just above the ionization potential of the compounds of interest. The 10.2 eV lamp provides the maximum sensitivities for those compounds it detects. The PID has a linear range of better than seven decades ( $>10^7$ ), is nondestructive, and can be used in series with other detectors.

#### **Far Ultraviolet Absorbance Detector**

The Far Ultraviolet Detector (FUV) provides a nearly universal response (except for the noble gases) to organic and inorganic compounds at low part per million (ppm) levels. The internal volume of the FUV is only 40 mL making it an ideal choice for use with capillary columns. The FUVAD consists of a 10.2 eV ultraviolet lamp, an absorption cell, and a photodiode. The photodiode produces a constant background current within the detector. The ultraviolet lamp generates light energy (photons) in the far ultraviolet (120-150 nm) range. As molecules in a sample pass through the absorption cell of the detector, they absorb the photons emitted from the UV lamp, creating negative ions which cause a decrease in the background current measured by the photodiode. The photodiode senses and measures this decrease in background current and generates an analog signal proportional to the concentration of the sample. The signal is amplified and linearized to provide in analog output for graphic recording or electronic integration. The FUV has a linear range of better

than four decades ( $>10^4$ ), is non-destructive, and can be used in series with other detectors.

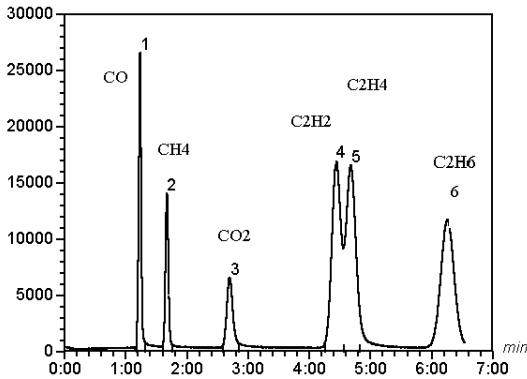
#### **Flame Photometric Detector**

The sample is burned in a hydrogen rich flame which excites sulfur or phosphorus to a low lying electronic level. This is followed by a resultant relaxation to the ground state with a corresponding emission of a blue (S) or green (P) photon. This type of emission is termed chemiluminescence. The emission is at 394 nm for Sulfur and 525 nm for phosphorus. The S:C selectivity ratio is  $> 10,000:1$ . The HNU detector uses rare earth filters instead of interference filters for S & P to improve detection limits and eliminate some of the deficiencies of interference filters. Detection limits in the 5 pg and 20 pg range for P and S respectively. The PROCESS ANALYZERS Flame Photometric Detector (FPD) incorporates a *rare earth* glass filter for improved performance. Our FPD offers a two to three-fold increase in sensitivity for sulfur (S) and phosphorous (P) compared to detectors with interference filters. Since band pass is no longer dependent on the viewing angle, results are more reproducible-regardless of flame geometry. Sensitivity is significantly increased due to improved interference rejection and a larger effective aperture. *Only PROCESS ANALYZERS's FPD offers rare earth glass filters for more reproducible results and increased sensitivity.*

#### **Flame ionization Detector**

The process of ionization which occurs in organic compounds when the carbon-carbon bond is broken via a thermal process in the flame that results in the formation of carbon ions. These ions are collected in the flame by applying a positive potential to the FID jet and the ions are pushed to the collection electrode where the current is measured. The response (current) is proportional to the concentration and is measured with an electrometer/amplifier. An FID consists of a combustion/ion chamber, a flame, a voltage source for the accelerating electrode (usually applied to the jet) and an amplifier capable of measuring down to one to five picoamperes full scale.

The FID is a mass sensitive detector, the output of which is directly proportional to the ratio of the compound's carbon mass to the total compound mass. Thus, the sample is destroyed in the flame. A typical example of transformer gases via FID is shown in Fig. 2 below.



**Fig. 2 ppm Levels of Hydrocarbons & Carbon Oxides using methanizer**

**Thermal conductivity detector**

Measures difference between the thermal transfer characteristics of the gas and a reference gas, generally helium but hydrogen or nitrogen can be used depending on the application. The sample and reference filaments are two legs of a Wheatstone Bridge. A constant current is applied with a resultant in a rise in filament temperature. As the sample passes through the detector, the resistance changes as the reference gas is replaced by the sample which has a lower thermal conductivity. This difference in resistance is proportional to the concentration. The response is universal since the detector responds to any compound that conducts heat. The minimum detection limit is in the 100-200 ppm. The maximum concentration is 100%.

**Electron Capture Detector**

The PROCESS ANALYZERS Electron Capture Detector (ECD) provides excellent sensitivity for halogenated and chlorinated compounds. This detector is optimized for the low flow characteristics of capillary columns, and offers detection limits in the low part per billion (ppb) and part per trillion (ppt) range for many compounds. The ECD consists of a sealed nickel 63 (Ni-63) radioactive source, a sample chamber, and a polarizing voltage source. Carrier gas flowing through the sample chamber is ionized by the Ni-6-3 radioactive source, creating positively charged ions that are collected and measured, providing a background current. The background current is kept constant by a polarizing voltage that pulses at variable frequencies. As a sample enters the chamber, its electrons bind to any free electrons creating negatively charged ions, resulting in a decrease in the background current. The electronics compensate for this decrease in current by increasing the voltage pulse

frequency. The increase in the pulse frequency is measured and is used to generate a voltage output proportional to the concentration of the sample. The signal is amplified to provide an analog output for graphic recording or integration. Although the ECD is a non-destructive detector and can be used in series with other detectors, the internal volume of the ECD precludes its use as the first detector in a series. Similarly, the ECD exhaust is located externally to the oven, to facilitate column flow measurements.

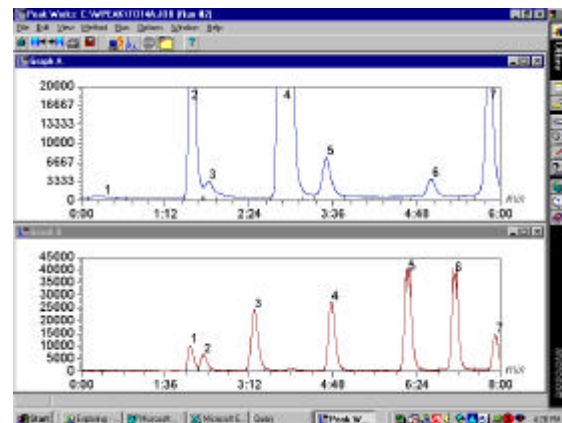
**OUTPUT**

The from the detectors is typically a 0-1V that is sent to the chromatography data system.

**Peakworks**

The, Peakworks software program offers the same analytical features of the on-board firmware, with the added flexibility of automatic data collection, integration, and storage within a personal computer, reintegration, peak overlays, scale expansion ...and many more features. All data and methods can be stored on disk and downloaded to spreadsheet or database programs for report generation or to a printer. Minimum computer requirements for Peakworks include an IBM compatible Pentium PC with Windows 95, 98 or NT operating system, 16MB RAM, and a color VGA monitor. This Windows software can be used with any Pentium PC as a data station for use with our Detectors..

**Fig. 3 PID/ECD chromatogram in Peakworks for Windows Software**



# Laboratory GC Detectors

**Environmental•Industrial Hygiene•Trace Impurities• Process  
R&D•Quality Control**



**Photo of the four detectors**

**Photoionization Detector- PID Model PI52  
Far UV Absorbance Detector- FUV Model 54  
Flame Photometric Detector- FPD Model 56  
Electron Capture Detector- not available**

## **Specific or General Purpose Detectors**

## **h•nu Detectors for Gas Chromatography**

HNU started the development of the first commercial photoionization detector (PID) for

gas chromatography in 1973 and introduced the PI51 in 1975. As we now introduce the fourth

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version, the PI52-02B, more than 11,000 have been sold worldwide.

The Far UV absorbance detector (FUV), another first, was introduced in 1984 as a complementary detector to the PID that responded to many compounds which the PID did not. The selective flame photometric detector (FPD) was redesigned to improve performance through the use of rare earth filters instead of interference filters in 1988. Our linearized ECD, one of the best available, was first introduced in 199\_ by our Finnish subsidiary, HNU Nordion, Ltd., OY.

### Should you upgrade your GC

More than 70%?? of the GC's sold in the last decade have only single detector capability (FID or TCD). This configuration is ideal for the measurement of hydrocarbons or inorganic gases at high levels but if your requirements extend to the measurement of other species, environmental or trace levels, **why buy another GC?** Simply add a selective or general purpose detector that will enhance the capabilities of your present GC. This can expand the capabilities of your laboratory without wiping out your budget. It can also extend the lifetime of your present GC.

### Detector Selection Guide

Application	Detector				
	PID	FUV	ECD	FPD (P)	FPD (S)
Alkanes	>C4 G	G			
Aromatics	G	G			
Sulfur Cpds.	G	G			S
PCB's	G		S		
Pesticides	G		S	S	S
Inorganics-O2, CO	0	G	0	0	0
Freons	M	G	S	0	0
Nitro cpds.	G		S	0	0
Phosphorus Cpds.	G	G		S	0
Chlorinated HC	G	G	S	0	0

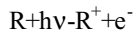
S= specific; G= general; 0 = No response

### Why is a Detector Upgrade needed?

#### Theory of operation

Photoionization is initiated by the absorption of short wavelength ultraviolet light by a molecule.

This can lead to ionization as follows:



ionization potential of the R the species ionized is < or equal to the energy of the photon, hv.

- Are you having problems with sensitivity, selectivity, difficult analyses, time of analysis? A detector upgrade may provide the solution
- Capability to respond to more compounds with **Selective** (PID), **Specific** {ECD, FPD (S), FPD (P)}, or **General** (FUV) detector response
- More sensitive detection capability for environmental or trace analysis- ng to pg detection limits compared to ug (TCD) or ng (FID) detection limits

### Comparison of Detector Characteristics

Detector	Dynamic Range	Concentration Range
PID	10 <sup>7</sup>	pg-µg
FUV	10 <sup>4</sup>	ng-µg
ECD	10 <sup>4</sup>	pg-ng
FPD (P)	10 <sup>4</sup>	pg-ng
FPD (S)	10 <sup>4</sup>	pg-ng

- Have you had to add a derivitization step to your method to make up for poor sensitivity to a target compound? Why waste precious time? Analyze directly by upgrading your detector capability instead
- Eliminate H<sub>2</sub> and air (for an FID) by adding a PID or FUV detector
- Add years to the lifetime of your capital equipment with a detector upgrade
- Reduction of capital costs- Why buy a new GC with autosampler, data system and other expensive items when you can just add capabilities with a new detector at a fraction of the cost?
- Extend your lab budget- spend approximately \$5K for a detector instead of \$20K for a new GC
- Save \$. Are you sending out analyses which could be more profitably done in your own lab?
- Save time on fast turnaround analyses needed for manufacturing processes or effluent analyses by using a more specific detector
- Easily Adaptable to Any GC- These detectors are easy to use with any gas chromatograph. It is mounted outside the oven on the column exit with a factory-supplied universal mounting bracket. Cartridge heaters in the detector provide temperatures up to 300 °C as required.

## Photoionization Detector

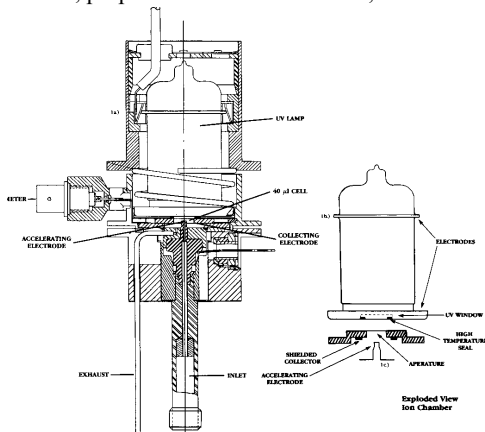
The sensor consists of a sealed *interchangeable* ultraviolet lamp that emits a selected energy line. Lamps with energies of 8.3, 9.5, 10.2, and 11.7 eV are available. Photons in this range are energetic enough to ionize many trace species, (particularly organics), but not to ionize such compounds as N<sub>2</sub>, CO, CO<sub>2</sub>, H<sub>2</sub>O, or He. An ionization chamber adjacent to the ultraviolet source contains a pair of electrodes. A

PID Analyzers, LLC

2 Washington Circle, Sandwich, MA 02563, USA

# Pioneers in Detector Technology Since 1973

positive potential applied to the accelerating electrode creates a field driving ions formed by absorption of ultraviolet light to the collecting electrode where the current, proportional to concentration, is measured.



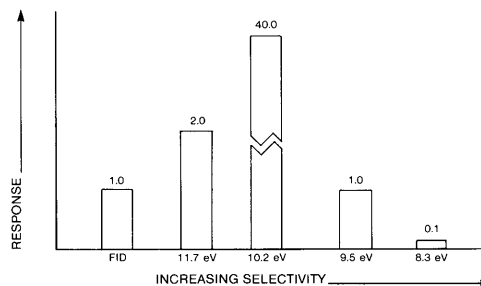
## Responds to wide range of organic and inorganic compounds

The photoionization detector can be used to analyze a wide variety of compounds. Any compound with an ionization potential (IP) < 12 eV will respond. This allows the detection of aliphatics (except CH<sub>4</sub>), aromatics, ketones, aldehydes, esters, heterocyclics, amines, organic sulfur compounds, and some organometallics. The detector also responds to inorganics such as O<sub>2</sub>, arsine, ammonia, hydrogen sulfide, HI, chlorine, iodine, and phosphine. When used with a 10.2 eV lamp, it does not respond to several commonly used solvents such as methanol, or to extraction solvents such as chloroform, dichloroethane, carbon tetrachloride, and acetonitrile. These can be used as extraction solvents and produce a minimal response.

## Selectivity

Four ultraviolet light sources (8.3 eV, 9.5 eV, 10.2 eV, and 11.7 eV) are offered by HNU Systems. The 10.2 eV is the most common, but the other sources either increase the number of compounds detected (11.7 eV), or allow additional selectivity in detection (9.5 or 8.3 eV). For maximum selectivity in a given PID application, the lamp with the energy (eV) output just capable of photoionizing the species to be detected should be selected. As indicated below:

Response for the Various Ultraviolet Lamps.  
RELATIVE SENSITIVITY vs. FID (benzene or biphenyl)



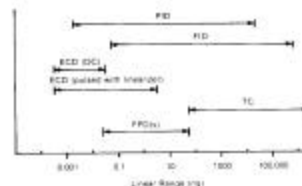
## Sensitivity and detection limits

One of the most significant characteristics of the HNU photoionization detector is its sensitivity. The lower limits of detection for organics are 10-100 times better than those of a flame ionization detector (FID). Lower limits of detection for inorganics are often 10-20 picograms, which makes the PID 2-10 times more sensitive than the flame photometric or Hall detectors.

## Wide dynamic range

The PID has the widest dynamic range of any GC detector, extending from 2 picograms through 30 micrograms. This covers virtually the entire dynamic range of many of the other GC detectors. The range and detection limits for the most common GC detectors are shown below.

Comparison of Linear Dynamic Ranges of Various GC Detectors



## Optimized for Capillary Columns

A concentration-sensitive detector like the PID has a natural advantage over a mass-flow detector like the FID for capillary column analyses, particularly where sensitivity is important. An ultra low dead volume (40 µl) capillary detector is available as an option for those researchers using 0.25 and 0.32 mm capillary columns. This is suggested for operation at flow rates of <5 ml/min. As a result, the PID can be 50-100 times more sensitive than the FID when used with capillary columns.

## Non destructive detector

The PID uses inert ceramic internal components plus glass-lined inlet and exhaust systems. Photoionization itself is virtually a non-destructive technique (apparent ionization efficiency  $\approx 10^{-4}$ ). The PID can be connected in series with other detectors such as an FID, ECD, IR, element selective detector, or with a mass spectrometer for further confirmation of the peak.

PID Analyzers, LLC

2 Washington Circle, Sandwich, MA 02563, USA

# Pioneers in Detector Technology Since 1973

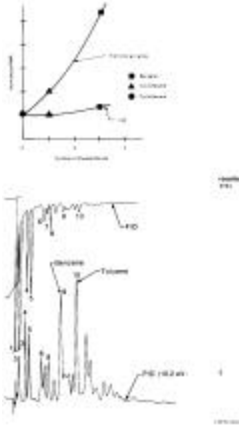
## Features

- High sensitivity- pg detection limits; 50 times more sensitive than the FID
- Non destructive- detectors can be run in-series
- Ideal for environmental or trace analysis; used by environmental agencies worldwide
- Wide dynamic range-  $> 10^7$
- Easily adaptable to any GC
- Selectivity- improves separations and analysis of trace species

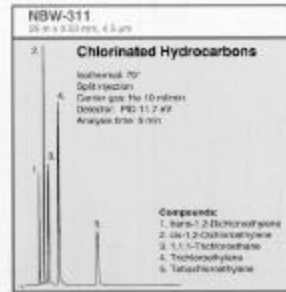
## Selected PID Applications-

### VOCs

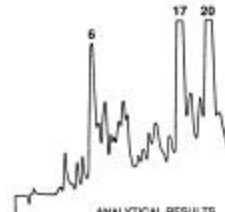
Use the differential response of the PID and FID to identify alkanes, alkenes and aromatic hydrocarbons in process streams or mixtures



Even TCA can be detected with an 11.7 eV lamp



The PID can detect ppb levels of BTX in soils



ANALYTICAL RESULT

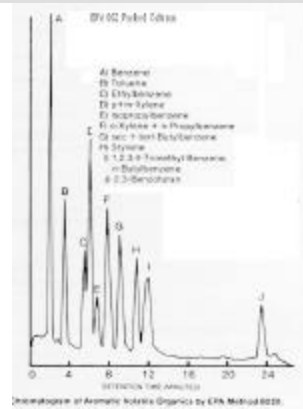
PEAK#	COMPOUND NAME	CONCENTRATION
6	Toluene	= 0.7 mg/kg
17	m-Xylene	= 6.3 mg/kg
20	o-Xylene	= 10.0 mg/kg

Chromatogram of soil extract on 60/80 Porapak Q (Chromat 113, 100mm, 0.05mm ID, 0.5mm film)

Low MW chloroalkanes can be measured via PID (11.7 eV)



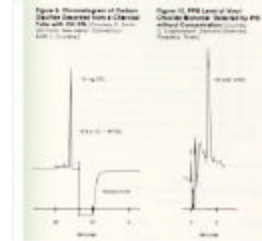
The PID was chosen by EPA for the analysis of VOC's in water as a result of its improved selectivity over the FID



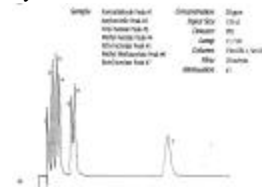
### 602 PID cap

### Industrial Hygiene- Fenceline

The PID is useful for low level industrial hygiene measurements as shown in the chromatograms of VCM and CS<sub>2</sub> below

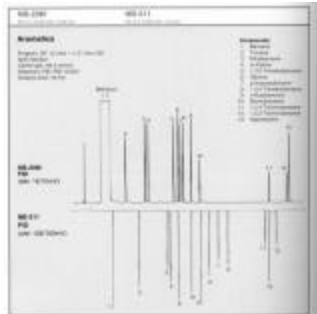


The PID with an 11.7 eV lamp can be used to monitor a variety of hydrocarbons

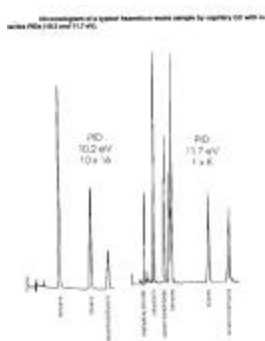


Automatic analysis of formaldehyde in air at 1ppm with an 11.7 eV lamp

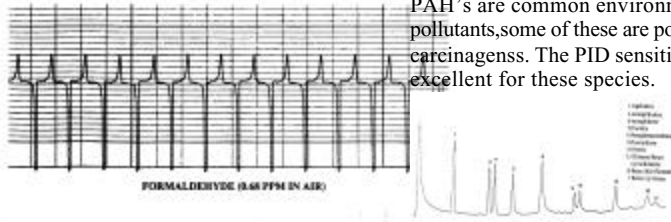
### Improve confirmation with one run and two detectors PID/FID



The selectivity of UV lamps can be useful on hazardous waste sites for identification



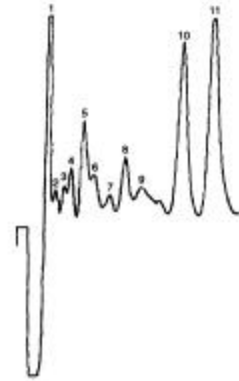
# Pioneers in Detector Technology Since 1973



PAH's are common environmental pollutants, some of these are potential carcinogens. The PID sensitivity is excellent for these species.

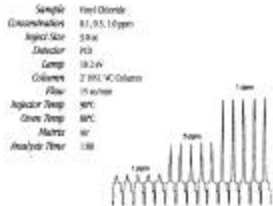
Caffeine with 9.5 eV

Odorants such as THT can be detected at sub ppm levels in natural gas

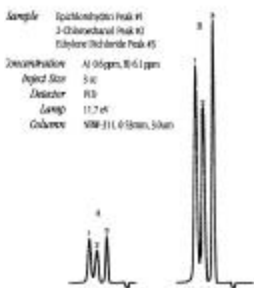


Sample: Tetrahydrothiophene in Natural Gas  
 Peak #11  
 Detector: PID  
 Lamp: 10.2 eV  
 Column: 10% Dinonyl Phthalate on Chromasorb Q HP, 2'  
 Flow: 25 cc/min (Helium)  
 Attenuation: x100  
 Injector Temp: 120°C  
 Oven Temp: 70°C

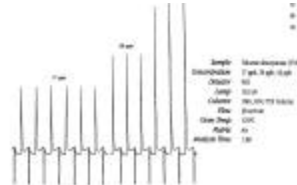
TLV or fenceline measurements of VCM at ppb levels



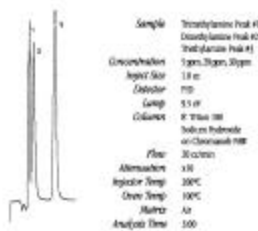
The PID with an 11.7 eV lamp is useful for chlorinated HC with high IP's



TLV or fenceline measurements of TDI



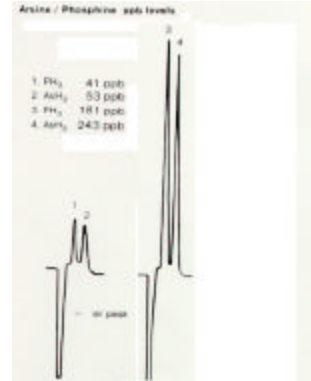
The PID (9.5eV) is useful for the detection of amines at low levels in the presence of ammonia



Semivolatiles-

PCB's in soil

Inorganics- The PID responds to inorganic hydrides with excellent sensitivity as shown below :



Other inorganic species respond with excellent sensitivity including those in the Table below

Detection Limits for Selected Inorganics	
Compound	LLD (pg)
H <sub>2</sub> S	15
PH <sub>3</sub>	20
I <sub>2</sub>	25
NO	52
PH <sub>3</sub> C <sub>2</sub> H <sub>5</sub> (TEL)	100
NH <sub>3</sub>	200
AsH <sub>3</sub>	25

Many other inorganics may be detected - contact factory.

Sulfur compounds



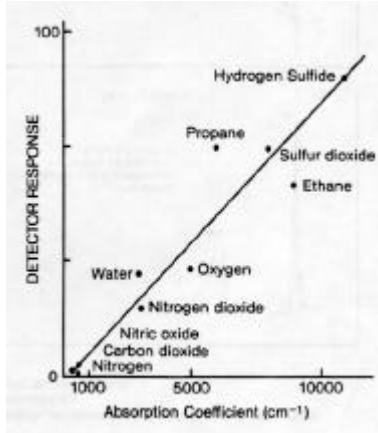
## Far UV Absorbance Detector

The HNU Far UV Detector (FUV) utilizes a simple, compact detector consisting of a stable UV source, absorption cavity (1 cm path), and novel UV photodiode. The detector has a universal response to

all species which absorb in the 120 nm region. See Figure \_ below. No response is observed for

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response is observed for noble gases or nitrogen. Thus, helium or nitrogen make ideal carrier gases. The detector responds in accordance with the Lambert Beer Law:

$$I = I_0 e^{-kx}$$

where **I** = Measured intensity  
**I<sub>0</sub>** = Incident intensity  
**k** = absorption coefficient  
**x** = path length

Photons emitted from the far UV lamp (**I<sub>0</sub>**) are absorbed by molecules passing through the cell causing a net decrease in photon flux to the photodiode (**I**). The changes in photon flux exhibits the Lambert Beers law relationship with concentration. The photodiode responds to the decrease in lamp flux and the change is amplified and recorded.

The linearity of this detector is better than 10<sup>4</sup>. The sensitivity of this detector is similar to the FID for methane and 25-100 times better than a TCD for selected compounds. In addition, the FAV detector is nondestructive and can be run in series with other detectors. Applications include trace levels of O<sub>2</sub>, H<sub>2</sub>O and inorganic gases which have been difficult to detect at sub-microgram levels previously.

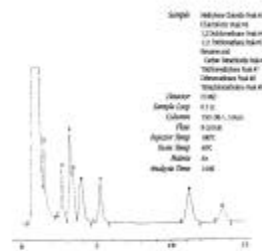
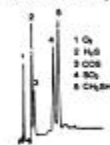
## Features

- *Universal Response-*

**FORMALDEHYDE, MECH, WATER**  
 Concentration: 1 µl Formalin  
 Solution:  
 Sensitivity: 400



**SULFUR GASES**  
 Concentration: ~100 ng



Responds to organic and inorganic compounds that absorb at 120 nm with **detection limits 100 times lower than TCD**

- *Sensitivity-*  
 Subnanogram for most compounds-  
 Suitability for Capillary Column Analysis  
 Low dead volume (<50mL) allows operation with minimum make-up
- *Non Destructive-*  
 Allows series operation of detectors
- *Simplicity of Response*  
 Unidirectional peaks, Beers Law Relationship
- *Adaptability-*  
 Is readily adaptable to any chromatograph
- *Ease of Operation-*  
 - no additional gases needed
- *Linearity-*  
 - >10<sup>4</sup>

The detection limits for a number of compounds are given below in Table:

**DETECTION LIMITS WITH FAR UV ABSORBANCE DETECTOR**

COMPOUND	LLD (ng)	COMPOUND	LLD (ng)
Sulfur Dioxide	0.7	Propane	1
Ammonia	2	Ethylene	1
Water	3	Formaldehyde	2
Hydrogen Sulfide	3	Methanol	27
Nitric Oxide	7	Freon 12	3
Carbonyl Sulfide	7	Methyl Chloride	8
Oxygen	14	Chloroform	5

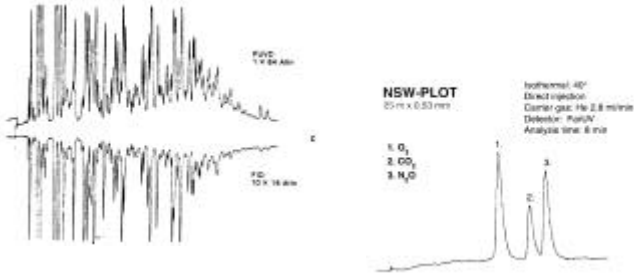
## Applications

- Trace water in helium, nitrogen, semi conductor gases, or process streams
- Detector with nearly universal response & detection limits in the low or sub ppm levels
- Responds to all hydrocarbons with equivalent or better sensitivity for CH<sub>4</sub> than the FID
- Ideal complement to the PID

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water by FUV

## Flame Photometric Detector

In a flame photometric detector, the sample is burned in a hydrogen rich flame and the resulting chemiluminescence (S or P) is detected using a selective interference filter and a photomultiplier tube. The HNU Flame Photometric Detector (FPD) incorporates a *rare earth* glass filter for improved performance.

Our FPD offers a two to three-fold increase in sensitivity for sulfur (S) and phosphorous (P) compared to detectors with interference filters.

Since band pass is no longer dependent on the viewing angle, results are more reproducible-regardless of flame geometry. Sensitivity is significantly increased due to improved interference rejection and a larger effective aperture.

*Only HNU's FPD offers rare earth glass filters for more reproducible results and increased sensitivity.*

Our FPD also includes a quartz flame jet and a cylindrical glass flame shield to reduce hydrocarbon quenching commonly encountered in the sulfur mode. The end of the capillary column is only 3 mm from the base of the flame and is confined within the quartz capillary flame jet-providing low dead volume

and a highly inert sample path.

The detector's clean, miniaturized design makes it ideal for installation onto any Gas Chromatograph. Our dual detection design allows simultaneous selective analysis of S and P compounds-significantly reducing the number of analyses and facilitating compound identification.

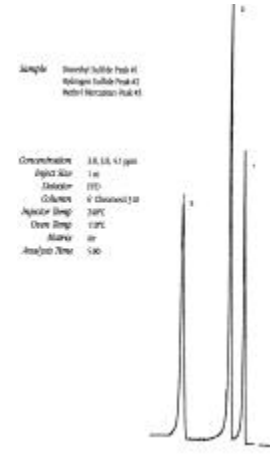
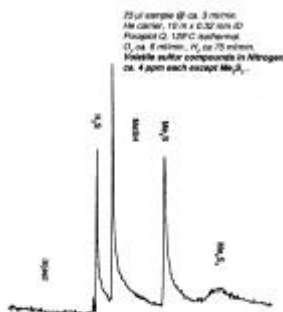
An adjustable root function in the range of XO I - XO-1 can be set to linearize the detector output.

The HNU FPD is ideal for use in the following applications:

- Mercaptans and sulfur compounds in paper plant
- Sulfur and Phosphorus based pesticides
- Environmental detection of S or P compounds
- Sulfur impurities petroleum streams
- Sulfur compounds in natural gas
- Process streams or stacks
- Ambient monitoring of S or P compounds

### Features

- Rare earth filters for S & P improve detector performance
- Quartz jet
- Improved sensitivity
- Improved reproducibility



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## Electron Capture Detector

The HNU electron capture detector (ECD) uses a sealed  $^{63}\text{Ni}$  beta emitter as the source. As electron absorbing species pass through the detector, they reduce the current between the electrodes and produce a response. The linearized response is due to constant current design of the electronics.

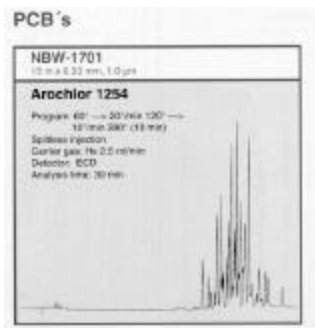
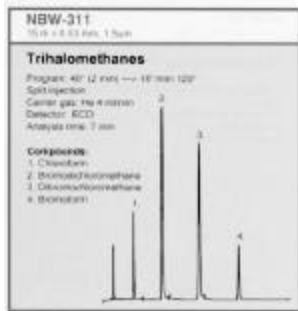
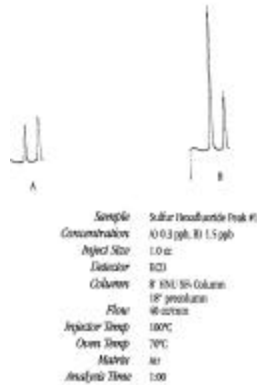
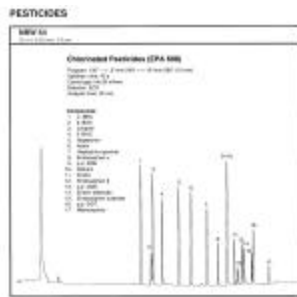
This compact detector can be easily added to any GC to enhance the environmental capabilities. Many of the semi-volatile species found in soil are chlorinated (PCB's, pesticides) and respond strongly to the ECD.

### Features

- Selective response to electron absorbing species- halogens, nitro compounds
- Wide linear range-  $> 10^4$
- Compact design
- High sensitivity- pg or sub pg detection limits
- *Adaptability*- Is readily adaptable to any chromatograph

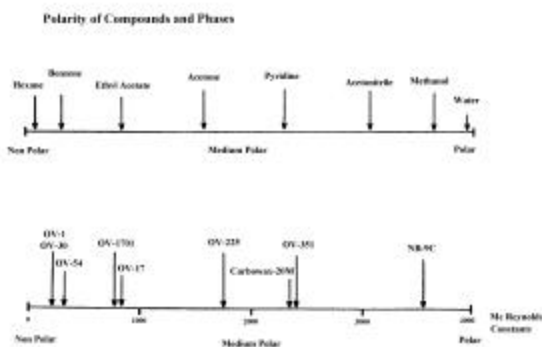
### Applications

- Specific detection of chlorinated hydrocarbons, PCB's, pesticides, chloro phenols, nitro compounds in soil, water, & air
- $\text{SF}_6$  tracer gas



# Column Selection

The stationary phase is most influential column parameter since it determines the final resolution and has an influence on the sample capacity and the analysis time. The most important thing to remember is that "likes dissolve likes". Separate non polar compounds on a non polar column and polar compounds on a polar column. In Fig. 1, the range of polarity of a group of organic compounds is compared with the polarity of different phases.

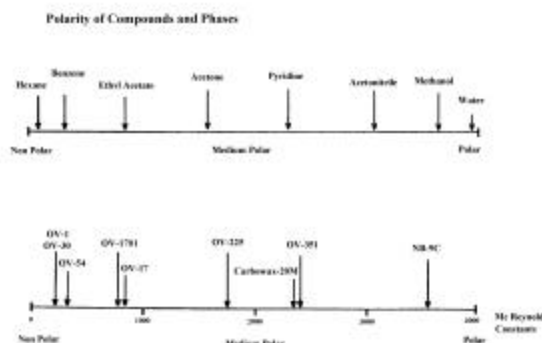


**Fig. 1 Polarity of Compounds and Phases**

In other words, if one has non polar hydrocarbons to separate, use a non polar phase like (SE30, NBW30); with more polar compounds like alcohols, esters use a polar phase like carbowax, etc. The data in Table II lists the optimum liquid phases on a packed or capillary column for a variety of analytes. The terminology in Table II is the of Ohio Valley Specialities (OV). These silicone phases in order of polarity are least polar (OV1, OV101), medium polarity (OV1701), and most polar (OV275). Their composition is as follows:

## List of GC Applications and Column Phases

Applications	Column Phases
Alcohols	Carbowax 20M, OV1701
Aldehydes	Carbowax 20M, OV1, SE30
Amines	OV54
Aromatic HC	Carbowax 20M
Dioxins	OV54
Glycols	Carbowax 20M, OV1701
Halogenated HC	OV54, OV1701
Ketones	OV1, OV54
PAH's	OV54, OV1701
PCB's	OV54, OV1701
Pesticides Triazine herbicides EPA 608	OV351, OV225 OV54, OV1701
Phenols Free Acetylated	OV1, OV225 OV54, OV1701
Solvents	OV54, OV1701



Many of the phases used in packed columns are also used in capillary columns with much greater effect on the latter. In general, a significantly larger number of peaks are usually detected with a capillary column compared to a packed column.