The Hazardous Environment Detection Company

Thank You for Attending Today's Webinar:

Intro to PIDs for Gas Detection Applications

Your Host

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What is a PID?

What is a PID?

- PID = Photo-Ionization Detector
- Detects VOCs (volatile organic compounds) and Toxic gases from <10 ppb to as high as 10,000 ppm
- A PID is a very sensitive broad spectrum monitor, like a “low-level LEL”

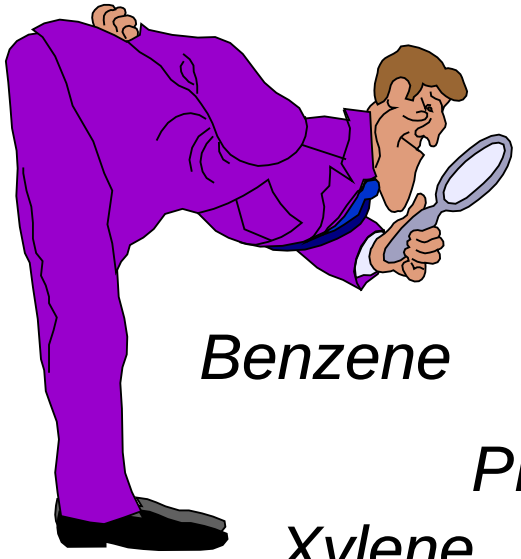
Who uses PIDs?

Anyone involved with the use of chemicals, gases and petroleum products

- Environmental
- Industrial Hygiene
- Safety
- Hazardous Materials Response (HazMat)
- Maintenance/Operations

A PID is like a Magnifying Glass

A Magnifying glass lets a detective see fingerprints; a PID lets us "see" VOCs



Ammonia

Carbon Disulfide

Benzene

Styrene

PERC

Jet Fuel

Xylene

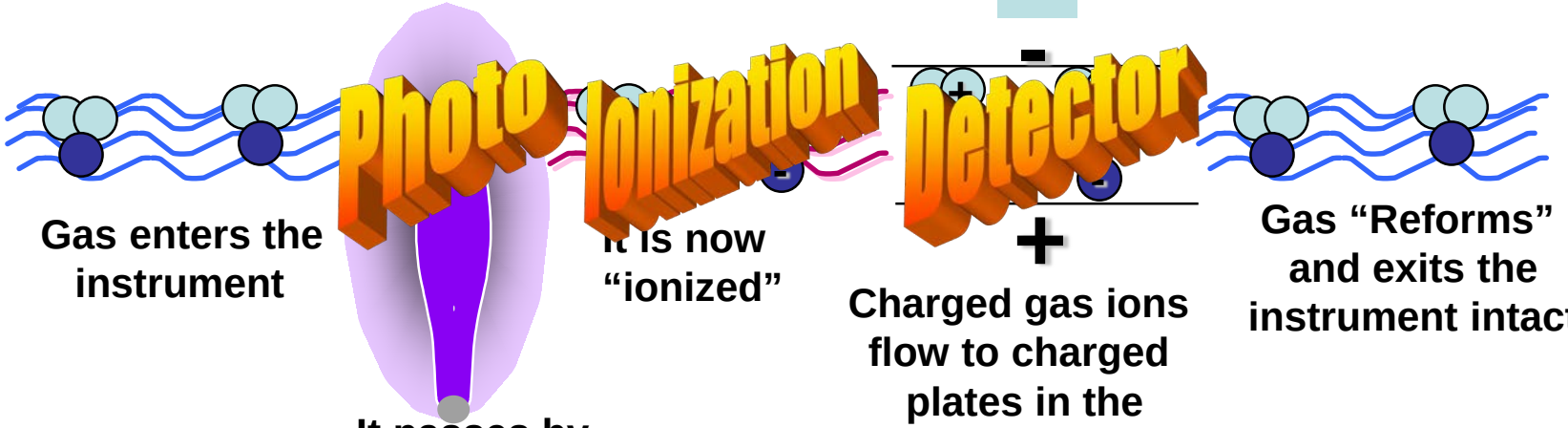
Identify then Quantify!

How does a PID work?

- Most gases have a specific Ionization Potential (IP), measured in Electron Volts (eV)
- An Ultraviolet lamp ionizes a sample gas which causes it to charge electrically
- If the IP of the gas is less than the eV output of the lamp the gas will be ionized
- The sensor detects the charge of the ionized gas and converts the signal into current
- The current is then amplified and displayed on the meter as “ppm”

How does a PID work?

An optical system using Ultraviolet lamp to breakdown vapors and gases for measurement



Current is measured and concentration is displayed on the meter.

Gas enters the instrument

It passes by the UV lamp

It is now "ionized"

Charged gas ions flow to charged plates in the sensor and current is produced

Gas "Reforms" and exits the instrument intact

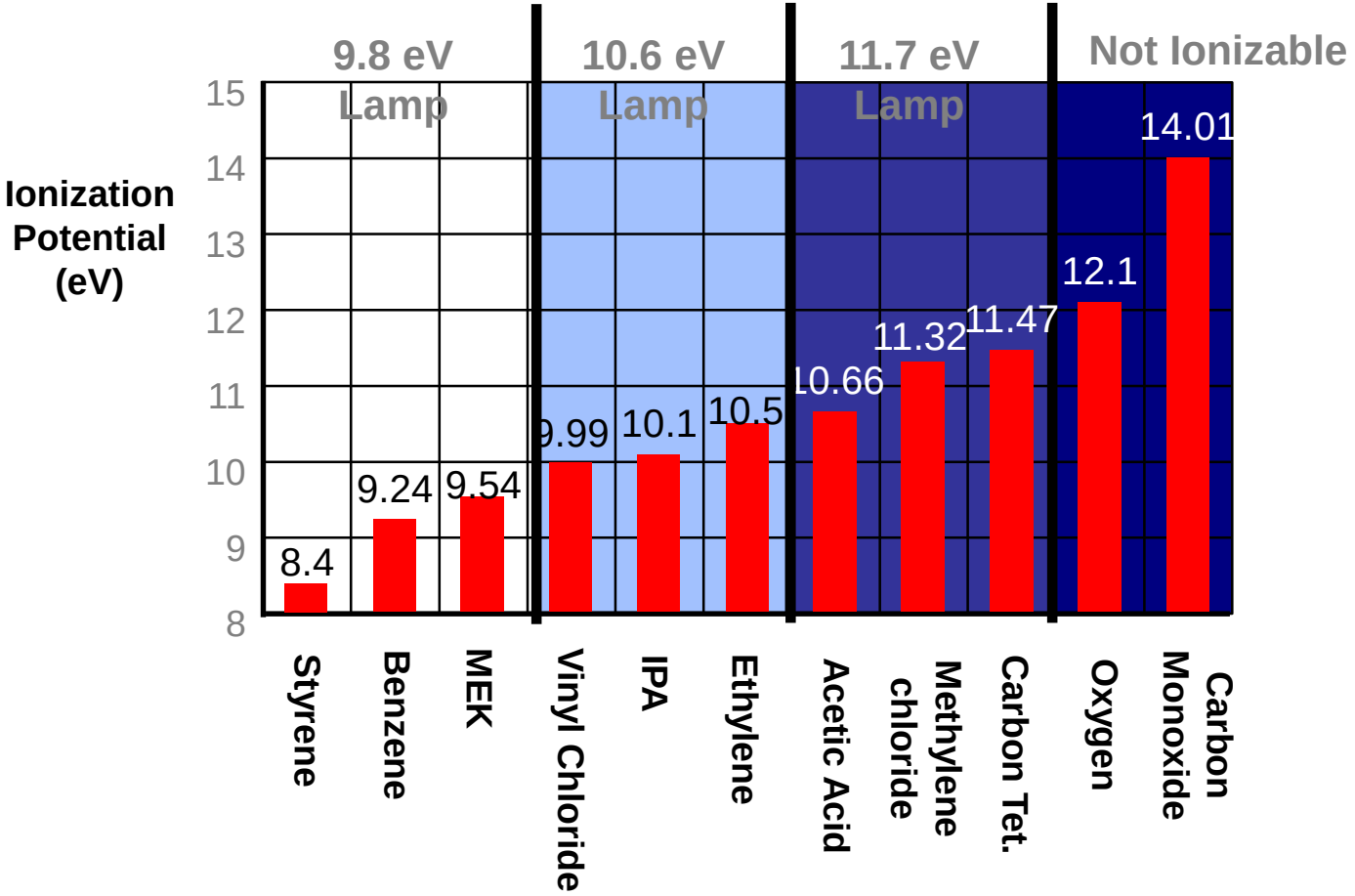
Ionization Potential

- IP determines if the PID can “see” the gas
- If the IP of the gas is less than the eV output of the lamp the PID can “see” it
- Ionization Potential (IP) does not correlate with the Correction Factor
- Ionization Potentials are found in RAE handouts (TN-106), NIOSH Pocket Guide and many chemical texts.

If the "wattage" of the gas or vapor is less than the "wattage" of the PID lamp then the PID can "see" the gas or vapor!

What does a PID Measure?

Some Ionization Potentials (IPs) for Common Chemicals



What does a PID Measure?

- Organics: Compounds Containing Carbon (C)
  - **Aromatics** - compounds containing a benzene ring
    - BETX: benzene, ethyl benzene, toluene, xylene
  - **Ketones & Aldehydes** - compounds with a C=O bond
    - acetone, MEK, acetaldehyde
  - **Amines & Amides** - Carbon compounds containing Nitrogen
    - diethyl amine
  - **Chlorinated hydrocarbons -** trichloroethylene (TCE)
  - **Sulfur compounds –** mercaptans, carbon disulfide
  - **Unsaturated hydrocarbons** - C=C & C C compounds
    - butadiene, isobutylene
  - **Alcohol's**
    - ethanol
  - **Saturated hydrocarbons**
    - butane, octane
- Inorganics: Compounds without Carbon
    - Ammonia
    - Semiconductor gases: Arsine

What PIDs Do Not Measure

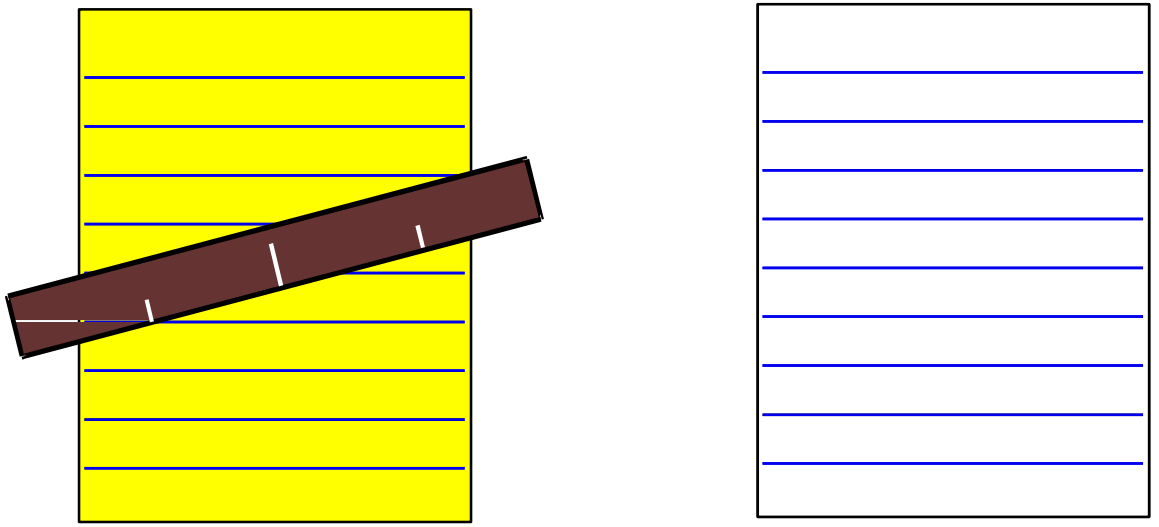
- Radiation
- Air
  - N_2
  - O_2
  - CO_2
  - H_2O
- Toxics
  - CO
  - HCN
  - SO_2
- Natural gas
  - Methane CH_4
  - Ethane C_2H_6
- Acids
  - HCl
  - HF
  - HNO_3
- Others
  - Freons
  - Ozone O_3

Why not always use 11.7 eV Lamps?

- 9.8 & 10.6 provide more specificity
- 10.6 lasts 24-36 months
- 10.6 provides best resolution
- 10.6 costs less ($195)
- 11.7 is required for high energy compounds like Methylene Chloride
- 11.7 crystal absorbs water and degrades
- 11.7 lasts about 2-3 months
- 11.7 costs more ($345 in ampule)

Selectivity Vs Sensitivity

- PID is very sensitive and accurate
- PID is not very selective



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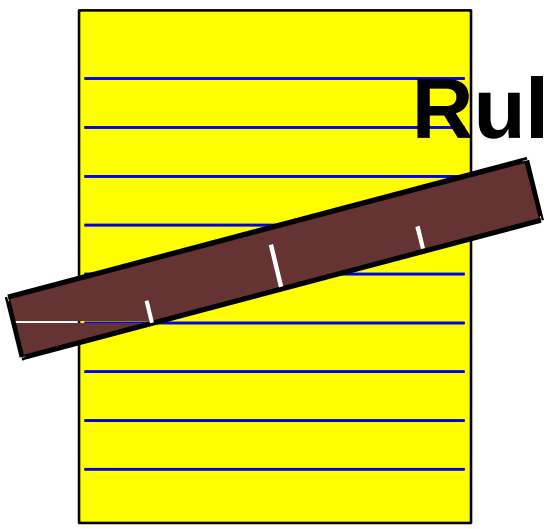

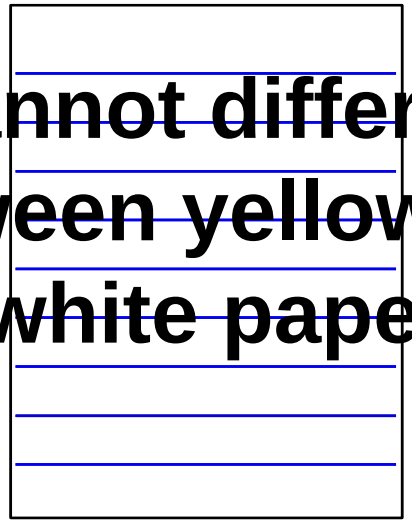

Ruler cannot differentiate between yellow and white paper

Selectivity Vs Sensitivity

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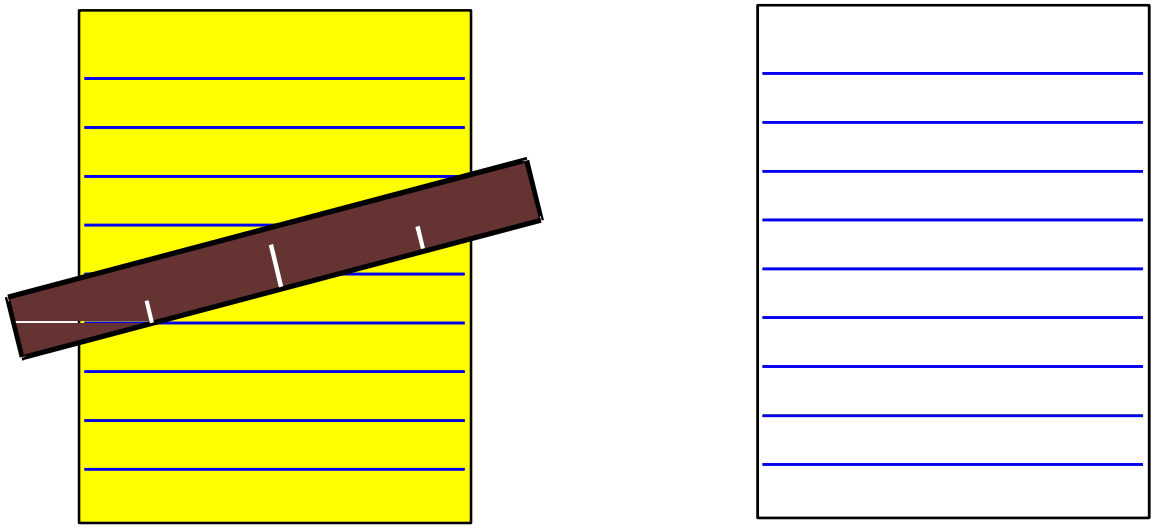


PID can’t differentiate between ammonia & xylene

Correction Factors are the key to unlocking the power of a PID for Assessing Varying Mixtures and Unknown Environments

What is a Correction Factor?

- **Correction Factor** (CF) is a measure of the sensitivity of the PID to a specific gas
- CFs are scaling factors, they do not make a PID specific to a chemical, they only correct the scale to that chemical.
- Correction Factors allow calibration on cheap, non-toxic “surrogate” gas.
- Ref: RAE handout TN-106

CF's measure sensitivity

Low CF = high PID sensitivity to a gas

- If the chemical is bad for you then the PID needs to be sensitive to it
  - ***If Exposure limit is < 10 ppm, CF ≤ 1***
- If the chemical isn't too bad then the PID doesn't need to be as sensitive to it
  - ***If Exposure limit is > 10 ppm, CF ≤ 10***
- Use PIDs for gross leak detectors when CF > 10

CF Example: Toluene

- Toluene CF with 10.6eV lamp is 0.5 so PID is very sensitive to Toluene
- If PID reads 100 ppm of isobutylene units in a Toluene atmosphere
- Then the actual concentration is 50 ppm Toluene units

$$0.5_{CF} \times 100\ ppm_{iso} = 50\ ppm_{toluene}$$

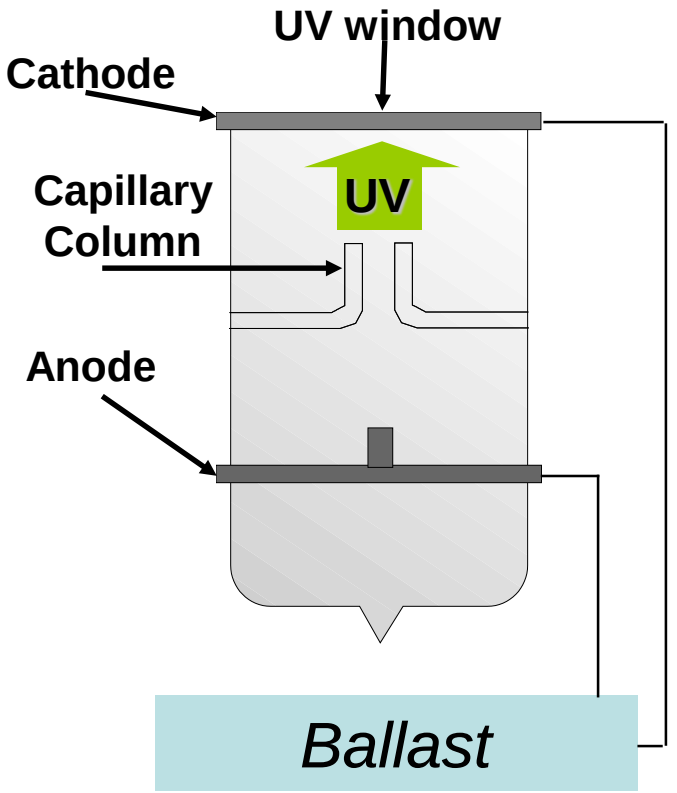
CF Example: Ammonia

- Ammonia CF with 10.6eV lamp is 9.7 so PID is less sensitive to Ammonia
- If PID reads 100 ppm of isobutylene units in an Ammonia atmosphere
- Then the actual concentration is 970 ppm Ammonia units

$$9.7_{CF} \times 100\ ppm_{iso} = 970\ ppm_{ammonia}$$

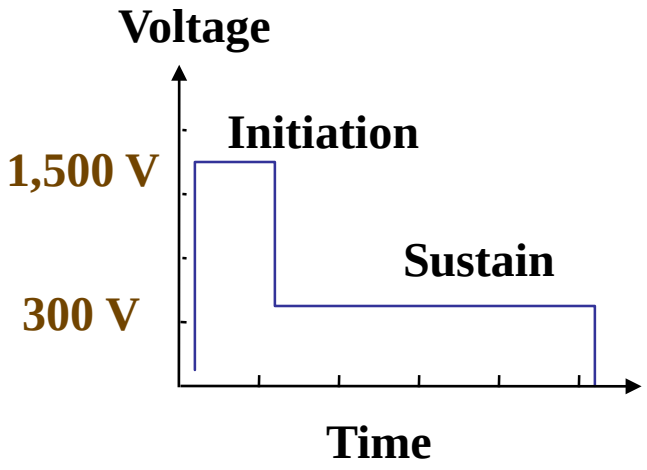
Electrode Discharge PID lamp

- Internal Contamination
  - Eroding electrodes deposit on glass reducing light output causing span & zero drift
- Metal to glass interfaces prone to failure
  - They expand & contract differently when heated (thermal stress) causing lamp failure
- High power consumption
- High RFI
- HNU & 580B



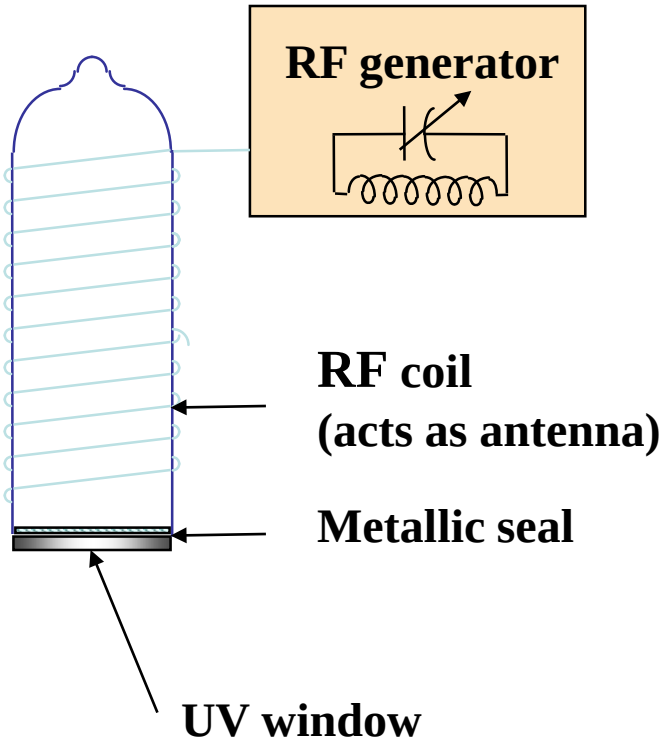
1960's valve electronics

- High Power Consumption
  - Several watt lamp wastes energy as heat, requires large batteries



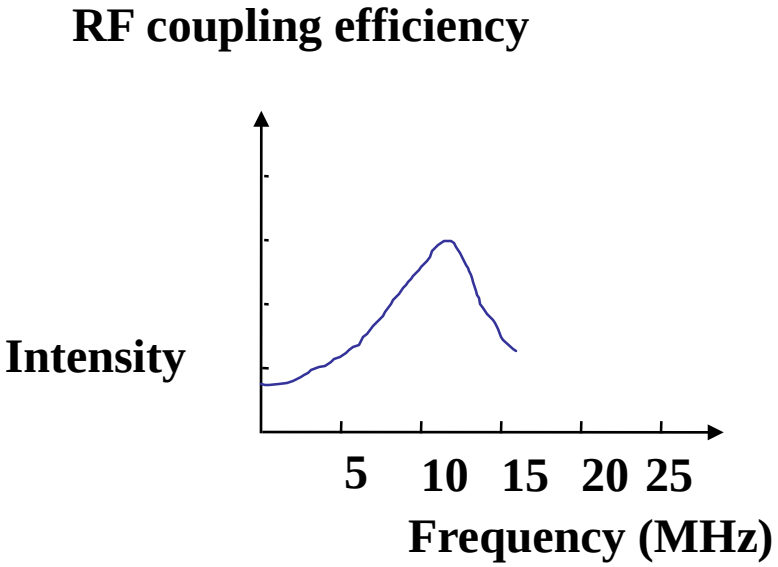
RF Excited PID lamp

- High Power Consumption
- Subject to RFI
  - High frequency energy (12-14 MHz) effected by radios & power lines
- Higher Maintenance
  - RF coupling efficiency requires perfectly tuned driving circuit
  - Complex circuits require constant tuning
- 2020, Passport, 580EZ



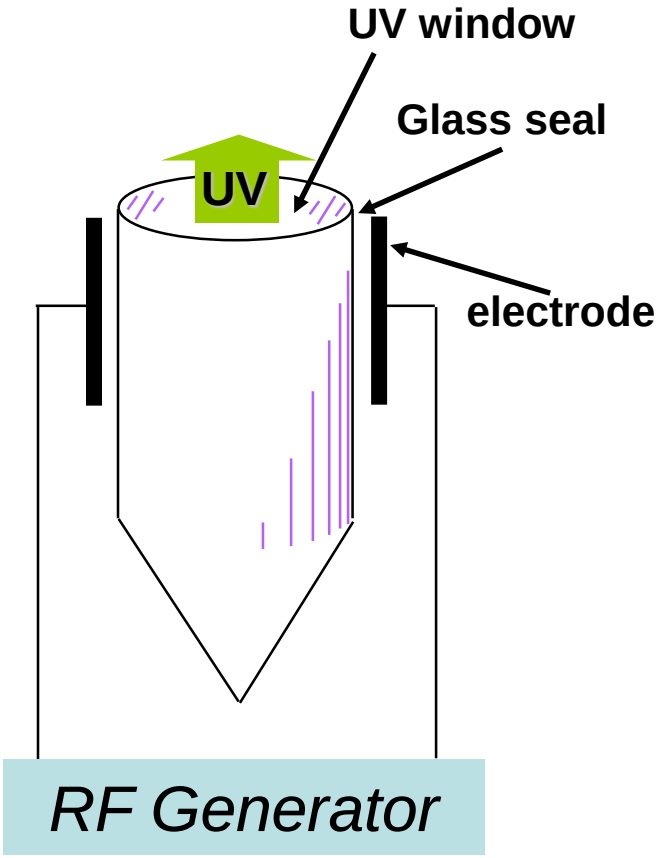
RF Excited PID lamp

- High Power Consumption



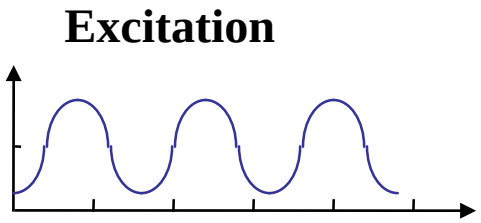
Electrodeless Discharge PID lamp

- Extremely low power draw
  - cool lamp and small batteries
- No internal contamination
  - externally excited with no metal in them to damage, erode or migrate
- Extremely rugged
  - Sealed lamp window with no metal to glass interfaces to fail (10.6eV)
- Inexpensive to replace
- RAE Systems

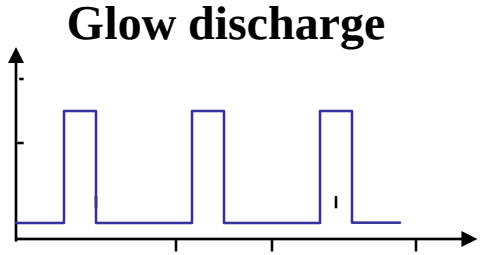


Electrodeless Discharge PID lamp

- Virtually no RFI or EMI
  - Low-frequency electric field excites lamp like cooking a hotdog in a microwave
  - Oscillation frequency is well below radio frequencies



Low frequency < 100kHz



Time constant of ionization chamber & PID circuit > RF excitation signal

Summary of UV Window Seals

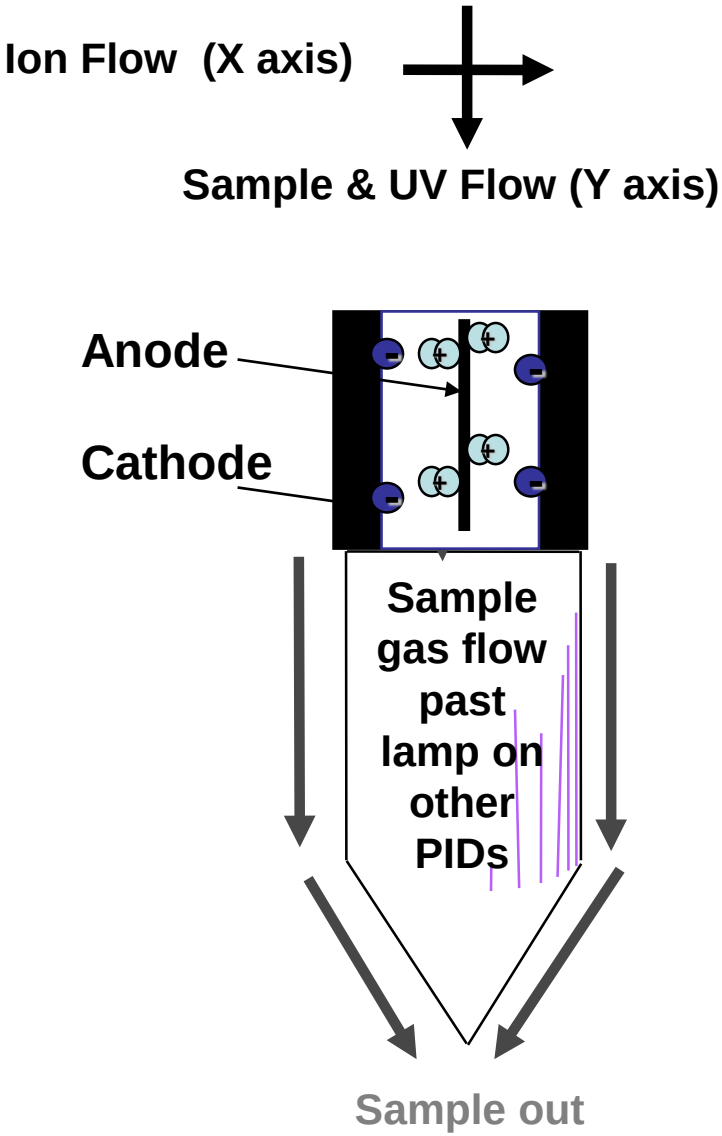
Glass to metal seal

- Metal vaporization of internal anode contaminates inside of UV lamp
- Different thermal expansion coefficients of glass & metal develops thermal stress
- Minute cracks & leakage leads to shorter lifetimes

Welded Glass to Glass Seal

- Laser welded - extremely strong seal
- Rugged - high mechanical strength
- Matched thermal expansion
- Low leakage
- Longer operating life (1-2 years)

Axial Flow PID Ionization Chamber

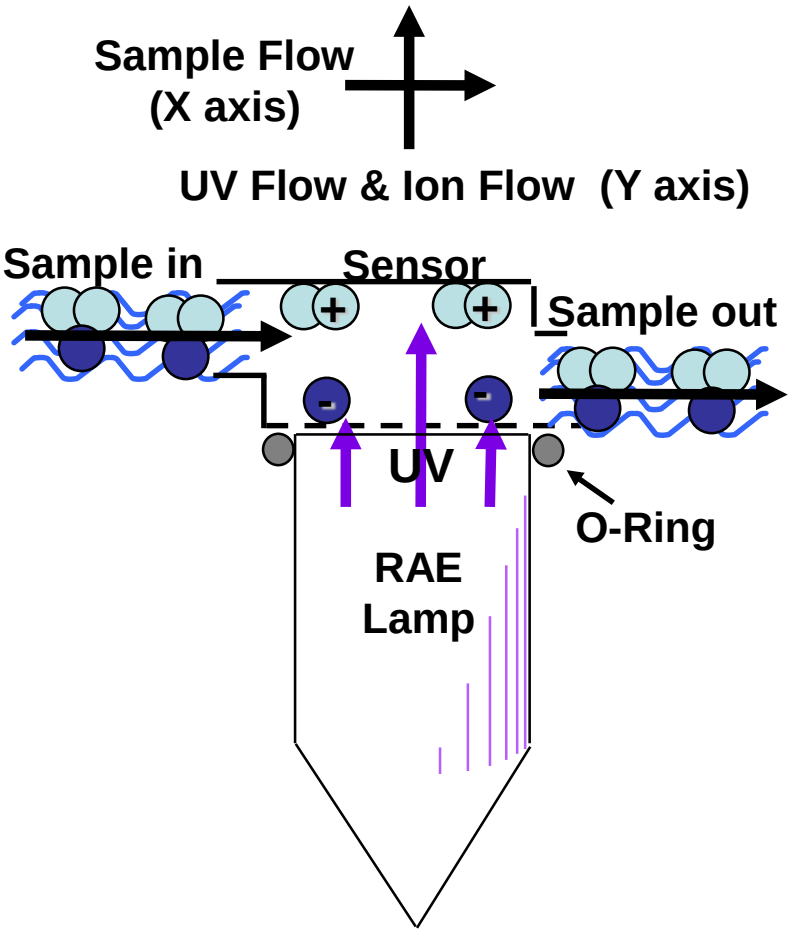


- **Slower Response Time**
  - High Sample Volume: Light has further to travel
  - High bias Voltage: requires more power
- **Slower Recovery Time**
  - More volume to clear of sample
- **Greater Humidity affects**
  - Light has further to travel
- **More lamp cleaning**
  - Sample & contaminants directed to lamp face

Advantages of the RAE "2-D" Sensor

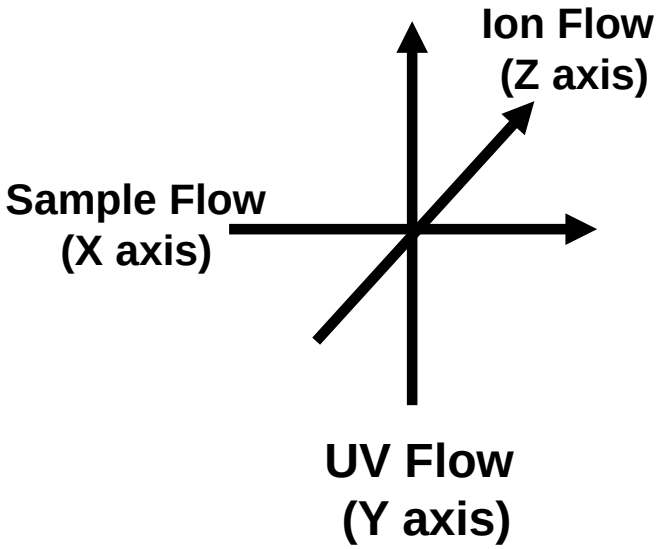
Laminar Flow

- **Faster response**
  - Less than 3 sec. to 90%
  - Reduced sensor chamber volume with lower bias voltage (less power)
- **Faster recovery**
  - Quickly returns to zero
  - O-ring seals lamp chamber
- **Lower humidity response**
  - Short light path reduces affects of humidity
- **Less lamp cleaning**
  - Dirt "keeps going"

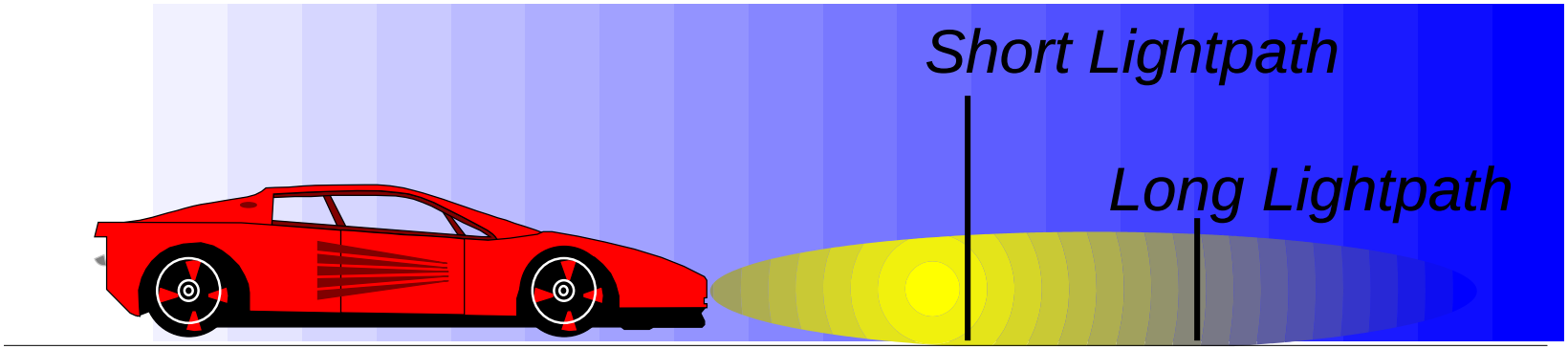


Advantages of the RAE "3-D" Sensor

- Extremely Linear
- Fastest response & recovery
  - Less than 3 sec. to 90% up to 10,000 ppm!
- Lowest humidity response
  - prevents dirt from shorting out sensor
- Simple lamp & sensor cleaning

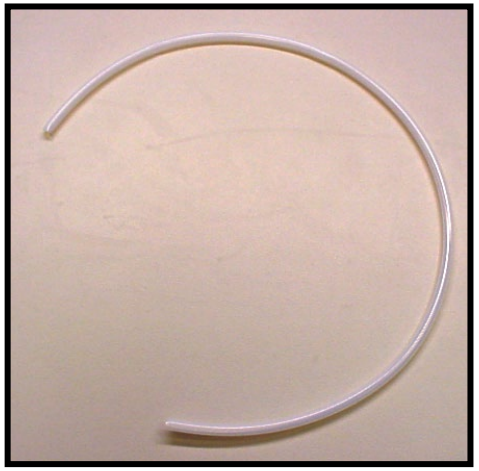


How Humidity Affects PID



- The closer to the headlights the easier it is to see something through fog.
- By reducing the distance the UV light travels in a PID the affects of humidity are drastically reduced

PID: Tubing



- Never Use Tygon tubing!
  - Absorbs chemicals like a “sponge”
  - Reduces ppm readout when chemicals exist
  - Causes “false positives” when chemicals don’t exist
- Always use Teflon or similar non-reactive tubing
  - Will not absorb chemicals but might get coated
  - Clean with anhydrous methanol if it gets dirty

PID: Maintenance

- PID Drift is Due to Poor Sampling Technique
  - Aspirating liquids & vapors into sample probe
  - Aspirating dirt samples into sample probe
  - Hot liquids and vapors condensing in probe & sensor
  - Touching contaminated surfaces with probes
- Clean PID Lamp & Sensor
  - When display creeps upwards after good zero
  - When PID responds to moisture
  - When movement of PID results in response on display

PID: Maintenance

- How to Clean PID Sensor
  - ***Always clean sample probe and replace or clean filters FIRST!*** If PID holds a stable zero after this step then further cleaning may not be necessary
  - Use isopropanol and NOT anhydrous methanol (Lamp cleaning solution)
  - Clean lamp face with lens tissue
  - Clean sensor by immersion in cleaning solution (an ultrasonic cleaner will speed cleaning)
- Drying the PID
  - Let air dry overnight
  - Warm air (not hot) will speed drying

Questions?

The Hazardous Environment Detection Company

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