

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)	
)	
PROPOSED AMENDMENTS TO)	
CLEAN CONSTRUCTION OR DEMOLITION)	R2012-009
FILL OPERATIONS)	(Rulemaking-Land)
(35 ILL. ADM. CODE 1100)	

NOTICE OF FILING

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Please take notice that I have today filed electronically with the Office of the Clerk of the Illinois Pollution Control Board the attached Pre-filed First Notice Comments of the Illinois Transportation Coalition and accompanying Attachments, a copy of which is served upon you.

HUFF & HUFF, INC.

By: 
 Senior Vice President

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JAMES E. HUFF, P.E., ON BEHALF OF THE ILLINOIS TRANSPORTATION COALITION
PRE-FIRST NOTICE COMMENTS ON THE PROPOSED CLEAN CONSTRUCTION
OR DEMOLITION DEBRIS FILL OPERATIONS

The Illinois Pollution Control Board (Board) has completed a series of hearings on the Illinois Environmental Protection Agency’s (Agency’s) proposed Clean Construction or Demolition Debris (CCDD) fill operations regulation. Subsequent to the last hearing, the Agency submitted Errata Sheet Number 3. This Errata Sheet amends proposed Section 1100.610(b) to allow the use of the TCLP or SPLP test method in lieu of the total concentration for inorganics where the background concentration was utilized to establish the Maximum Allowable Concentration (MAC). This is particularly significant with respect to arsenic, where naturally occurring arsenic in soil across all of Illinois above the *background* concentration of 13 mg/kg are routinely present. This subject was a source of significant confusion during the hearings by both the regulated community and the Agency¹. This change will eliminate the economic burden of landfilling naturally occurring arsenic, and the Transportation Coalition² supports this change.

There remains a number of troubling aspects with the proposed regulation, as described during the various testimonies. Central to some of these issues is the interpretation of the statute by the Agency used in drafting regulations. Thus, starting with the statute is a logical place to begin before getting into the more detailed aspects of the regulations.

HB1671 – Section 3.160(c) simply defines “uncontaminated soil” as “soil that does not contain contaminants in concentrations that pose a threat to human health and safety and the environment.” Nowhere is there any requirement that the maximum concentrations of contaminants shall be uniformly applied, while the same section repeatedly references 35 IAC 742, which utilizes a number of site specific conditions to determine *uncontaminated* soils. The Agency testified that it “wanted uniformity for CCDD sites and soil fill operations,”³ while minimizing any economic impact.⁴ Nowhere is there any requirement to apply ingestion and

¹ October 26, 2011 transcript, page 51-64.

² Illinois Tollway; Kane County Division of Transportation, Lake County Division of Transportation, DuPage County Division of Transportation, McHenry County Division of Transportation, and Will County Department of Highways; the Cities of Geneva and St. Charles, and the Villages of Hinsdale, Libertyville, New Lenox, Villa Park, and Woodridge.

³ Doug Clay, Transcript September 26, 2011, page 103.

⁴ The Statement of Reasons filed on pages 6 and 7 only identified the cost of completing the soil certification form from generators of CCDD and clean soil, ignoring totally the cost for rejected loads or material that no longer can go to such sites.

inhalation tier 1 remedial objectives to CCDD and clean soil placed below the water table, which is the vast majority of the material, when those pathways are not relevant to water saturated soils.

Claire Manning, who was very involved in the legislative development on behalf of the Chicago Public Commission, noted that there is nothing in the legislative history that requires uniform Maximum Allowable Concentrations.⁵

Soil pH – For most inorganic and for ionized organic compounds, the limiting pathway is the soil migration to groundwater pathway. As the pH declines, the amount of most metals that will leach into the groundwater increases, thus TACO has a table of remedial objectives for these compounds based on pH ranges. Under TACO, the soil pH of the material is measured, and from this the remedial objective can be determined. The Agency elected to take a different approach under the proposed CCDD regulations, attempting to utilize a single pH range for establishing the MACs.

The Agency's has proposed using the lowest pH range for soils found anywhere within Illinois for specifying MACs for ionized organic and most inorganic compounds. This is the most controversial part of the proposed regulations remaining. It is actually unclear from the record whether the Agency is concerned about 1) soil pH in the vicinity of the former quarries; 2) the pH of the material brought into a quarry; or 3) both.

The Agency utilized **soil** data from the U.S. Department of Agriculture that covers only the top 80 inches of soil in Illinois. The former quarries currently being used for CCDD and clean soil fills mined sand and stone, not soil. It makes no technical sense to use **soil** pH data to establish possible pH ranges in these former **stone/sand** quarries. These quarries routinely dewater during filling with CCDD and clean soil, and routinely monitor groundwater pH. Despite the Agency's unsupported belief that such data "more accurately represent groundwater conditions than they do conditions in the fill,"⁶ these data do reflect the local impact from fill material. Attachment 1 is a copy of pH data provided by the Illinois Association of Aggregate Producers from its members from pumped groundwater under the NPDES permit program. These data are from the de-watering discharges from the quarries. It is our understanding that the Illinois Association of Aggregate Producers provided this table to the Illinois EPA. From a representative perspective, the average pH column is indicative of actual conditions. **The lowest average pH at any facility is 7.17**, well above the pH range of 4.5 to 4.74 proposed by the Agency in establishing MACs for inorganic compounds and ionizing organic compounds. In fact, the lowest pH value recorded was 5.40, and the next lowest was 6.11.

Limestone aggregate, clay, and organic matter all contribute to a significant buffering capacity in soils and any aggregate present in the material will result in alkaline pH values as clearly evidenced by the data in Attachment 1. Limestone is routinely used to raise the pH of acidic soils, and it typically takes only 0.6 pounds of limestone per ton to increase the soil pH from 5.5 to 6.5. This built in buffering capacity of the soil and lime (concrete and stone) present in CCDD material, would make acidic pH values highly unlikely within any CCDD and clean soil fill sites. This statement was confirmed in the pre-filed testimony of John E. Hock, who reported on 44

⁵ October 25, 2011 Transcript, page 140.

⁶ September 26, 2011 Transcript, page 45.

soil samples collected from within CCDD facilities. The pH of the samples ranged from 7.3 to 11.0 with an average value of 8.1.⁷ **No pH values below a pH of 7.0 were encountered in any of the 44 samples.**

Recall from James Huff's pre-filed testimony Attachment 2, First Environmental Laboratories has 8,500 pH analyses in its database since January 2006 on solid samples (soil and non-soil samples). For the entire database, 97.35% exceeded a pH of 6.25, and the laboratory noted that a significant portion of the lower pH samples were on non-soil samples.

In summary, taken collectively the record shows;

- the Illinois Association of Aggregate producers groundwater pH data,
- the collection of 8,500 solid pH measurements by an Illinois laboratory that indicate 97.35% of the solid samples have had a pH in excess of 6.25, and
- the 44 samples from fill areas reported by Mr. Hock, which had a minimum pH of 7.3.

There is sufficient basis to justify using the approach of computing the MACs for inorganic compounds and ionizing organics using the site specific pH data from each source of material accepted. This is totally consistent with the TACO program currently, and would be our recommendation. Such an approach has worked well in the TACO program, and there is no reason to expect it would not work as well in this program. There is sufficient buffer capacity in the fill material that low pH values are not a real concern, and both the available groundwater and soil fill data support this position. Uniform MACs for convenience does not support the very significant extra economic burden to support such an approach.

Should the Board concur with the Agency's interpretation that the legislative intent to require only one numerical list of MACs, we would suggest they be based upon a pH range of 6.25 to 6.64. Based on Mr. Hock's findings of a minimum pH of 7.3 within the fill at these sites, there would be a significant margin of safety with use of this pH range to set MACs. Factored in with the groundwater data from these same facilities such an approach would be conservative. If the Agency remains concerned over the potential impact of lower pH soils having a negative impact, despite the buffering capacity of the soil and alkaline nature of fill material, a minimum pH limit on the CCDD and clean soil accepted could be set at 6.25. Note, this approach is only offered as an alternative should the Board believe a uniform approach is required under the statute.

Compositing versus Grab Samples-Implementation of HB-1671 has been on-going since July 2010, without any guiding regulations. The professionals that have been called upon to certify material as uncontaminated have utilized their training and experience to carry out their responsibilities. Testing has routinely been conducted, even when *no recognized environmental conditions* are present. The Agency noted that TACO allows averaging and compositing in some cases, so for "practicality and to remain protective" the Agency has decided to disallow compositing (and averaging).⁸ When trying to have the Agency acknowledge that composite samples are more representative, Dr. Hornshaw responded, "The Agency does not require

⁷ Pre-filed testimony of John E Hock, P.E. pages 3-4.

⁸ Pre-filed Testimony of Thomas C. Hornshaw, page 5.

representative soil samples when demonstrating compliance using Section 1100.610B”.⁹ Dr. Hornshaw goes on to note, “In the absence of a logical and meaningful averaging and compositing strategy for fill operations, the Agency has determined that averaging and compositing are inappropriate.”¹⁰ Yet Dr. Hornshaw acknowledged that for arsenic, if 20 samples are collected, statistically he would expect one (1) sample to exceed the 13 mg/kg MAC due to naturally occurring arsenic.¹¹ Doug Clay opined that the area with naturally occurring arsenic above 13 mg/kg should be “treated as waste, and taken for disposal.”¹²

The Agency’s position is illogical, and Errata 3 is a partial recognition of this, which proposes using the SPLP or TCLP test in lieu of testing for total arsenic. It still does not correct for the problem this creates if the P.E. or P.G. elects to test for total arsenic on grab samples. All material that goes to CCDD and clean soil fill sites are excavated, loaded in trucks, and transported to the facilities. Often the material is stockpiled between excavation and loading of trucks. The material could be tested at this point, after it has been mixed, would be more representative of the material brought into CCDD and clean soil fill sites. However, this practice has the potential to cause construction delays, and typically there is limited room to stockpile any significant amount. Thus, the industry practice on all but small construction jobs is to pre-sample using a drill rig prior to the soil being excavated at the start of construction. The Agency’s proposal will result in a significant increase in the amount of soil rejected that could be placed in CCDD and clean soil facilities that would meet the definition of uncontaminated at the time of placement, and therefore would not pose any unacceptable risk to human health or the environment.

Analytical costs for discrete samples are significant, and for linear projects, these costs add up rapidly. When fill has been used historically prior to any construction, it was placed in layers. Below the fill are the natural soils. To address this fill-to-native soil change, standard sampling practice has been to composite samples by depth prior to analysis, (except for volatiles organic compounds). This procedure has been effective in identifying and testing fill layers separately from soil layers. Fill layers have a higher probability of containing elevated levels of polynuclear aromatic hydrocarbons (PNAs) and metals than do native soils.

Under the proposed Agency change to grab samples only, analytical costs will increase dramatically. For example, a simple one mile road project with no recognized environmental conditions (RECs) would typically have six soil borings, and if four samples from each boring were necessary to reach the necessary construction depth, then four composite samples would be analyzed. Now if each discrete sample is analyzed, the costs increase six-fold, or in this example to 24 samples for analysis. The alternative is fewer samples for analyses, but this would increase the potential for missing contaminated soil, which was not tested. **Such an approach would be less protective of the environment than compositing.** The proposed regulations rely on the P.E./P.G. to use their expertise to assure protection of the environment, and the type of samples should be left to the professional, just like the number and location of samples. To address the Agency concern about attempting to dilute contaminated soil by compositing samples, a more

⁹ October 26, 2011 Transcript, page 25.

¹⁰ October 26, 2011 Transcript, page 27.

¹¹ October 26, 2011 Transcript, page 29.

¹² October 26, 2011 Transcript, page 30-31.

logical approach would be to require grab samples where RECs are being addressed, and allow compositing for all areas without any identified RECs. In theory no testing is required where no RECs have been identified, but as Mr. Huff testified, the CCDD facilities have routinely required analytical on all projects, and many P.E./P.G.s also are not comfortable with signing the 663 Form without actual analytical results.¹³

Potentially Impacted Property-The October 26, 2011 hearing was dominated by the Agency trying to explain the term “potentially impacted property”. There remains considerable confusion on this definition. The Agency continued to reference ASTM Standard Practices for Environmental Site Assessment Phase 1 Environmental Site Assessment E1527-05.¹⁴ This ASTM standard uses a term *Recognized Environmental Condition* or *REC* that has been used nationally for more than two decades. In attempting to get the Agency to acknowledge that *Potentially Impacted Property* and *REC* are the same thing, the Agency avoided answering directly, but finally acknowledged they could be the same.¹⁵ This confusion could simply be eliminated by replacing *Potentially Impacted Property* with *Recognized Environmental Condition*, as defined by ASTM. As the ASTM standard has been THE standard used for over 20 years by environmental professionals, adoption of RECs would eliminate much confusion.

Section 1100.755(d) Corrective Action that achieves compliance with 35 Ill Adm. Code 620 beyond the fill operation’s property boundary – This section has no place in the CCDD regulations and will cause very significant economic hardship within Illinois. As the Agency noted, “we have our interpretation” of the non-degradation requirements, and declined to answer a question as to what non-degradation requirement means.¹⁶ As the draft regulations already require achieving the Class I groundwater standards on the property, that should be sufficient to protect our State’s groundwater resources. We would propose the Board remove Section 1100.755(d) from final regulations.

Groundwater Monitoring and Achieving Class I Standards-The lack of data on groundwater impacts from CCDD and clean soil fill sites motivated the Agency to propose a groundwater monitoring program and the requirement of achieving Class I standards. Despite the groundwater data provided with Mr. Huff’s pre-filed testimony,¹⁷ that showed no impact from a CCDD operation, the Agency believes monitoring is necessary. The problem with groundwater monitoring at existing CCDD and clean soil fill sites is that there is no consideration for any impacts associated with historical operations. Compounds like chlorides, sulfates, manganese, and iron will likely be present in the groundwater at fill sites, as described in Mr. Huff’s testimony.¹⁸

The regulated facilities will have a year to install the monitoring wells, if they decide they might want to continue to accept CCDD and clean soil. If early monitoring indicates a well exceeds a

¹³ October 25, 2011 Transcript, pages 18-19.

¹⁴ October 26, 2011 Transcript, pages 5 -22.

¹⁵ October 26, 2011 Transcript, page 22.

¹⁶ October 26, 2011 Transcript, page 35 and 36.

¹⁷ Pre-filed Testimony of James E. Huff, pages 4-7.

¹⁸ Pre-filed Testimony of James E. Huff, page 6.

Class I groundwater standard, the facility will simply decide to exit the program. Such a decision process will not benefit anyone.

An alternative would be to establish existing groundwater conditions during the first year, and allow such facilities to achieve Class I or existing groundwater conditions going forward. However, if a groundwater standard is exceeded, then it would also be appropriate to specifically allow use of a groundwater use restriction, identical to the TACO program, and that could easily be spelled out in Section 1100.755. Such an approach would reduce the potential risks the CCDD and clean soil fill facilities assuming they elect to stay in the program, and for the chlorides, sulfates, manganese and iron, this will be particularly important. If one of these four compounds are above the Class I groundwater standard (or above background at the property line if this section is not eliminated from the draft regulations), there is no viable corrective action that can be taken.

Photoionization Detector- The proposed regulations rely on photoionization detector (PID) readings to control acceptance at CCDD and clean soil fill sites over analytical results. This is the only such program the Agency manages where this is the case. Mr. Huff's pre-filed testimony pointed out the concerns with false positives from PID meters.¹⁹ Amazingly the Agency is "unaware of any propensity for a PID to yield a false positive result."²⁰ This false positive propensity is common knowledge to all practitioners, and has been described by OSHA, the equipment manufacturers, and others. Attachment 2 includes samples of the false positive concerns of PID meters. The five (5) ppm screening threshold proposed by Mr. Huff²¹ would eliminate the unnecessary rejections of uncontaminated soils due to false positives and the associated costs. That the Agency is unaware of these false positive readings with a PID is even more surprising, as the Agency rejected screening with an x-ray fluoroscope (XRF) in part because, "the precise quantification is unreliable. The Agency uses the XRF as a tool that allows field staff to focus on where a sample would be collected for subsequent laboratory analysis."²² This description is exactly how the profession has historically utilized PID meters, for deciding which samples are submitted for laboratory analysis.

The Agency's Errata Sheet Number 2 appears to be an attempt by the Agency to address this issue, but it is far from clear. If the reason for rejection is a PID reading above background, then even with analytical to demonstrate the MACs are not exceeded, this does not satisfy 1100.205(a)(4)C "demonstrating that the reasons for rejection of the load have been corrected" (in this case a PID reading above background). Clarifying that analytical results can be used for acceptance so long as the analytical sample is representative of the subject load would avoid future confusion and allow facilities to actually reconsider rejected loads.

Summary-John Hock reported that of the 44 soil samples collected from within CCDD facilities, and 36 failed the Maximum Allowable Concentrations proposed by the Agency, **or 82 percent of all of the samples**. This high failure rate is simply due to the very low pH range used by the Agency (4.5 to 4.75) to set the MACs compared to the pH range in groundwater at these sites,

¹⁹ Pre-filed testimony of James E. Huff, pages 7 to 9.

²⁰ October 25, 2011 Transcript, page 185.

²¹ Pre-filed testimony of James E. Huff, page 9.

²² October 25, 2011 Transcript, page 193

where the site with the lowest pH averaged 7.17 and the soil pH results within these facilities which had a minimum pH of 7.3.

In addition to the metal issue, Mr. Hock reported 7 out of 44 samples failed the MACs for at least one polynuclear aromatic (PNA) compound, or 16 percent, primarily attributed to asphalt in the fill samples.²³ If only the soil-migration-to-groundwater pathway is used, as appropriate for material placed below the water table, then the number of samples for PNAs above the objectives would decline to 3 out of the 44.²⁴ When asked during the hearings, Mr. Hock estimated that the soil content in the samples averaged "something greater than 80 percent."²⁵ Mr. Hock also opined that the samples he collected were reasonably representative of material that is taken to CCDD facilities and that if the regulations are adopted as proposed this material will go to a landfill or an unregulated Illinois facility.²⁶ Not only will this result in significant increased costs to the generators of CCDD, but also Mr. Hock noted that additional CCDD facilities will cease operations.²⁷ This economic burden was corroborated by Mr. Randi Wille's Testimony, where he described his company's decision to close one of its facilities already due to the requirements/liabilities imposed by Public Act 96-1416.²⁸

Claire Manning noted that cost of sending material to a landfill is four times the cost of sending the same material to a CCDD facility.²⁹ This is only part of the economic burden, as average distances to landfills are further, just due to the fewer number of them. In addition, CCDD and clean soil sites are routinely associated with active quarries, so the trucks can return with clean stone to the construction site. These additional factors result in costs more on the order of 7 times for landfilling versus being able to use CCDD and clean soil facilities. Based on Mr. Hock's findings 82 percent of all material currently taken to CCDD and clean soil fills will have to be redirected, and at four times the cost, this a severe economic impact on everyone in the State of Illinois. The additional costs to transportation organizations, counties, and communities, who operate with fixed budgets, will result in the construction of fewer projects and loss of construction jobs. The economic impact of these proposed regulations is real and significant to the transportation industry of Illinois and the overall economy of the State. The unsupported minimum pH values utilized by the Agency are the single biggest reason for this 82 percent of the CCDD and clean soil material that will have to be redirected; however, the requirement to only analyze grab samples will also contribute significantly to the rejection rate.

While the economic impact will be significant, what benefit will be realized? The only groundwater data in the record was contained in Mr. Huff's pre-filed testimony that showed there were no groundwater impacts at one former CCDD facility that was extensively sampled. To the extent there have been groundwater impacts from historical operations, those facilities will simply elect to cease accepting any CCDD or clean soil fill prior to the compliance date, so whatever impacts that may be present will not be addressed through this new program. If the compliance costs are so great, any facility with groundwater issues will simply exit the program.

²³ Pre-filed testimony of John E. Hock, pages 3-5.

²⁴ October 25, 2011 Transcript, page 49.

²⁵ October 25, 2011 Transcript, page 39.

²⁶ October 25, 2011 Transcript, page 47.

²⁷ October 25, 2011 Transcript, page 48.

²⁸ Pre-filed testimony of Randi Willie, page 2.

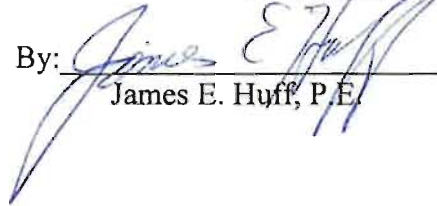
²⁹ October 25, Transcript, page 140.

The Board should weigh carefully the economic impact of these proposed regulations and alter them to encourage the CCDD and clean soil fill operations to remain functional. Suggestions for these modifications have been presented herein that will provide protection of the human health, safety, and the environment, with a sufficient margin of safety.

Dated: December 2, 2011

ILLINOIS TRANSPORTATION COALITION

By:


James E. Huff, P.E.

ATTACHMENT 1

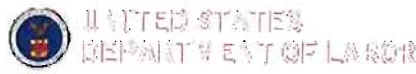
CCDD FACILITY GROUNDWATER PH DATA

Various facilities throughout Illinois, listed by County.
pH Values of NPDES Permitted Outfalls or Groundwater Monitoring Wells

County	Type	Actual Minimum	Actual Maximum	Average
Adams	Limestone	6.94	8.51	7.87
Adams	Limestone	7.50	8.46	8.03
Boone	Limestone	7.45	8.08	7.78
Cook	Limestone	6.39	8.10	7.17
Cook	Limestone	7.70	8.50	8.09
Cook	Limestone	7.20	7.80	7.50
Grundy	Sand & Gravel	8.22	8.62	8.45
Hancock	Limestone	7.64	8.34	8.01
Henry	Limestone	7.60	8.00	7.76
Iroquois	Limestone	7.22	9.00	7.92
Kane	Sand & Gravel	7.49	8.40	8.08
Kane	Sand & Gravel	7.49	8.22	7.95
Kane	Limestone	6.58	8.50	7.39
Kane	Sand & Gravel	7.83	8.33	8.14
Kane	Limestone	7.61	8.41	8.03
Kankakee	Limestone	7.45	8.61	7.87
Kendall	Sand & Gravel	7.86	8.78	8.34
LaSalle	Limestone	7.90	7.90	7.90
LaSalle	Sand & Gravel	7.10	7.60	7.30
Livingston	Limestone	7.43	8.60	8.13
McDonough	Limestone	7.64	8.43	8.03
McHenry	Sand & Gravel	6.11	8.96	7.40
McHenry	Sand & Gravel	7.60	8.20	8.00
Montgomery	Limestone	7.40	8.40	8.00
Pike	Limestone	7.50	8.46	8.03
Pike	Limestone	6.54	8.53	7.86
Rock Island	Limestone	7.70	8.00	7.88
Rock Island	Limestone	7.40	8.20	7.88
Warren	Limestone	6.70	8.20	7.74
Will	Limestone	7.73	8.36	8.03
Will	Limestone	7.80	8.20	8.01
Will	Limestone	7.60	8.10	7.80
Will	Limestone	5.40	8.78	7.57
Winnebago	Limestone	7.50	9.03	8.13
Winnebago	Limestone	7.63	8.85	8.10
Winnebago	Limestone	7.04	8.66	7.90

ATTACHEMENT 2

LITERATURE ON PID METERS AND FALSE POSITIVES



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OSHA Technical Manual

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Directive Number: 08-05 (TED 01)
Effective Date: 6/24/2008

SECTION II: CHAPTER 3

TECHNICAL EQUIPMENT: ON-SITE MEASUREMENTS

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- V. [Radiation Monitors and Meters](#)
- VI. [Air Velocity Monitors/Indoor Air Quality \(IAQ\) Assessment Instrumentation](#)
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[Appendix II: 3-3. Instrument Chart](#)

I. Introduction

The purpose of this chapter is to provide a broad overview of the types of equipment and instrumentation available for use by OSHA personnel. This information is not a comprehensive resource for specific types of instrumentation, nor is it intended to replace the owner's manual. Rather, its purpose is to provide a broad understanding of the principle of operation for the particular type of equipment and an understanding of the capabilities and limitations of the equipment. End users should always follow the owner's manual and manufacturer recommendations regarding the specific operation and maintenance of the equipment being used.

II. Direct-Reading Instrumentation

Direct-reading instruments (sometimes termed real-time instruments) provide information at the time of sampling, thus enabling rapid decision-making. These instruments can often provide the trained and experienced user the capability to determine if site personnel are exposed to concentrations which exceed instantaneous (ceiling or peak) exposure limits for specific hazardous materials. Direct-reading monitors can be useful in identifying oxygen-deficient or oxygen-enriched atmospheres, immediately dangerous to life or health (IDLH) conditions, elevated levels of airborne contaminants, flammable atmospheres, and radioactive hazards. Periodic monitoring of airborne levels with a real-time monitor is often critical, especially before and during new work activities. Data obtained from direct-reading monitors can be used to evaluate existing health and/or safety programs and to assure proper selection of personnel protective equipment (PPE), engineering controls and work practices.

The following general considerations apply to instrumentation which might be used in potentially explosive atmospheres or in atmospheres which may contain highly toxic airborne chemicals (as defined by 29 CFR 1910.1200 App. A and noted below) and/or carcinogenic chemicals that may have contaminated surfaces or may be found in airborne concentrations:

1. Instruments shall not be used in atmospheres where the potential for explosion exists (see 29 CFR 1910.307) unless the instrument is listed by a Nationally Recognized Testing Laboratory (see 29 CFR 1910.7) for use in the type of atmosphere present. Check the class and division ratings prior to use. When batteries are being replaced, use only the type of battery specified on the safety approval label. Do not assume that an instrument is intrinsically safe. If uncertain, verify by contacting the instrument's manufacturer or the Cincinnati Technical Center (CTC).
2. For atmospheres containing carcinogens or highly toxic chemicals, a plastic bag should be used to cover equipment to limit contamination. Ensure that the plastic bag is not tightly sealed as this can cause back pressure on the pump. Properly decontaminate all equipment to minimize potential contamination of persons or objects when sampling is complete. To the extent possible, gross decontamination should be performed after use on-site.

NOTE: Definition of Highly Toxic from Appendix A of 1910.1200

"Highly toxic:" A chemical falling within any of the following categories:

(a) A chemical that has a median lethal dose (LD_{50}) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

(b) A chemical that has a median lethal dose (LD_{50}) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

(c) A chemical that has a median lethal concentration (LC_{50}) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

A. Photoionization Meters

Application and Principle of Operation.

Photoionization detectors (PIDs) use a high energy ultraviolet (UV) light source to ionize chemicals in an air stream. The charged molecules are collected on a charged surface which generates a current which is directly proportional to the concentration of the chemical in the air being sampled.

The ability of a chemical to be ionized is a function of its ionization potential (IP). If the energy of the UV lamp is greater than or equal to the IP of the chemical being sampled, then the chemical will be detected. Typically, PID detectors will come equipped with a UV lamp at 10–10.6 electron volts (eV). Tables listing the IP for chemicals and their relative sensitivity are generally available from the manufacturer. Higher energy lamps (11.7 eV for the Photovac Model 2020Pro) are available to detect chemicals which have high IPs. For example, methylene chloride requires use of the 11.7 eV lamp for detection because the IP for methylene chloride is 11.35 eV. In general, these higher energy lamps have a much shorter lifetime than the 10.6 eV lamps.

In general, aromatic hydrocarbons such as benzene, toluene and xylene provide a sensitivity of approximately 0.1 ppm with photoionization detection. Unsaturated hydrocarbons, alcohols, ethers, and chlorinated hydrocarbons have intermediate sensitivity by PID, and saturated hydrocarbons such as n-hexane tend to be the least sensitive. For example, n-hexane is approximately 1/10 as sensitive as benzene by PID. While it might be expected that the sensitivity of a chemical would be related to its IP, this is not always the case. For example, benzene with an IP of 9.245 eV, and which has a relatively high sensitivity by photoionization detection, is actually slightly less sensitive than vinyl bromide with an IP of 9.80 eV.

Calibration.

In many instances a reference gas is used to calibrate the PID. Frequently, isobutylene gas in air is used as a calibration gas. The meter can then be used to read directly in isobutylene units. If gases other than isobutylene are measured, the isobutylene units can be converted using the appropriate response obtained from the instrument manual for the PID meter used. For example, if the response factor listed in the manual for benzene (relative to isobutylene) is 0.5 and if a meter which had been calibrated with isobutylene was used to measure benzene, the actual benzene concentration in air will be one half of the meter reading. Thus, if the meter reads 5.8 ppm isobutylene in a benzene atmosphere, the benzene concentration is actually 2.9 ppm. Similarly, if the meter reads 10 ppm isobutylene in an atmosphere of ethyl acetate, the ethyl acetate concentration is 38 ppm because the response factor for ethyl acetate is 3.8.

Many PID meters are programmed with internal response factors based upon isobutylene gas and the instrument can be set up to read ppm for the gas of interest. Direct calibration of the instrument, or verification of the calibration if stored response factors are used to calibrate the instrument, is desirable. This can be done by testing a known concentration of an atmosphere containing the chemical of interest prepared in a gas bag.

Special Considerations.

Photoionization sensitivity is dependent upon the age of the lamp and cleanliness of the lamp window. Over time, the output of the lamp will be reduced and also the accumulation of organic deposits on the surface of the lamp will reduce sensitivity. A buildup of film on the lamp will reduce the sensitivity of the meter. The meter also has a reduced sensitivity in high humidity. One manufacturer (RAE Systems) reports up to a 30% reduction in response for measurements in high humidity air when compared to calibration of the same chemical in dry air. For the most accurate results, it is best to calibrate the meter using representative air.

MicroRAE also reports that a "quenching effect" can be observed in which the UV lamp light rays are scattered by the presence of non-ionizable gas molecules. Water vapor, carbon dioxide, methane, and carbon monoxide can all produce a low reading for the gas of interest if present in the air being sampled.

Maintenance.

Follow the manufacturer's recommendations for maintaining the detector in optimal condition. This will include routine cleaning of the UV lamp and frequent replacement of the dust filter. Because of the fragile nature of the lithium fluoride window on the 11.7 eV lamps, special precautions must be followed and cleaning should only be done using Freon or chlorinated solvents. The exterior of the instrument can be wiped clean with a damp cloth and mild detergent, if necessary. Keep the cloth away from the sample inlet and do not attempt to clean the instrument while it is connected to a power source.

B. Infrared Analyzers

Application and Principle of Operation.

Infrared (IR) analyzers are useful for measuring a broad range of inorganic and organic chemicals in air. Depending upon the chemical, the sensitivity of IR analyzers can be sufficient for industrial hygiene purposes. Because most chemicals absorb IR light, an infrared analyzer may not be selective unless the chemical of interest can be measured at a wavelength which is unique for that chemical in the air sample, or the industrial hygienist is able to determine that other interfering chemicals are not present in the work environment. Some of the routine applications for IR analyzers include measuring carbon dioxide in indoor air quality (IAQ) assessments; anesthetic gases, including, nitrous oxide, halothane, enflurane, penthrane, and isoflurane; ethylene oxide; and fumigants, including ethylene dibromide, chloropicrin, and methyl bromide.

IR analyzers emit an infrared light which is generated from a heated metal source. The infrared portion of the electromagnetic spectrum typically used in infrared analysis ranges from the far infrared region at 400 cm^{-1} (25 micrometers) to the near infrared region 4000 cm^{-1} (2.5 micrometers). The amount of infrared light that a chemical absorbs varies with the particular

Photo Ionization Detector

Description

The Photo Ionization Detector (PID) is a portable vapor and gas detector that detects a variety of organic compounds. Photo ionization occurs when an atom or molecule absorbs light of sufficient energy to cause an electron to leave and create a positive ion.

The PID is comprised of an ultraviolet lamp that emits photons that are absorbed by the compound in an ionization chamber. Ions (atoms or molecules that have gained or lost electrons and thus have a net positive or negative charge) produced during this process are collected by electrodes. The current generated provides a measure of the analyte concentration. Because only a small fraction of the analyte molecules are actually ionized, this method is considered nondestructive, allowing it to be used in conjunction with another detector to confirm analytical results. In addition, PIDs are available in portable hand-held models and in a number of lamp configurations. Results are almost immediate.

Limitations and Concerns

The PID is not suitable for the detection of semi-volatile compounds.

The PID indicates if volatile organic compounds (VOCs) are present, but they do not identify type (unless combined with a gas chromatograph).

The PID may give false positive readings for water vapor. Rain may also affect performance. High humidity can cause lamp fogging and decreased sensitivity. This can be significant when soil moisture levels are high or when a soil gas well is actually in ground water.

High concentrations of methane can hinder performance.

Rapid variations in temperature at the detector, strong electrical fields, and naturally occurring compounds, such as terpenes in wooded areas, may affect instrument response.

The PID must be re-calibrated frequently

Detection limits for most PIDs are in the parts per million range. Thus they are unsuitable for most vapor intrusion indoor air investigations, where screening or action levels are normally in the parts per billion range.

Applicability

The PID is used mostly to detect VOCs in soil, sediment, air and water. It is often used to detect contaminants in ambient air and soil during drilling activities and during spills to identify potential problems.

Technology Development Status

The PID is commercially available and routinely used.

Web Links

http://www.frtr.gov/site/6_2_1.html

Other Resources and Demonstrations

Because this method is so widely used, numerous commercial sites are available. See, for example:
<http://www.afcintl.com/gasdet/rae/ultrarae3000.htm>, <http://www.raesystems.com/products/minirae-3000>



RAE Systems PID Training Outline

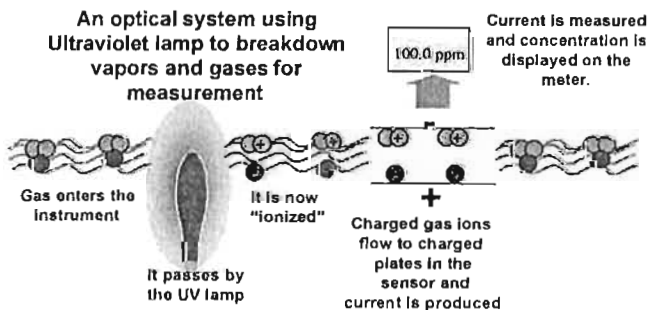
What is a PID?

A PID (photoionization detector) measures VOCs and other toxic gases in low concentrations from ppb (parts per billion) up to 15,000 ppm (parts per million) or 1.5% by volume. A PID is a very sensitive broad-spectrum monitor, like a low-level LEL monitor. RAE Systems' improvements in PID technology have miniaturized and "ruggedized" PIDs allowing them to provide new and innovative monitoring solutions for:

- **LEL Measurements.** PIDs provide a more reliable means of measuring LEL in applications like Jet Fuel and Turpentine vapors (see AP-200, 204, 219).
- **Ammonia.** See AP-201.
- **HazMat.** Hazardous Materials Response (see AP-203).
- **Heat Transfer Fluids.** See AP-205.
- **Arson.** See AP-207.
- **Industrial Hygiene.** To help determine chemical exposures (see AP-211).
- **Indoor Air Quality.** See AP-212.
- **Environmental.** Residual soil, air, or water contamination (see AP-214).
- **Safety.** Confined Space Entry (see AP-211).
- **Maintenance.** Leak detection and fugitive emissions monitoring (see AP-214).
- **Domestic Preparedness.** See AP-216.
- **Clan Labs.** See AP-220.

How does a PID Work?

A photoionization detector (PID) uses an ultraviolet (UV) light source (*photo* = light) to break down chemicals to positive and negative ions (*ionization*) that can easily be counted with a *detector*. Ionization occurs when a molecule absorbs the high-energy UV



light, which excites the molecule and results in the temporary loss of a negatively charged electron and the formation of positively charged ion. The gas becomes electrically charged. In the PID, these charged particles produce a current that is then amplified and displayed on the meter as "ppm" (parts per million) or even in "ppb" (parts per billion). The ions quickly recombine after passing the electrodes in the detector to re-form their original molecule. PIDs are non-destructive; they do not "burn" or permanently alter the sample gas, which also enables them to be used for sample gathering.

What does a PID Measure?

All elements and chemicals can be ionized, but they differ in the amount of energy they require. The energy required to displace an electron and "ionize" a compound is called its *Ionization Potential (IP)*, measured in electron volts (eV). The light energy emitted by a UV lamp is also measured in eV. **Note:** If the IP of the sample gas is less than the eV output of the lamp, then the sample gas will be ionized.

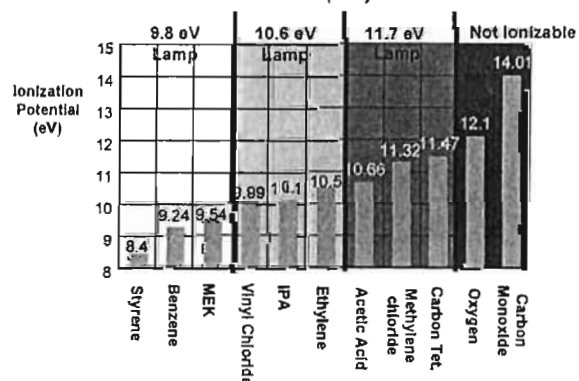
PID Operation Simplified

While this sounds complicated, it is very simply explained, using a familiar analogy, such as wattage. A PID uses a lamp to break down gases and vapors.

- If the "wattage" of a gas or vapor is less than the "wattage" of the PID lamp, then the PID can "see" the gas or vapor.
- If the "wattage" of the gas or vapor is greater than that of the PID lamp the PID cannot "see" the vapor.

Therefore, a PID with a "75-watt" lamp could see a

Some Ionization Potentials (IPs) for Common Chemicals





50-watt gas but could not “see” an 85-watt gas. Although we used wattage for this explanation, energy for PIDs is expressed in electron-volts, or eV, and is known as the Ionization Potential (IP) for a particular gas or vapor. Ionization Potential is a measure of the bond strength of a gas, or how well it is “built.” Benzene has an IP of 9.24 eV and can be seen by a “standard” 10.6 eV lamp. Methylene Chloride has an IP of 11.32 eV and can only be seen by an 11.7 eV lamp. Carbon monoxide has an IP of 14.01 eV and cannot be ionized by a PID lamp.

IPs can be found in the NIOSH Pocket Guide, PID manufacturer literature and in many chemical texts. RAE Systems uses a NIST (National Institute of Science & Technology) Database containing over 11,000 compounds to determine IPs of new compounds to be measured (see RAE Systems Technical Note TN-106: Correction Factors, Ionization Energies and Calibration Characteristics).

What Does a PID Measure?

The largest group of compounds measured by a PID are the Organics: compounds containing Carbon (C) atoms. These include:

- **Aromatics.** Compounds containing a benzene ring including benzene, toluene, ethyl benzene and xylene.
- **Ketones and aldehydes.** Compounds with a C=O bond including acetone, methyl ethyl ketone (MEK) and acetaldehyde.
- **Amines and amides.** Carbon compounds containing nitrogen, like diethylamine.
- **Chlorinated hydrocarbons.** Trichloroethylene (TCE), perchloroethylene (PERC)
- **Sulfur compounds.** Mercaptans, sulfides
- **Unsaturated hydrocarbons.** Like butadiene and isobutylene
- **Alcohols.** Like isopropanol (IPA) and ethanol
- **Saturated hydrocarbons.** Like butane and octane

In addition to organic compounds, PIDs can be used to measure some Inorganics. These are compounds without carbon and include:

- Ammonia
- Semiconductor gases: arsine, phosphine
- Hydrogen sulfide
- Nitric oxide
- Bromine and iodine

What PIDs Do Not Measure

- Radiation
- Air (N₂, O₂, CO₂, H₂O)
- Common toxics (CO, HCN, SO₂)
- Natural Gas (methane, ethane)
- Acid gases (HCl, HF, HNO₃)
- Others: Freons, ozone (O₃), hydrogen peroxide
- Non-volatiles: PCBs, greases

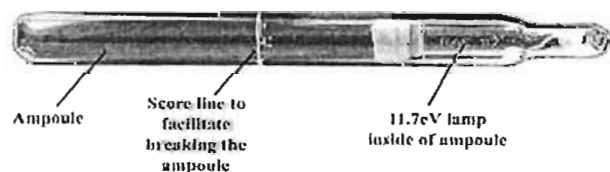
9.8 & 10.6 eV versus 11.7 eV PID Lamps

At first glance, it may appear that to measure the broadest range of gases with a PID, an 11.7eV lamp should be used instead of a 10.6eV lamp. However, the following must be considered:

- **9.8 and 10.6 are more specific.** Lower IP means that they “see” fewer chemicals.
- **9.8 and 10.6 last a few years.** About the same lifetime and cost as a CO sensor.
- **9.8 and 10.6 are more sensitive.** 11.7 eV lamps provide lower resolution: The lithium fluoride crystal in the 11.7 eV lamp does not allow as much light energy through, effectively making the 11.7 eV lamp “dimmer” than the 10.6 eV lamp. Less energy transmitted means less ionization taking place, which reduces the potential resolution. Essentially a 10.6 eV lamp is 10 times more powerful than an 11.7 eV lamp. Therefore, for best accuracy, it is not recommended to use 11.7 eV lamps for applications requiring very high sensitivity. Examples include formaldehyde, which has an OSHA TWA of just 0.75 ppm.
- **11.7 eV lamps have a shorter life than 9.8 or 10.6.** All 11.7 eV lamps (including those made by RAE Systems’ competitors) have a window made of Lithium Fluoride to transmit the high energy UV light. Lithium fluoride is harder to seal to the lamp glass, is very hygroscopic and readily absorbs water from air even when not in use. This causes the window to swell and decreases the amount of light transmitted through the window. Lithium fluoride also is degraded by UV light; the more the instrument is used, the greater the damage. These factors contribute to a shortened lamp life. While a 10.6 eV lamp can last 24 to 36 months, an 11.7 eV lamp typically lasts only two to six months.



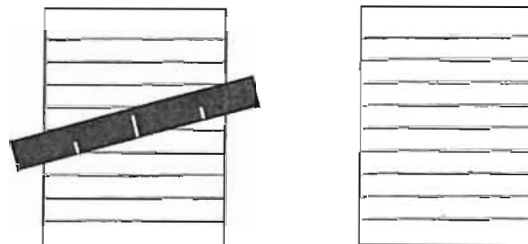
- **11.7 eV bulbs should only be used when compounds with IPs over 10.6 eV are expected.** Examples include methylene chloride, chloroform, and carbon tetrachloride.
- **Least expensive and easiest to change 11.7 eV lamp.** While RAE Systems' 11.7 eV lamp is the least expensive in the PID market (with some 11.7 eV lamps costing as much as \$500), they still are more expensive than a 10.eV lamp. Unlike some PIDs that require expensive conversion kits, RAE Systems' 11.7 eV lamps drop right into our instruments. No modifications are necessary. You change the lamp, recalibrate and measure.
- **Long-Term Storage of 11.7 eV Lamps.** As a solution to the problem of a short lifetime for 11.7 eV lamps, RAE Systems offers them packaged in sealed glass ampoules. The gas in the ampoule is the same as in the lamp. The ampoule effectively packages a new lamp in a lamp. When the 11.7 eV lamp is required, the ampoule is broken, the lamp removed and inserted into the PID. This ampoule is only available for the 1/4" lamps used in the AreaRAE, MultiRAE Plus and ToxiRAE PIDs.
- **Extending 11.7eV Lamp Life.** 11.7eV lamp life can be extended if the lamp is stored in a desiccant environment (in or out of the PID) between uses. This can simply be a container containing silica gel drying packs like those that ship with electronic and camera equipment. It is not recommended to store MultiRAE Pluses in a desiccant environment because this decreases the life of its electrochemical sensors.



Selectivity & Sensitivity

A PID is a very *sensitive* monitor that can accurately measure gases and vapors in low ppm or even ppb levels. However, the PID is not a *selective* monitor. It has very little ability to differentiate between chemicals. To visualize this, let's compare the PID to a ruler. A ruler is a sensitive and accurate means of measuring the width of a sheet of paper. But it cannot

tell the difference between gray and white paper. Therefore, if one wants to know the width of the gray sheet of paper, that person must first select the proper sheet of paper before measuring with the ruler. We



use our head to determine which sheet of paper is gray.

The PID is similar to the ruler. It can tell us how much of a gas or vapor is present, but we must use our head to determine the exact gas or vapor present. When approaching an unknown chemical release, the PID is set to its calibration gas of isobutylene. Once the chemical is identified by means of placard, manifest, waybill or other means, the PID sensitivity can be adjusted to that chemical so that it reads in an accurate scale. For example, if we calibrate with isobutylene and happen to measure a toluene leak of 1 ppm the PID will display 2 ppm because it is twice as sensitive to toluene as it is to isobutylene. Once we have identified the leak as toluene, then the PID scale can be set to a toluene Correction Factor and the PID will accurately read 1 ppm if exposed to 1 ppm of toluene. Remember: We use our head for selectivity and the PID for sensitivity. No Correction Factor is used until a compound is identified.

What Is a Correction Factor?

Correction Factors (CF, also known as Response Factors) are a powerful tool in the use of PIDs. They are a measure of PID sensitivity to a particular gas. CFs permit calibration with one gas while directly reading the concentration of another, eliminating the need for multiple calibration gases. PID manufacturers determine Correction Factors by measuring a PID's response to a known concentration of target gas (See TN-120: Measuring Correction Factors for Volatile Compounds with PIDs). Correction Factors tend to be instrument and/or manufacturer specific so it is best to use the CFs from the manufacturer of the PID. Therefore, it may be best to choose a PID manufacturer with the largest listing of CFs. RAE Systems has the largest list of Correction Factors available for PIDs (see TN-106).



However, while correction factors are convenient, it is always best to calibrate on the gas/vapor of interest for the highest measurement accuracy.

CF Measures Sensitivity

Correction Factors are scaling factors used to adjust the sensitivity of the PID to directly measure a particular gas compared to the calibration gas. The lower the Correction Factor (CF), the more sensitive the PID is a gas or vapor. The following example uses CFs from a RAE Systems 10.6eV lamp:

- Toluene's CF is 0.5, so the PID is very sensitive to toluene.
- Ammonia's CF is 9.7, so the PID is less sensitive to ammonia.

The PID is approximately 19 times more sensitive to toluene than it is to ammonia ($9.7/0.5=19.4$).

Guidelines for using Correction Factors

1. If a PID is going to be used to measure a very toxic chemical, the PID should be very sensitive to that chemical. Therefore, if the chemical has an exposure limit of 10 ppm or less, a PID is an appropriate tool for personal safety decisions if the chemical's CF is less than 1.0 (e.g., benzene has an exposure limit of 1 ppm and a CF of 0.5).
2. If a chemical is not extremely toxic, then the PID doesn't need to be as sensitive to it. Therefore, if the chemical has an exposure limit of over 10 ppm, a PID is an appropriate tool for personal safety decisions if the chemical's CF is less than 10. (e.g.: ammonia has an exposure limit of 25 ppm and a CF of 9.7).
3. If the chemical's CF is greater than 10 PIDs are still appropriate as gross leak detectors (e.g., ethylene oxide has a CF of 13 with a 10.6 lamp) and are only appropriate for personal safety decisions for chemicals with very high exposure limits.

Microprocessor PIDs such as the MiniRAE 3000, ppbRAE 3000, and UltraRAE 3000 can automatically store and apply over 100 CFs.

CF Example: Toluene

- If a PID reads 100 ppm of isobutylene units in a Toluene atmosphere, then the actual concentration is 50 ppm toluene units:

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

CF Example: Ammonia

- If a PID reads 100 ppm of isobutylene units in an Ammonia atmosphere, then the actual concentration is 970 ppm ammonia units:

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

How to Determine if a PID can Measure a Particular Gas

1. Is the IP of the compound less than the eV output of the lamp?
 - **Yes:** Go to step 2.
 - **No:** Select a higher energy lamp. If none available, then the PID cannot measure that gas.
 - **Don't Know:** Most PID manufacturers can help.
2. Is the CF less than 10?
 - **Yes:** A PID is an appropriate way of measuring that gas.
 - **No:** A PID is not an accurate means of measuring that gas, but it could still be a good way of gross measurement like leak detection.

Don't Know: Call RAE Systems at 877-723-2878.

Why Calibrate with Isobutylene?

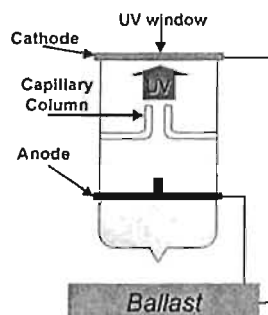
Isobutylene has been used to calibrate PIDs because its responsiveness is about at the midpoint in the range of sensitivity of PIDs. It is relatively easy to obtain and is non-toxic and non-flammable at the low concentrations used for calibration. For years PIDs were calibrated with benzene, but because of its carcinogenic properties benzene calibrations have been phased out. While PIDs are typically calibrated with isobutylene, they can be calibrated with any ionizable gas. For example, if a PID is to be used to measure only vinyl chloride, the PID can be calibrated directly with a known concentration of vinyl chloride.



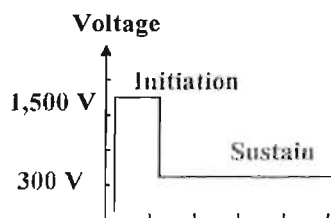
How Has RAE Systems Advanced PID Lamps?

Competitors' Electrode Discharge lamps

A high-energy electric current is conducted to a gas mixture via electrodes. The electrodes directly excite the gas mixture to produce light. A form of vacuum (or radio) tube these "valve electronic" devices have a number of issues.

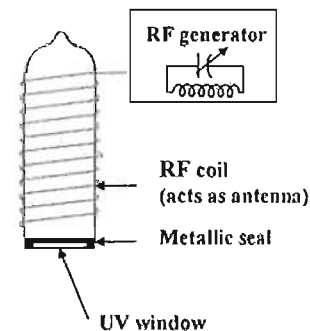


- Internal contamination.** Electrode discharge lamps suffer from eroding electrodes that deposit on the lamp and reduce lamp output. We see this on fluorescent tubes when the ends darken as the lamp ages. While a 10% drop in light output is not detectable by the human eye, it can severely affect instrument readings and require more frequent calibration and ultimately reducing lamp life.
- Metal-to-glass interfaces are prone to failure.** We often screw incandescent lightbulbs in too tight and they break loose from their base. This is a good example of *metal-to-glass interface failure*. It is difficult to bond glass to metal, and every metal to glass interface is a potential failure point. Like incandescent lightbulbs, metal-to-glass interfaces in electrode discharge lamps are potential failure points.
- High power draw.** Electrode discharge lamps have a high power draw compared to electrodeless discharge lamps. These several-watt lamps waste energy as heat, requiring large batteries, and are not as easy to use or carry.
- High RFI (radio-frequency interference).** We often get a hum on our personal radios when working near fluorescent lights. Electrode discharge lamps suffer from the same high RFI problem.

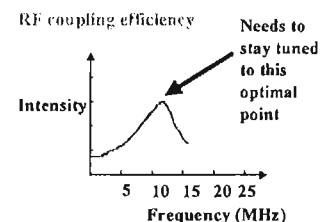


Competitors' RF-Excited Lamps

The electrodeless lamp is put into a coil of wire and is subjected to high-frequency excitation energy (12 to 14 MHz) to generate a glow discharge in the lamp.

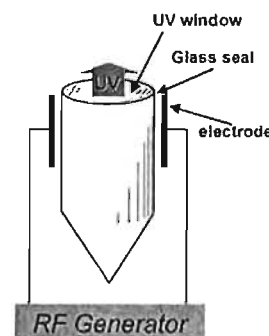


- High power consumption**
- Subject to RFI.** High-frequency excitation energy is affected by radios and power lines because a radio-frequency (RF) coil can act as an antenna.
- Higher maintenance.** RF coupling efficiency requires a perfectly tuned driving circuit. These complex circuits require constant tuning.



Advantages of RAE Systems' Electrodeless Lamp

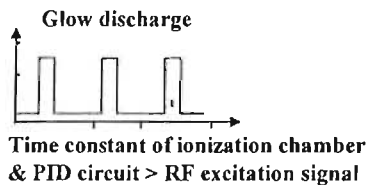
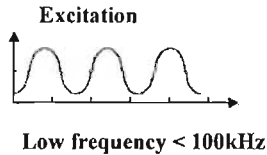
The RAE Systems lamp is put into a low-frequency RF field, which indirectly excites the bulb to glow. This is like using a microwave oven to cook food. Both the lamp and the food are excited to radiate (heat for the food, light for the lamp) by an external field.



Application Note AP-000

rev 2a tm 06-10a

- **Extremely low power draw:** RAE Systems' electrodeless discharge lamps have an extremely low power draw. This results in a cool lamp that



uses small batteries. Low power draw is a key factor in decreasing the size of RAE Systems PIDs.

- **No internal contamination.** Electrodeless discharge lamps are externally excited and have no metal in them to damage, erode or migrate.
- **Extremely rugged.** Because they reduce or eliminate metal to glass interfaces electrodeless discharge lamps are extremely rugged. RAE Systems has totally eliminated all metal-glass interfaces in its 10.6 eV lamp. The magnesium fluoride crystal is welded to the lamp's glass.
- **Virtually no RFI or EMI.** RAE lamps are powered by a low-frequency electrical field. Compared with electrode discharge lamps, this method virtually eliminates RFI and EMI (electromagnetic interference).

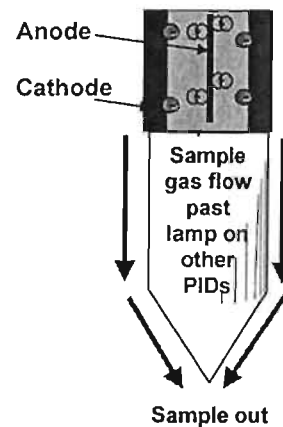
How has RAE Systems Advanced PID Sensors?

Competitors' Axial Flow Sensor

A sample enters a large sensor chamber with a central anode and cathode surrounding it like a drum. The sample stream is directed directly at the lamp (axial flow).

- **Slower response time.** Sensor has large sample volume and this requires a high bias voltage, resulting in high power demand and big batteries.
- **Slower recovery time.** More volume to clear of sample.

Ion Flow (X axis) Sample & UV Flow (Y axis)



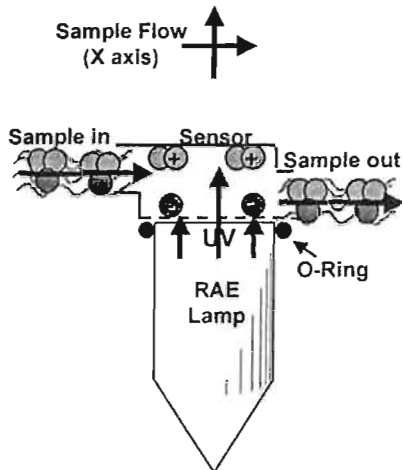
- **Greater humidity effects.** Light has further to travel, so moisture can block more light reducing PID response.
- **More lamp cleaning.** Sample and contaminants are directed to the lamp face, resulting in the need for frequent lamp cleanings.

Advantages of RAE Systems' "2-D" Sensor

In the two-dimensional, or "2-D," sensor the sample is drawn across the lamp in a laminar manner rather than at the lamp in an axial manner. This is the first of the two dimensions, represented in the accompanying flow diagram as the X axis. The light comes up from the UV lamp at a 90° angle and is in parallel with the ion flow in the Y-axis of the accompanying diagram. Together they form the second dimension. This sensor was used in the ppbRAE Plus, UltraRAE 3000 and ToxiRAE PID.



The “2-D” sensor has a very small sensor chamber volume with a lower bias voltage and lower power requirements.



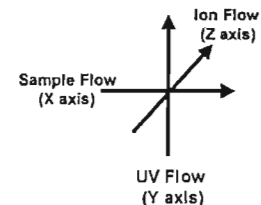
- **Fast Response.** Placing the sensor directly on top of the lamp minimizes the sample chamber volume and with the O-ring seal provides nearly instantaneous response times of less than 3 sec. to 90% to 2000 ppm. This extremely fast response means more accurate and quicker leak, or “hot spot,” detection. To demonstrate this benefit of the MiniRAE 2000, take a non-water-based marking pen like a Sharpie or a white-board marker and make a small line on a piece of paper. The MiniRAE 3000 will easily “find” this line in seconds.
- **Fast recovery.** Because the sample flow travels across rather than directly towards the lamp face, the top of the lamp chamber can be sealed with an O-ring. This helps to decrease response and recovery times of RAE Systems PIDs because it prevents sample gas from accumulating around the lamp. Fast recovery means that the reading quickly returns to zero. Fast recovery between samples means that multiple sampling (like headspace samples) proceeds much faster than with any other PID. Fast recovery also provides for succinct detection of vapor leaks.
- **Low humidity response.** Laminar flow and placing the sensor on top of the lamp face maximize the exposure of the gas stream to UV light. This drastically reduces humidity and non-ionizing gas interference in RAE Systems PIDs. Water molecules absorb UV in much the same

way as fog absorbs light from your car headlights. Because of this, you drive slower on foggy days because you can only see things that are close to your headlights. By keeping the sensor and the sample gas close to the UV light source (like the “short lightpath” in the accompanying diagram), RAE Systems PID sensors allow the UV light to get to the sample gas before the water molecules can absorb or diffuse the UV light. The extremely fast response of the MiniRAE 3000 even allows users to add an external GoreTex™ membrane (water trap) to prevent condensation from entering the MiniRAE 3000. This external filter is in addition to the standard internal hydrophobic filter and is recommended for sampling in wet sample pits or anytime an 11.7 eV lamp is used. Even with this water trap in place, response time is only five seconds.

- **Moisture Elimination vs. Compensation.** RAE Systems does not eliminate the effect of moisture in PIDs, but compared with other PIDs the affects of moisture are drastically diminished. This method of eliminating moisture rather than compensating for it has fewer inherent disadvantages. Compensating for moisture, using such means as an electronic moisture compensating circuit, only turns up the amplifier circuit. This can lead to false alarms and presents an additional part of the monitor that requires calibration.
- **Less Lamp Cleaning.** RAE Systems’ laminar flow PID sensors direct the sample flow across the lamp lens rather than directing the sample flow towards the lamp lens like many other PIDs. This results in less dirt and solvent vapors accumulating on the lamp lens because contaminants ideally keep going past the lamp face.

Advantages of the RAE Systems “3-D” Sensor

The “3-D” sensor builds on the success of the “2-D” sensor. It has all the advantages of the “2-D” sensor with additional features. In the RAE Systems three-dimensional or “3-D” sensor, the sample is drawn





across the lamp in a laminar manner forming the first of three dimensions. The light comes up from the UV lamp at a 90-degree angle to the sample flow. The ion bias and sensing electrodes are not plates like in the 2-D sensor. Rather they are fingers placed in the sample flow so that the ion flow is across the sample in the Z-axis. This sensor is used in the MiniRAE 3000, UltraRAE 3000, MiniRAE Lite, and ppbRAE 3000.

- **Lowest humidity response.** The 3-D sensor eliminates the walls of the sensor in the 2-D version. Dirt can accumulate on sensor walls providing nuclei of condensation. Moisture is attracted to these nuclei first. If enough dirt is present, the moisture can condense and form an electrical path from the bias to the sensing electrode. This is called sensor "leakage" and users will obtain abnormally high readings. By eliminating the wall in the 3-D sensor, this source of moisture response is eliminated.
- **Increased linearity.** The 3-D sensor increases linearity from 0 to 2000 ppm in the 2-D sensor up to 15,000 ppm.
- **Fastest response & recovery.** Less than 3 seconds to 90%, up to 15,000 ppm!
- **Simple lamp & sensor cleaning.** The 3-D sensor is easily removed from the PID without tools. This allows operators, not instrument technicians, to quickly and easily clean grossly contaminated sensors. Under normal usage, the 3-D sensor will clean itself while on charge (see TN-165).

Tips on using a PID

Never Use Tygon Sample Tubing

Because Tygon sample tubing quickly absorbs many chemical vapors, it should *never* be used with PIDs. Tygon tubing will reduce the PID readout when measuring many chemicals and may cause "false positives" when chemicals do not exist due to the "outgassing" of old chemicals from the Tygon tubing. Tygon tubing is typically found as the remote sampling tubing supplied with most confined space monitors. Only Teflon, Teflon-lined Tygon or similar non-reactive tubing should be used with PIDs. Teflon tubing will not absorb chemicals, but it can get coated. Clean contaminated Teflon tubing with anhydrous methanol (lamp-cleaning solution) if it gets coated with a chemical.

When to Clean a PID

From time to time, a PID lamp and sensor requires cleaning. Historically, some PID users cleaned their lamps daily, often neglecting the sensor and sample components before the sensor. Frequent cleaning typically is not necessary and can lead to inadvertent damage to the PID lamp and sensor. The following are guidelines for determining when a PID lamp and sensor require cleaning:

- When display creeps upwards after good zero.
- When PID responds to moisture.
- When movement of PID results in response on display.
- **How to Clean the PID Lamp & Sensor**
 1. Use anhydrous methanol (lamp-cleaning solution).
 2. Clean sample probe and replace or clean filters. If the PID holds a stable zero after this step, then further cleaning may not be necessary.
 3. Clean the lamp face with lens tissue
 4. Clean the sensor by immersion in cleaning solution (an ultrasonic cleaner will speed cleaning).
- **Drying the PID**
 1. Let the cleaned PID air dry overnight.
 2. Warm air (not hot) speeds drying.

References

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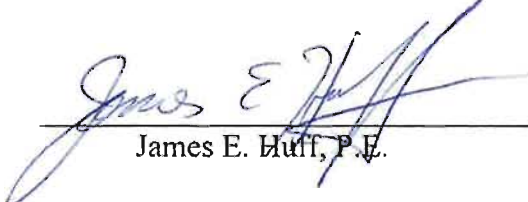


CERTIFICATE OF SERVICE

I, the undersigned, certify that on this 2nd day of December, 2011, I have served electronically the attached Pre-Filed First Notice Comments of the Illinois Transportation Coalition and accompanying Attachments, and Notice of Filing upon the following person(s):

John Therriault, Clerk Pollution Control Board James R. Thompson Center 100 West Randolph Street - Suite 11-500 Chicago, IL 60601	
and by U.S. Mail, first class postage prepaid, to the following person(s):	
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