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# On-Line Process Analyzers
# The Culture & Topical Issues


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# Agenda

## Process Analytical Instrumentation (“PAI”) Industry

- PAI portion of the entire Process Control Enterprise
- Analytical technologies, industry trends
- The profession, the culture, the engineering & sciences
- ATOP (Analyzer Technician Opportunity Program), ISA-AD

## Case Studies

- Two of the “Seven Deadly Sins” with case study examples

# GLOBAL MARKETS FOR PROCESS ANALYTICAL INSTRUMENTS (PAI) 2014 to 2017

**Analysis & Forecast of Global Markets for PAI Products & Services**



**AD 2015**
**60th Analysis Division Symposium**
**Galveston, TX**

**www.pai-processanalyticalmarkets.com**

# PAI is a Significant Specialty Niche in the Global Process Control Enterprise

Cumulative value of Process Control Enterprise will exceed $650 Billion during 2014 to 2017 (~163 billion / year)

PAI accounts for about 6% of this (~10 billion / year)

Comprised of spending by ALL market participants

- End users (70% of which is the Oil, Gas & CPI)
- Engineering Procurement Construction (EPC)
- Manufacturers of instrumentation, control systems, software, and related products and services
- Process control system integration (SI) specialists

# PAI Historical Perspective

PAI implementation started in 1930s

- PAI developments require unique solutions for process applications
- PAI solutions often parallel lab developments

Microprocessor introduction in mid 1970s had enormous effect on PAI designs

- Computer intensive methods (FTIR, NIR, Raman)
- Integration with DCS and APC
- Onboard (remote) diagnostics to reduce lifetime costs

Outside resources (telecomm) producing recent advances

- Tuneable Diode Array Laser Spectroscopy (TDLAS)

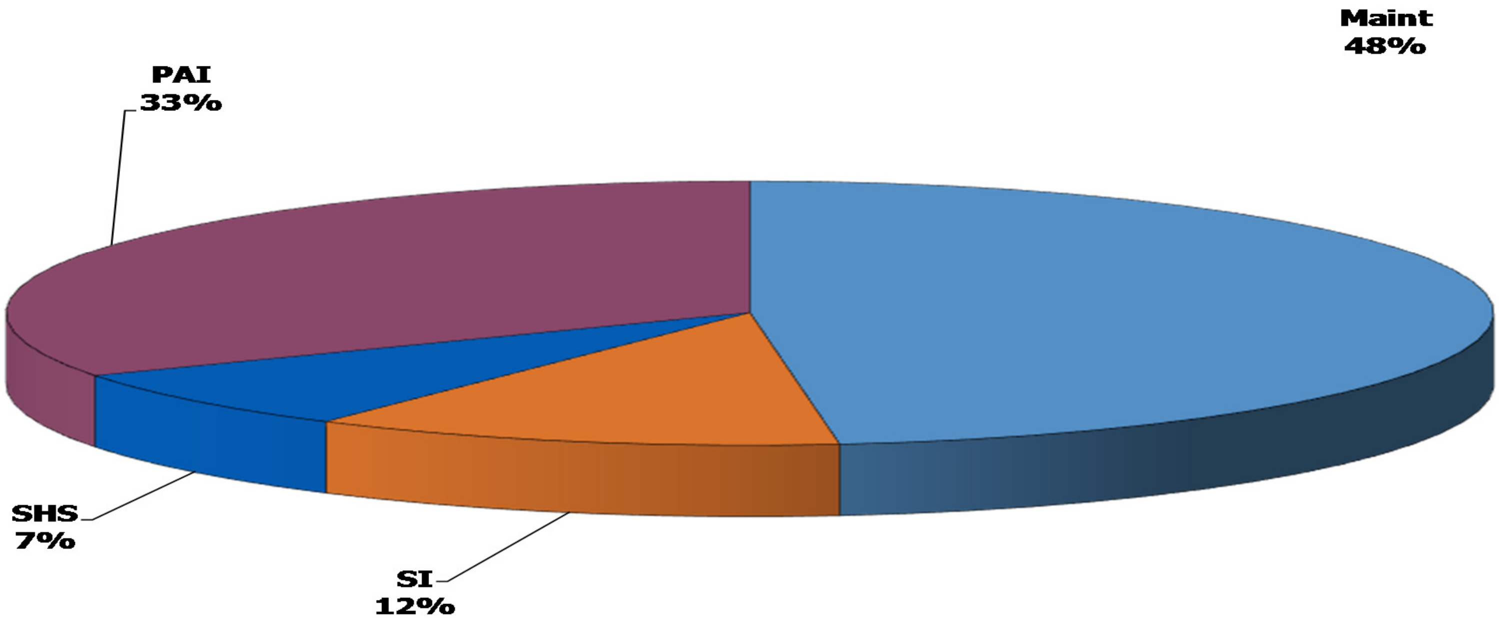
# PAI Timeline

| | |
|---|---|
| 1930s | ◆Thermal conductivity analyzer for $CO_2$ by Hartmann and Braun (1929)<br>◆Infrared absorption recorder developed by I.G. Farbenindustrie<br>◆Commercial pH by Beckman<br>◆Commercial optical emission spectrometer by ARL |
| 1940s | ◆Commercial UV/VIS by Beckman<br>◆I.G. Farbenindustrie deploys 400 NDIRs, 15 Mag. Oxygen recorders during WWII<br>◆PAI usage expands at US refineries and chemical plants |
| 1950s | ◆Process GCs developed by Union Carbide and Phillips<br>◆Fixed filter UV/VIS photometers developed by DuPont<br>◆Std. Oil of NJ Baton Rouge refinery is a major user of PAI |
| 1960s | ◆Real time computers (minicomputers) incorporated for data reduction<br>◆FTIR becomes possible in labs but unreliable for on stream usage<br>◆On stream TOC and TOD developed by Dow Midland |

# PAI Timeline

| | |
|---|---|
| 1970s | ◆First commercial NIR instrument announced at Illinois State Fair<br>◆LSI Microprocessors enable computer intensive analysis methods—FTIR, NIR<br>◆Dow deploys process MS for ethylene oxide process<br>◆DuPont deploys NIR in chemical manufacturing |
| 1980s | ◆PAI academic centers formed: CPAC, MCEC, CPACT (UK)<br>◆Chemometrics applied to on stream data analysis |
| 1990s | ◆Process NMR implemented by Texaco for refinery applications<br>◆NeSSI GEN I for standardizing SHS substrates |
| 2000s | ◆FDA introduces PAT/QbD initiative to improve pharma manufacturing<br>◆On stream spectroscopy adopts rugged, low-cost telecom optical data transmission technology<br>◆NeSSI GEN II integrates smart SHS with DCS |
| 2010s | ◆Analyzer miniaturization<br>◆The Photonics decade : rising influence of laser-based PAI |

# Global PAI Enterprise - 2014 to 2017




$39 Billion (4 year Cumulative)

# CPI Market Characteristics
# Choosing Products and Services

Use broad range of PAI products (no one company dominates)

Conservative about adopting new technologies, especially during times of high project activity

Plant operations decisions based on a mix of product-related and company-related attributes

- High product reliability
- Good (after sale) tech support
- Easy to maintain
- Low total cost of ownership
- Attitudes about the supplier (honesty, application knowledge, existing relationships, support, etc.)

Capital project decisions are driven by competitive bidding mentality (Lowest 1$^{st}$ price) and this can drive "mis-applications"

# CPI Market Characteristics
# Outlook for Services & Support

Maintenance continues as the largest expense component of the life-cycle cost equation

Activities (circa 2015) will focus on reliable operation of PAI installed base to support higher uptimes

Continuing reliance on off-site service orgs and modular replacements to deal with reduced staffing

Training will challenge maintenance organizations

- Impending retirement of veteran staff
- Changing skill sets for new technologies (e.g., laser spectroscopy, computers)
- Huge demand for analyzer technicians created by ACC's list of new chemical projects (plus hundreds of related projects in plastics, tires, iron & steel, etc.)

# Challenges & Opportunities in Analyzer Technician Training

## ATOP (Analyzer Technician Opportunities Program)

- To date 80 ATOP graduates (Lee & San Jacinto colleges) are employed
- ISA AD is continuing to support this program at Brazosport College
- See Charlie Smith for a copy of the National Sciences Foundation "Analyzer Technician Competency Model" (a 38 page synopsis)

## Challenges at the Refinery Level

- Getting Analyzer Technicians acknowledged as a distinct tradecraft
- Premium pay scale to attract techs into a challenging field
- The gestation period to "home grow" an analyzer tech can be 5-10 years

# Process Analyzer Profession Resources

- ISA Analysis Division
  - www.ADSymposium.org
  - An essential organization for your organization
  - Annual Symposium, 900 professionals, contact network
- Analyzer Technician Opportunities Project (ATOP)
  - www.analyzertech.org
  - Distance learning program developed by 2 Houston colleges
  - The necessary education to grow a lifetime skill set

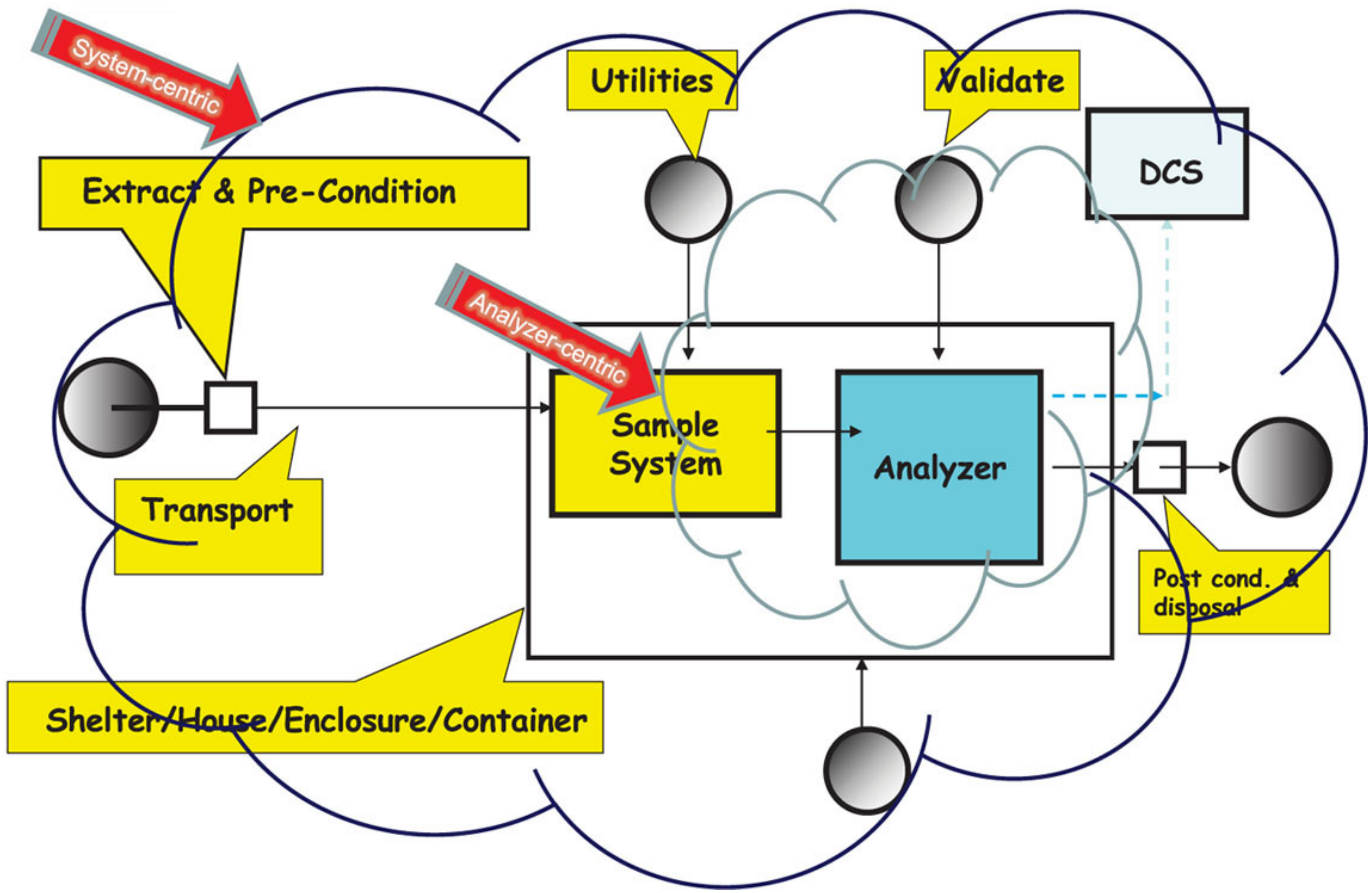
# The Big Picture of Process Analyzer Systems

## Two of the “Seven Deadly Sins” with Supporting Case Studies

# Grouping of Analyzer Categories for Maintenance Purposes

| Complexity Factor | | Type of Analyzer | Estimated Man-hours/month Maintenance |
|---|---|---|---|
| 1~5 | Simple | pH, conductivity, gas detection, $O_2$ | 2 |
| 6~8 | Physical Property | Boiling point, flash point, freeze point, RVP, viscosity, etc | 3 |
| 9 | Environmental | CEMs , $SO_2$, CO, ~~$H_2S$,~~ Opacity, | 2.5 |
| 10~15 | Complex | Tail gas, $H_2S$ GC, NIR, FTIR, Mass Spec | 4 |

# Analyzer System Scope of Supply



# Physical Laws that (mostly) Rule Analyzer World

The Four Laws of Thermodynamics

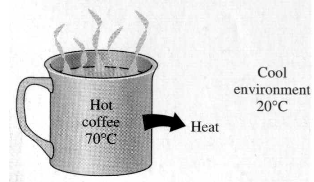
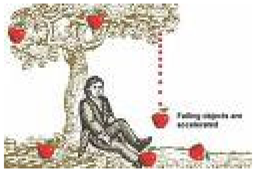
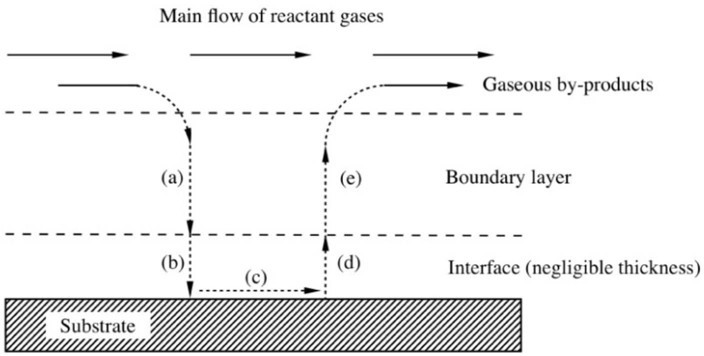



**FIGURE 1–3**
Heat flows in the direction of decreasing temperature.

Newton's Law of Gravitation



Ficks's Law of Diffusion
Langmuir Adsorption Isotherms
Henry's Law for fractional surface coverage



# Real World Laws that (also) Apply

**Pareto**

- Pareto's Law
- 20 % of the system will cause 80% of the problems

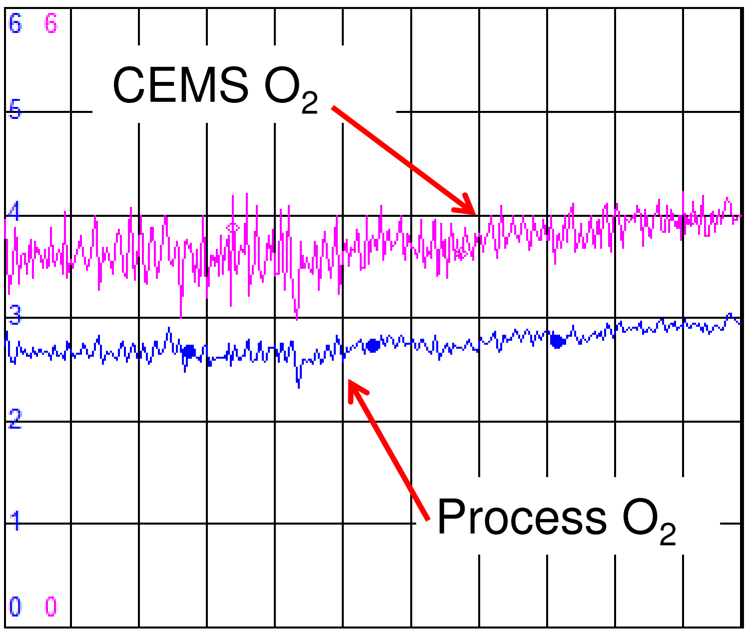
**Murphy**

- Murphy's Law (and corollaries)
- Anything that can go wrong – will (at the worst possible time)
- Chaos always wins because it is better organized

**Heinlein**

- Heinlein's Law (paraphrased)
- Never ascribe to bad design what can be explained by stupidity, but don't rule out bad design

# Case Study 1 / Boiler $O_2$ Readings
## Why don't they match?




When a CEMS $O_2$ can NOT be used to validate a Process $O_2$ measurement:

- CEMS $O_2$ measures on a dry basis

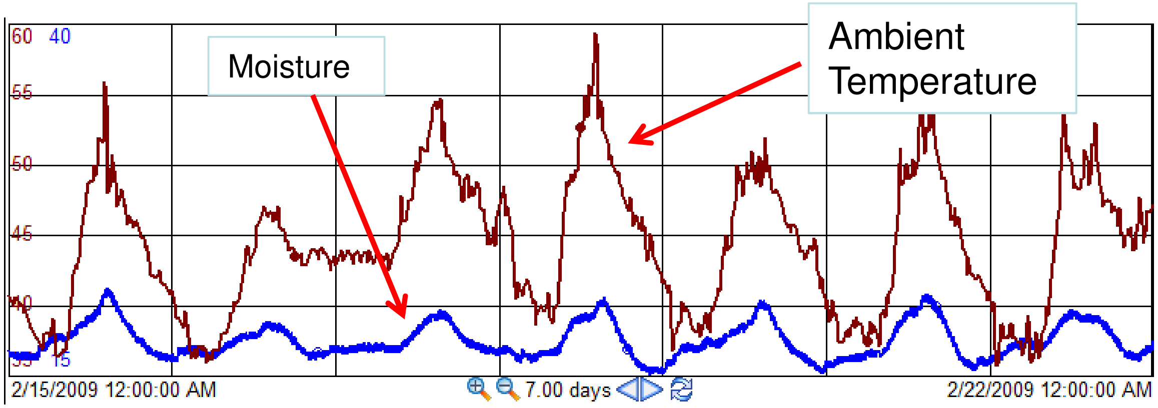
$$\%O_{2dry} = \frac{100 * \%O_{2wet}}{(100 - \%H2O)}$$

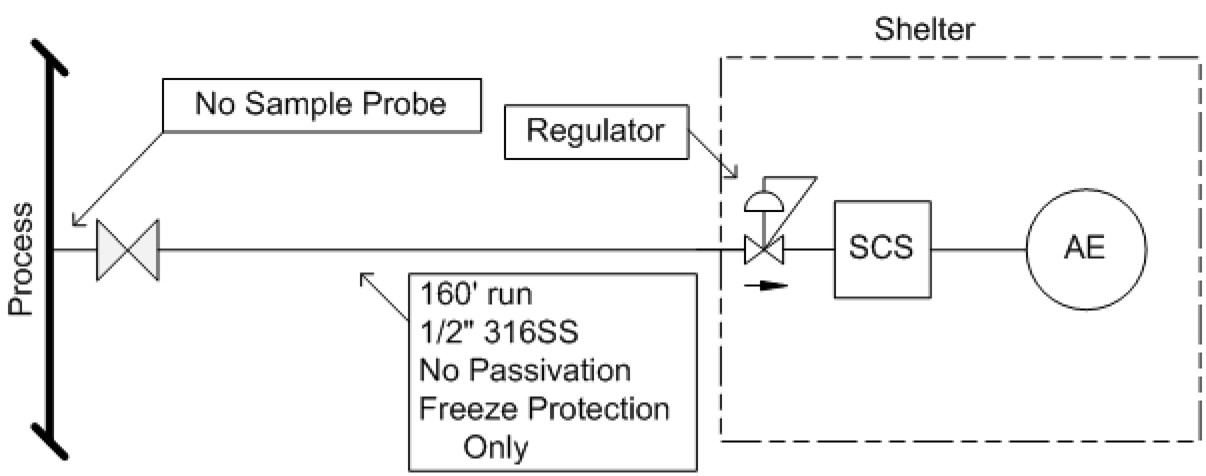
- CEMS tie in location is further downstream than Process tie in

- Different $O_2$ detection principles will not match under all conditions
  - i.e. $ZrO_2$ vs Paramag with combustible breakthrough

# Case Study 2 / Moisture Analyzer

## Reformer Recycle Gas

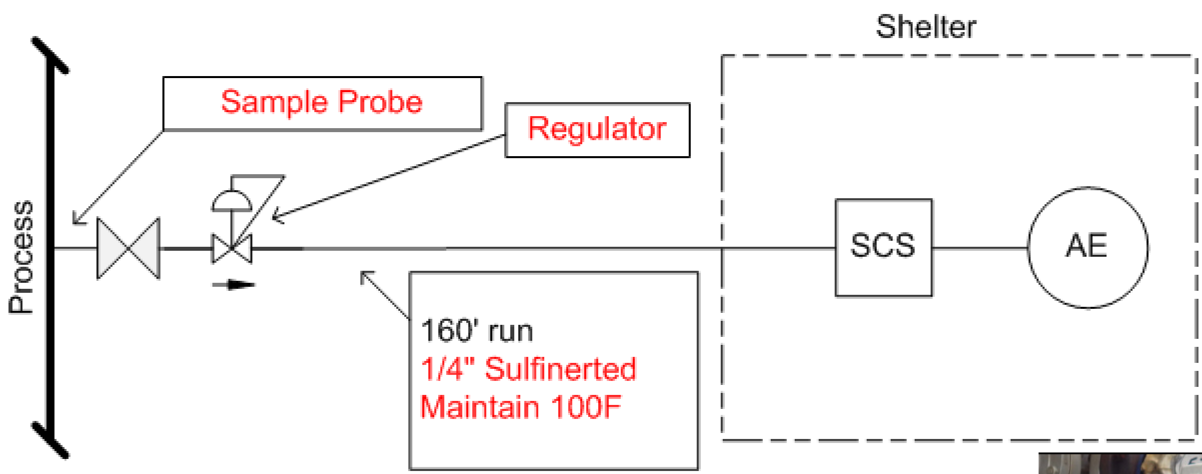



Observations:

- Unstable readings
- Liquid Hydrocarbon condensing in line
- Particulate plugging flow
- Transport lag time calculated at 30 minutes

# Moisture Analyzer in Reformer Recycle Gas




| Effect |
|---|
| Lag time reduced to 60 sec |
| Hydrocarbon Dew Point Decreased |
| Particulate Plugging Eliminated |
| Decreased moisture adsorption and desorption |

# Q&A

## Thank you for your time

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