Selecting Accurate Calibration Gases - Beyond The Obvious

Air Liquide America Specialty Gases

Or,

Bad Calibration Gas - Why Should I Care?

Air Liquide America Specialty Gases

Outline

- The Meaning of Accuracy
- The Cost of Inaccuracy
- Achieving Accuracy in Calibration Mixtures
- The Dollarized Advantage of Accuracy

The Dollarized Advantage …

- Cal Gas Accuracy Affects Operating Cost
- Small Improvements in Cal Gas Accuracy Can be Worth Big $$ in Cost Avoidance
- Accurate Cal Gases Yield True Cost Savings

Calibration Gas Certificates

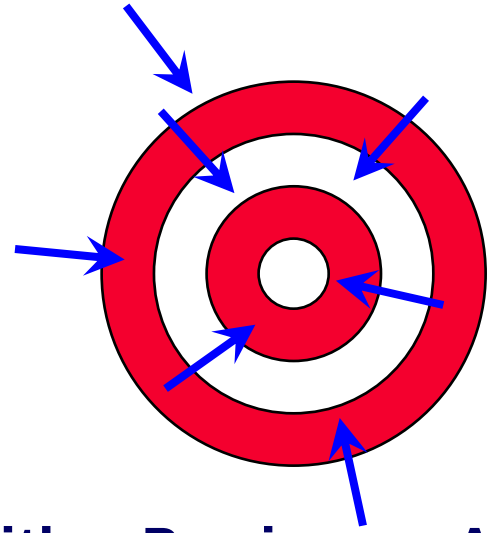
- **Concentration: ”100 ppm NO in N_2”**
  - Measured Concentration of Component
- **Accuracy: “+ / - 1%”**
  - Estimated Deviation from True Value
- **Traceability: “NTRM-1684”**
  - Citation of Reference Standard(s) Used

The Meaning of Accuracy

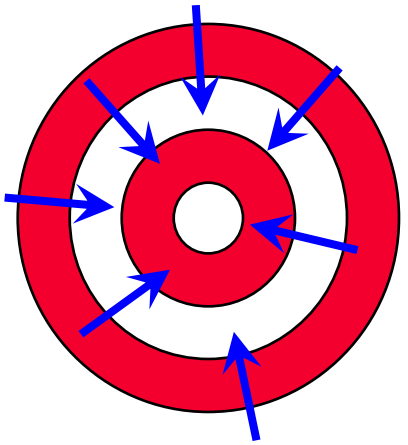
- **Accuracy**
  - A statistical estimate of how closely a measured value approaches the **“true value”**.

- **“+ / - 1% Accuracy”**
  - “Our certified value is within 1% of the **true value**, having evaluated all known sources of underlying measurement uncertainty.”

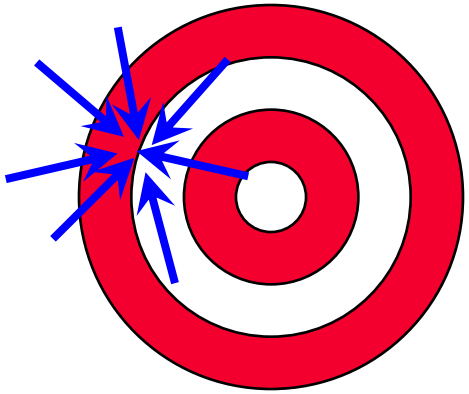
Accuracy vs. Precision



- Neither Precise nor Accurate



- Accurate, But Not Precise



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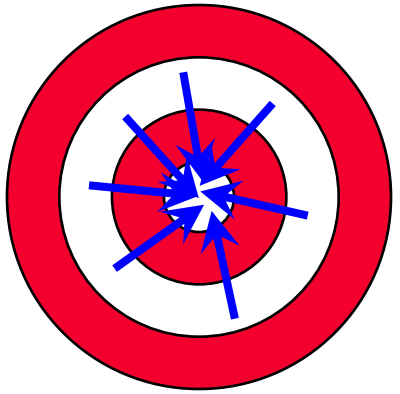


- Precise and Accurate

Sources of Cal Gas Error

"Basic" Uncertainty Sources

Reference Material	0.5 - 1.5%
Analyzer Calibration	0.1 - 0.8%
Analyzer Precision	0.1 - 0.5%

"Extra" Uncertainty Sources

Bad Cylinder Prep	0 - 5%
Contaminated Raw Materials	0 - 10%
Analyzer Interferences	0.1 - 5+%
Correction Factors	0.1 - 2%
GMIS / "Daisy Chain" Standards	0.5 - 2%

Minimizing Cal Gas Error

- **"Basic" Uncertainty Sources**
  - Reference Material (U_s) 0.5%
  - Analyzer Calibration (U_c) 0.4%
  - Analyzer Repeatability (U_p) 0.2%

- **"Propagation of Error" Calculation**
  - Accuracy = $\pm \sqrt{(0.5)^2 + (0.4)^2 + (0.2)^2} = \pm 0.71\ \%$

- **Control the Main Uncertainty Contributors = Control the Overall Cal Gas Accuracy**

Air Liquide Toolbox for Accuracy

- Cylinder Preparation
- Raw Material Advantage
- Blending Advantage
- Instrumentation Advantage
- Reference Standards Advantage
- Traceability Advantage

Cylinder Preparation Advantage

- **ALTech® and Aculife® Cylinder Treatments**
  - Metal Surface Finishing
  - Physical Treatments (Evacuation and Baking)
  - Gas / Gas Mixture Treatments
  - CVD and Chemical Modifications of Surface

- **Results**
  - Rigorous Exclusion of Oxygen and Moisture
  - Elimination of Component “Stick” and “Drop Out”
  - Stability of Reactive Mixtures e.g., Low NOx

Raw Material Advantage

- **World-Wide Sourcing of Pure Materials**
- **In-House Purification of Raw Materials**
- **In-House Manufacture of 99.995% NO**
  - Only Such Plant in North America
- **100% Analytical QC of Blend Components**

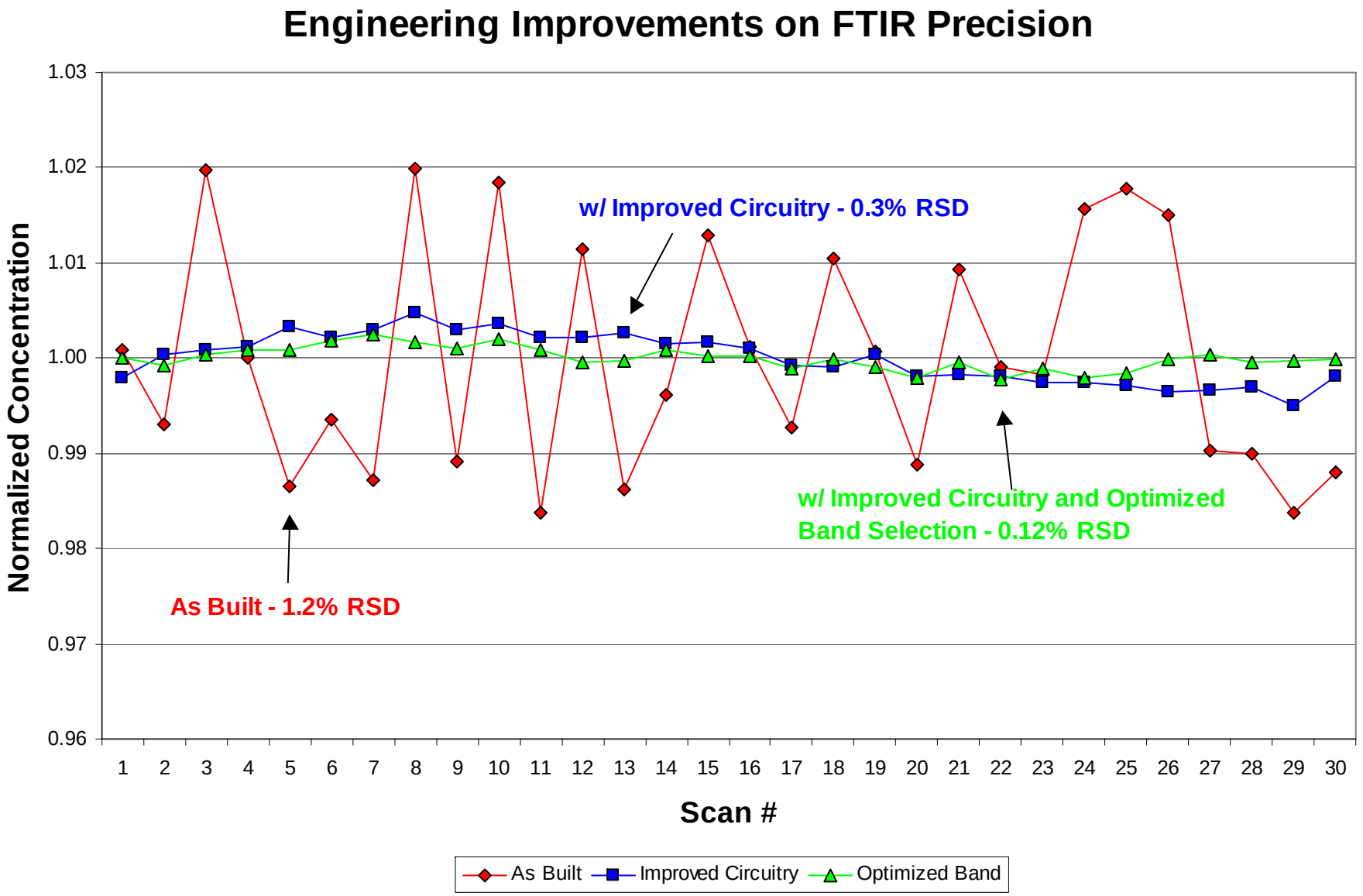
Air Liquide Blending Advantage

- **Acublend® Dynamic Blending**
  - Dynamic Blending with “Real-Time” Analysis
  - Calibrated Process Analyzers / NIST Traceable
  - Accuracy to +/- 1%
  - Cylinder-to-Cylinder, Batch-to-Batch Reproducibility
  - “Zero” Blend Tolerance
- **GravStat™ Gravimetric Blending**
  - Statistically Controlled Gravimetric Blending
  - Calibrated Scales / NIST Traceable (by Weight)
  - Accuracy to +/- 0.1% or Better
  - Statistical Calculation of Concentration and Accuracy

Instrumentation Advantage

- **Interference-Free™ Instrument Platform**
  - $2 MM Investment to Standardize All FTIRs
    - Full Automation of All FTIR Systems
    - Identical Systems in All ALASG Regions
  - Development of Low Noise Circuitry
  - 6 Months R&D on Improved Accuracy Analysis
- **Active Instrumentation R&D Program**
  - Evaluation of Newer Technologies (QCL, TDL, CRDS)
  - Direct Collaboration with Instrumentation Developers

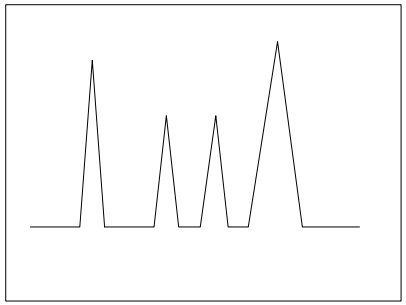
Air Liquide FTIR Optimization



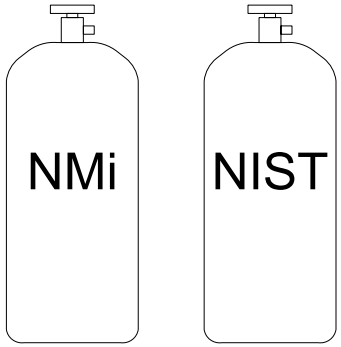
Air Liquide Standard Advantage

- **Large Inventory of Reference Standards**
  - SRM, NTRM and RGM Reference Standards (NIST)
  - Individually Certified NIST SRMs
  - PRM and CRM Reference Standards (NMi)
- **NIST Contractor for SRMs**
  - NIST SRM / NTRM Lot Control Standards
  - NIST Primary Standards
- **Strong Metrology Institute Relationships**
  - NIST / NMi / NPL
  - Declaration of Equivalence

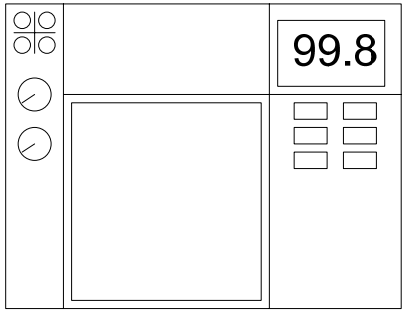
Direct Analytical Traceability



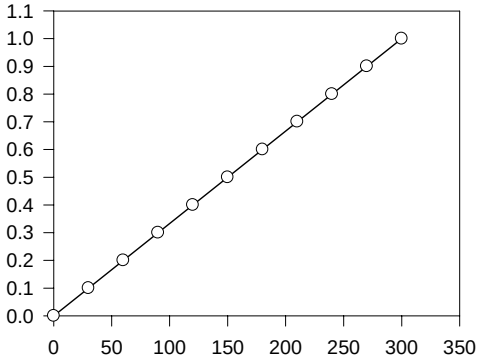
Responses



Reference Standards

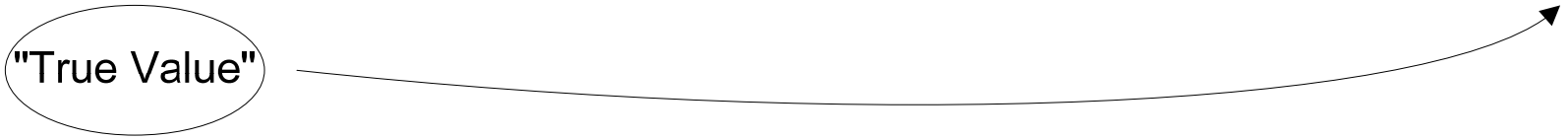


Instrument



Calibration Curve

Product



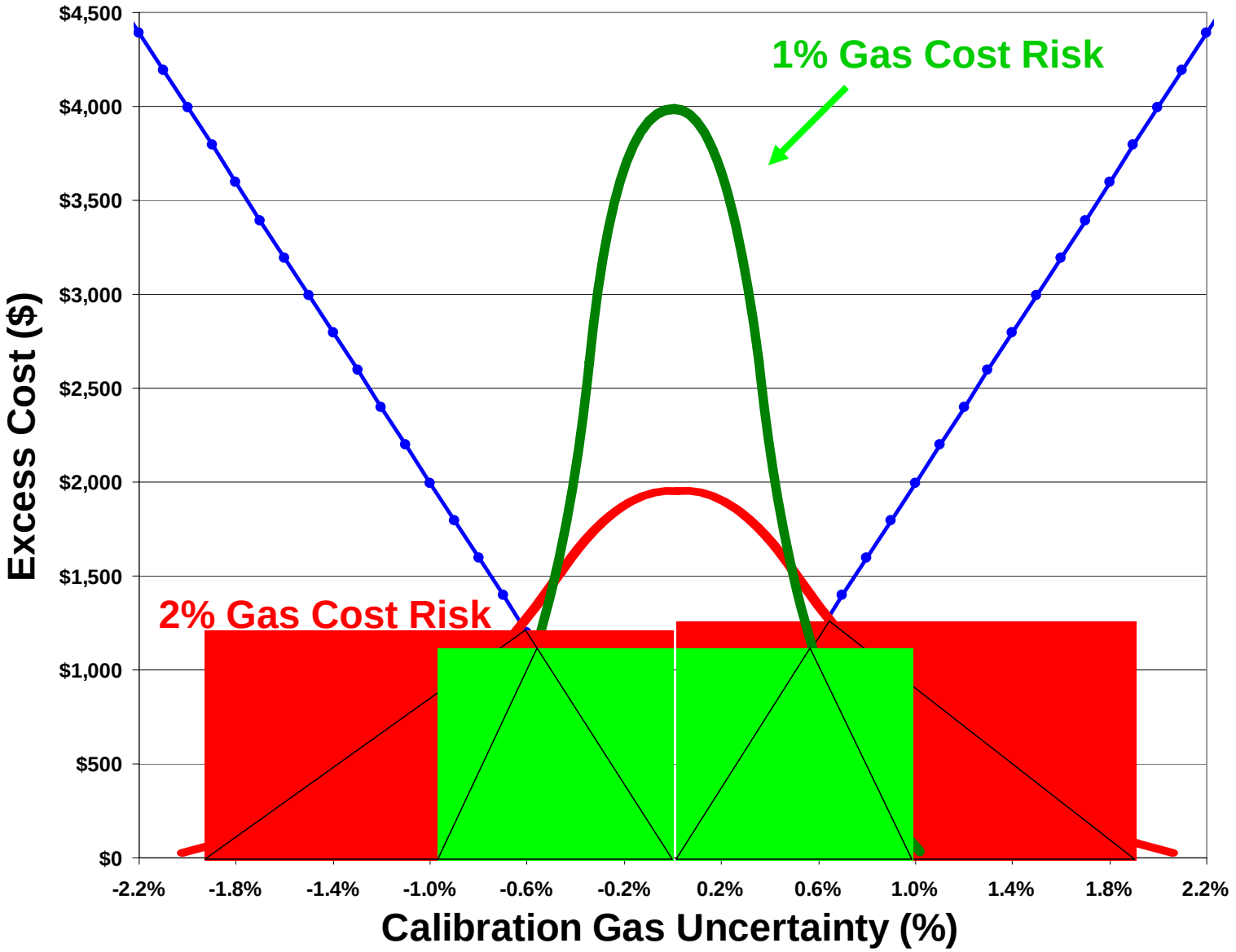
Potential Cost of Inaccuracy

Customer Model Case

- One Emissions Test Cell
- Average Value per Operating Hour = $1500
- Operating Regime 40 Hours per Week (8 x 5)
- Total Value of Business = $3,000,000

Source of Cost	Excess Cost	
Potential Vehicle Recalls (Voluntary and Mandatory)	$	110,000
Emission Test Cell Down Time	$	48,000
Emergency Technical Troubleshooting	$	17,680
Excess Cylinder Inventory	$	17,120
Emergency Gas Purchases	$	5,840
Poor Supplier Service	$	960
Grand Total - Annual Cost of Inaccuracy	**$**	**199,600**

Cost Risk of Cal Gas Accuracy



Cost Exposure Calculation

- **1% Accuracy Gas**
  - "Over": 0.5 x 1 (%) x $1,000 ($) = $500
  - "Under": 0.5 x 1 (%) x $1,000 ($) = $500
  - Total Cost Exposure = $1,000
- **2% Accuracy Gas**
  - "Over": 0.5 x 2 (%) x $1,250 ($) = $1,250
  - "Under": 0.5 x 2 (%) x $1,250 ($) = $1,250
  - Total Cost Exposure = $2,500
- **Area of a Triangle = 1/2 * Base * Height**

Dollarized Value of Accuracy

- **Cost Exposure Related to Gas Accuracy**
  - 1% Gas = $1,000
  - 2% Gas = $2,500
- **Dollarized Accuracy Difference = $1,500**
- **2% Gas Has 2.5X More Cost Exposure**

Key Takeaways

- **Air Liquide Cal Gases are More Accurate**
  - Greater Work Input and Attention to Detail
  - Strict Control of Underlying Sources of Errors
  - Assessment of Combined Impact of Errors
- **Proven Track Record**
  - Uniformly Positive Customer Results
  - Success in Competitive Tests and Audits
- **Cal Gas Accuracy Directly Equates to Cost**
- **Higher Accuracy Cal Gas Saves Money**
  - More Accurate Gas Reduces Excess Cost Exposure
  - 2% Gas ~ **2.5X** More Costly to Use than 1% Gas

More Value from Air Liquide Offer

- **Consistent Calibration Gas Accuracy**
- **High Quality Companion Products**
  - Alphagaz Pure Gases and Support Mixtures
- **Metrology Services**
  - Cross Reference Service
  - “ReAL Time™” Gas Subscription Service
- **Equipment and Delivery Systems**
- **Cylinder Inventory Minimization**
- **eScott On-Line Services**
  - Folio Services, C of A’s, MSDS’s
  - Product Ordering and Data Management