



Houston

**SIGMAFINE SUMMIT 2019**™

engineering data for digital transformation

## Lost with Losses

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### *The Hidden Impact of Measurement Technology in Closing Mass Balances*

By: Julie Valentine, Director, Global Refining Flow Solutions,  
Emerson Automation Solutions

October 23<sup>rd</sup> 2019



# Agenda

Role of Field Instrument accuracy in  
Production Accounting and Losses

Business Challenges

Using Sigmafine to Identify Measurement  
Issues

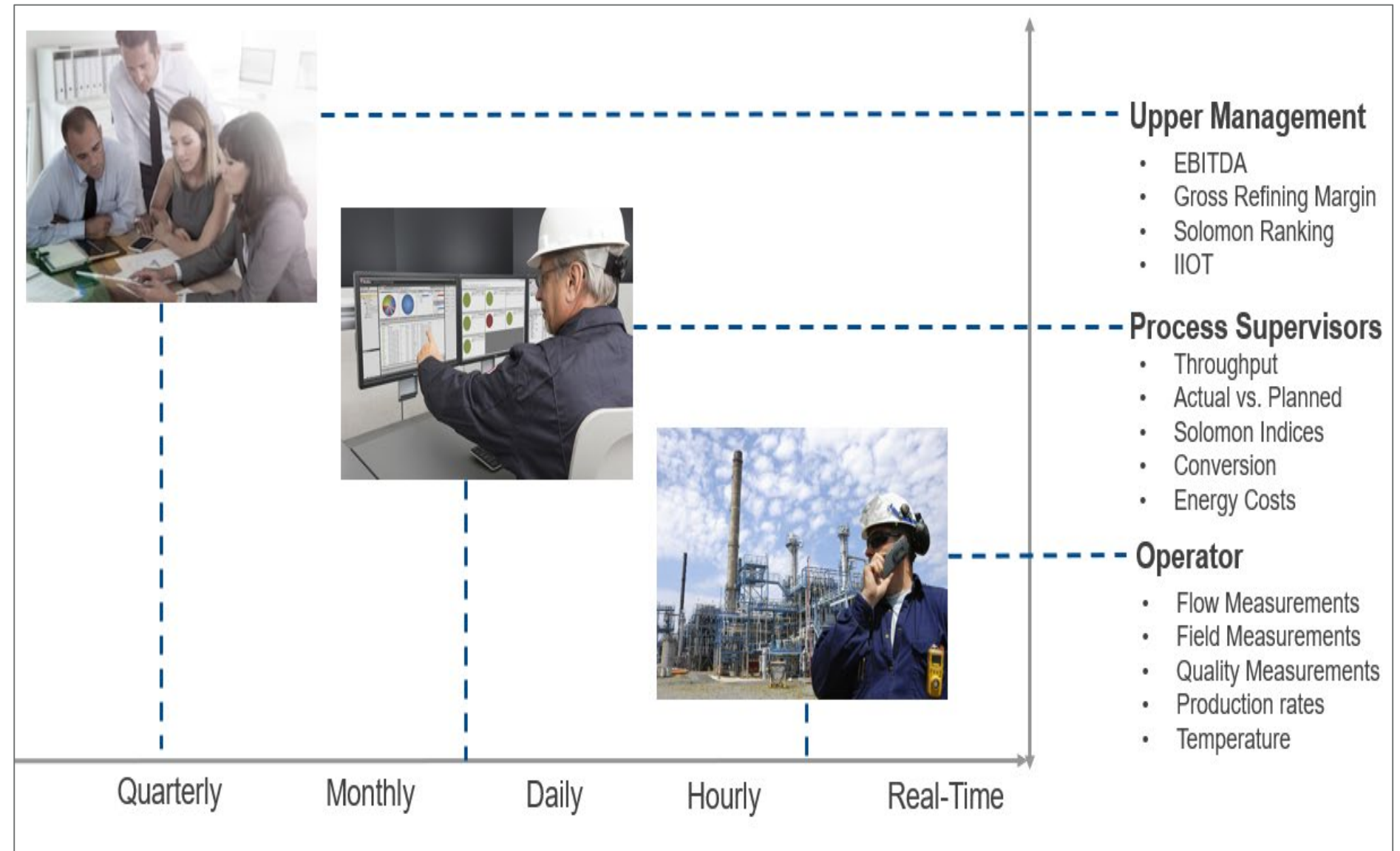
Current Measurement Technologies and  
Standards

Recommended Practices for Improvement



# Typical Refinery Losses

- With **poor** instrumentation and procedures: 1.5-2.5% mass
- With **average** instrumentation and procedures: 0.7% - 1.5% mass
- With **good** instrumentation and procedures: < 0.5 % mass
- Good information enhances business functions:
  - Planning and scheduling
  - Process Operations
  - Management Decision



**Mass losses for the overall refinery must be less than 0.5% to meet Solomon Index reporting requirements**

# Why Mass Balances Matter



## Profitability

- Not overpaying for what you buy or getting underpaid for what you sell
- You are getting paid for on what your custody measurement is reading not on your reconciled measurement
- Assurance, control, and validation of movements (i.e. theft prevention)



## HSE

- Accurate emission reporting to avoid overpaying fines
- Accurate reporting of Energy Intensity Index (EII)
- Ensure not operating above design limits

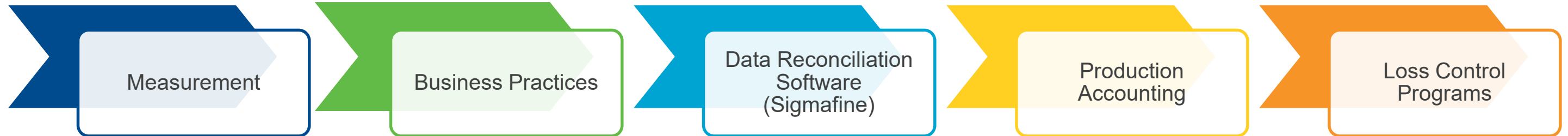
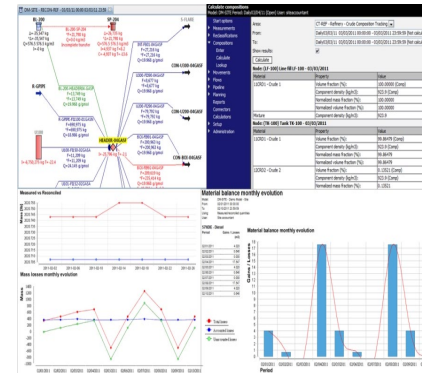
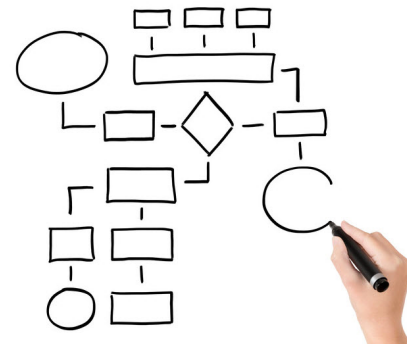


## Process Optimization

- Pinpointing of losses early
- Identification and minimization of unaccounted losses
- Unit performance optimization by calculating efficiencies, catalyst conversions and yields

**Savings of \$2-10 million per year for an averaged sized refinery**

# Refinery Loss Control Process



**Flow measurement is the foundational step for production accounting and loss control**



## Case in Point

### Scale of theft at Shell's Singapore refinery much greater, court documents show

Around \$150 million worth of oil was stolen from Shell's biggest global refinery over several years, [Singapore](#) court documents reviewed by Reuters show, far more than reported when police first revealed the heist earlier this year.

“Fuel is both ubiquitous and untraceable, making its theft a seemingly low-risk criminal operation compared to something like drug smuggling or arms trafficking, where the concern about being caught is much higher,” said Ian Ralby, a maritime crime expert who works with both the U.N. and the U.S.-based

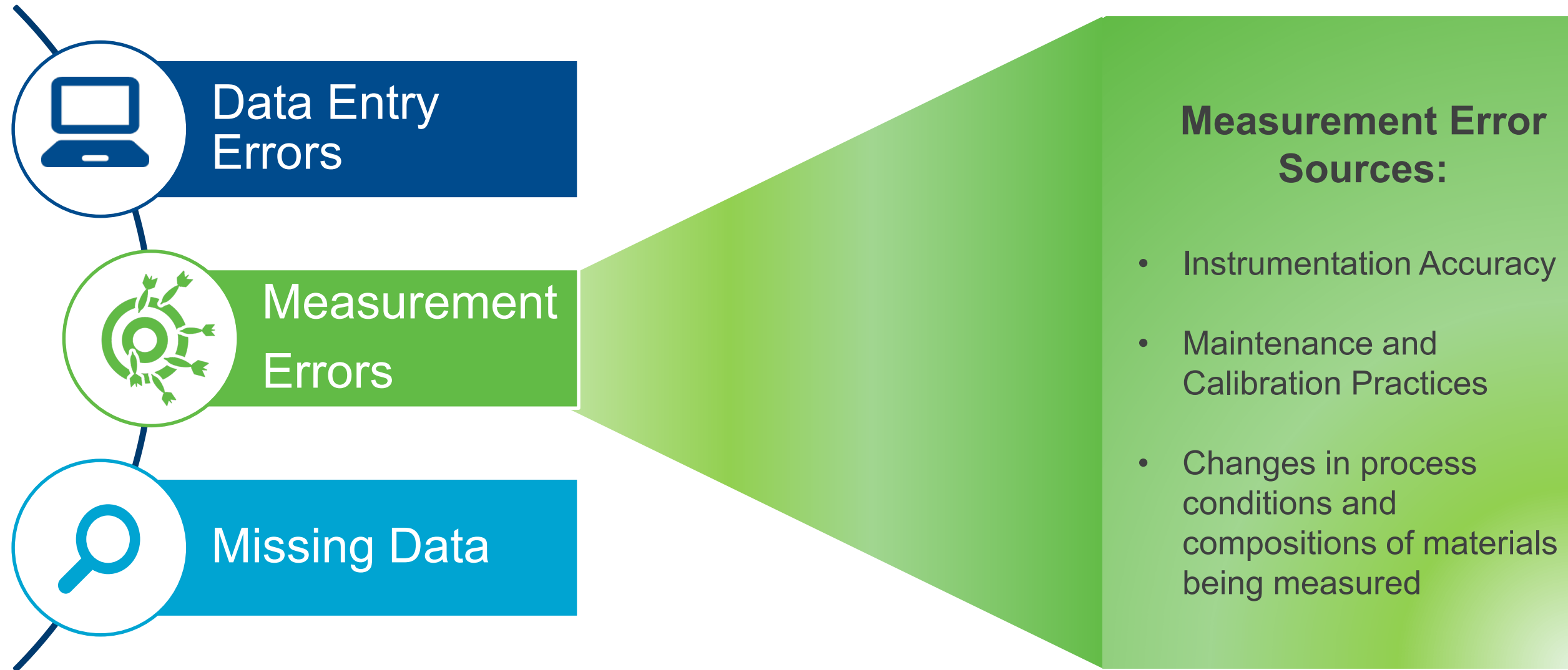


### Shell has taken measures to avoid repeat incidents:

“These include closer monitoring of products moving in and out of Bukom, tightening vessel management procedures, and stepping up ethics and compliance training,” the spokeswoman said in an emailed statement to Reuters on Thursday.

**Fuel theft could be worth \$113 billion a year globally, according to industry estimates**

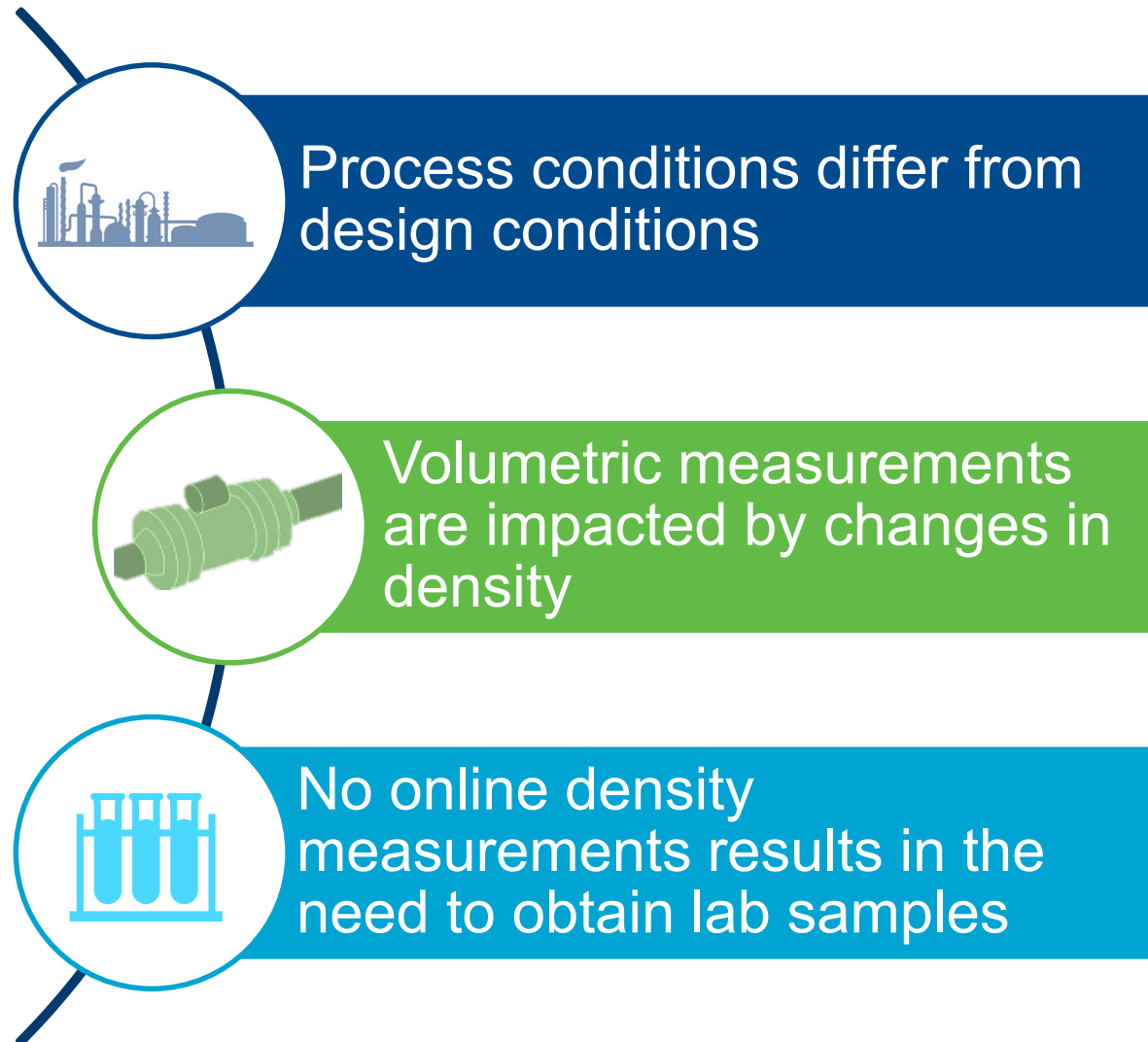
# Challenges With Closing Mass Balances



**Accurate flow measurements are key to accurate mass balances**

# Refinery Plant Wide Mass Balance Challenges

## Flow Measurement Challenges



## Sources of Error

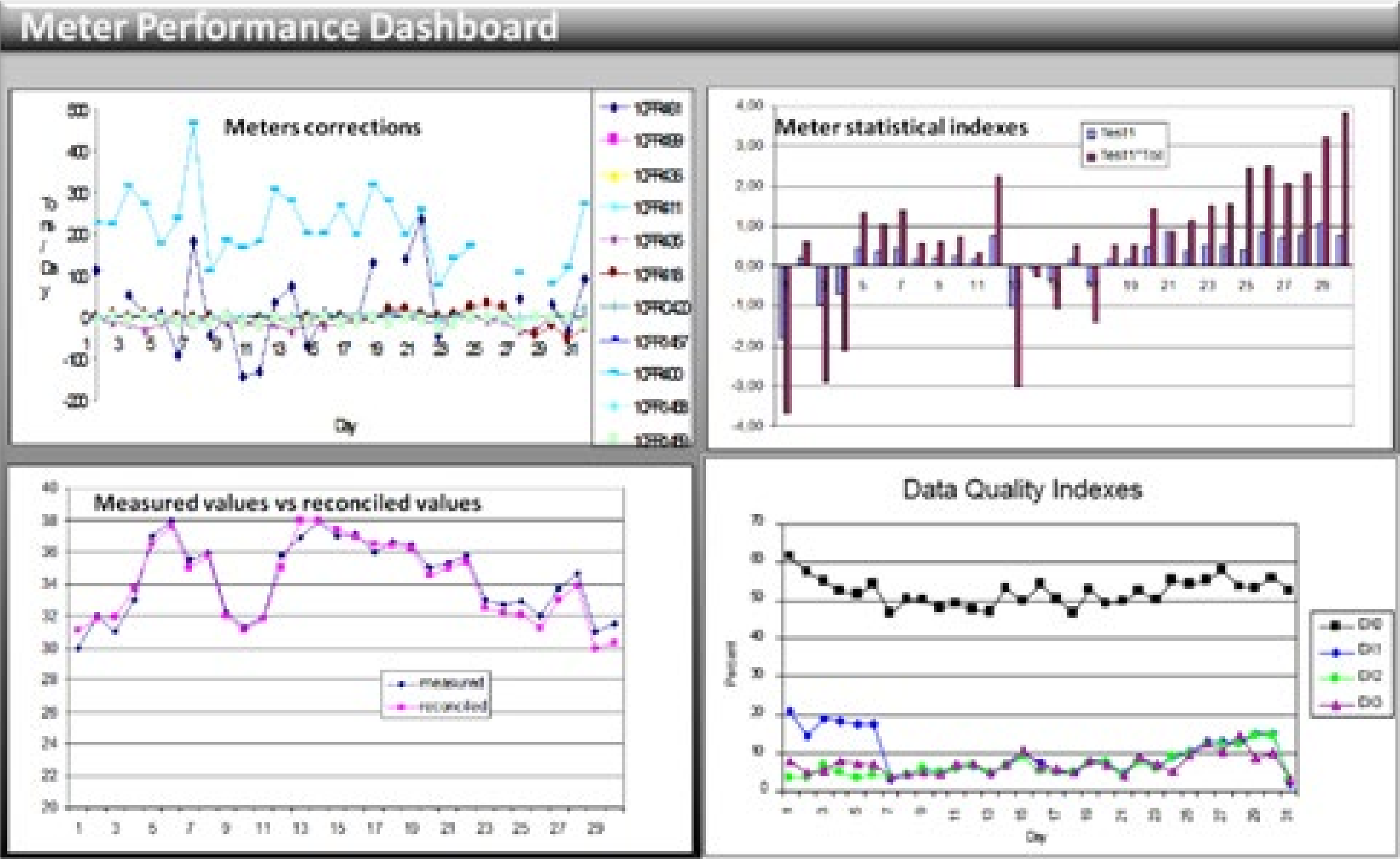
1. Crude Import Custody Transfer Measurement
2. Density Measurements
3. Natural Gas Measurements
4. Fuel Gas
5. Inventory Changes

### Additional Sources:

1. Coke
2. Flare



# Meter Performance from Sigmafine



# How Sigmafine<sup>®</sup> works

Build Model

- How the process information is related
  - Plant, Process unit, Business Unit, Unit operations, Equipment, Process, etc

Apply Engineering Principles

- Automate calculations
  - Simple - PT Compensations/UOM/M to V conversions
  - Complex - Eq. of state (e.g. Peng Robinson), Property estimation (e.g. Klosek McKinley)

Apply Conservation Principles & Analysis Rule(s)

- $\sum \text{In} - \sum \text{Out} + \sum \text{Generation} + \sum \text{Consumption} - \sum \text{Accumulation} = 0$ 
  - Analysis Rules: Mass, Energy, Composition, Properties

Solve Model for minimal error

- Error Minimization (SSR)

$$\text{Minimize } \sum_{i=1}^N \left( \frac{\text{Raw}_i - \text{Reconciled}_i}{\text{Absolute Tolerance}_i} \right)^2$$

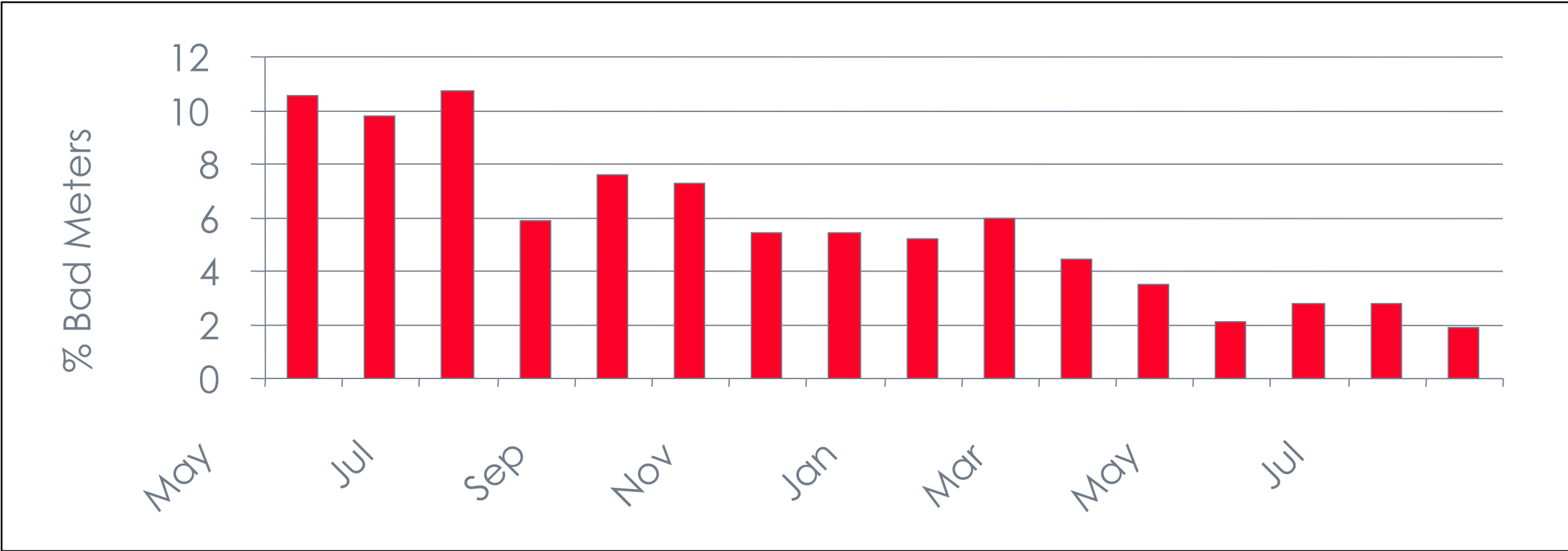
# Data Quality KPI - Case

DX Indicator	Value	Used for assessing
DX0 – Redundancy	> 85 %	Sufficiency of flow measurements
DX 1 – Imbalance	< 10 %	Overall quality of a set of measurements
DX 2 – Reconciled Correction	< 5 %	How much correction required to reconcile
DX 3 – Tolerance	DX3 > (DX2, DX1)	How well the tolerances are assigned
DX 4 – Reconciled Difference	< 0 (negative)	Level of distortion between reconciled and measured

- Generate prescriptions for improving data over time
  - Classic example: stack ranking of bad meters

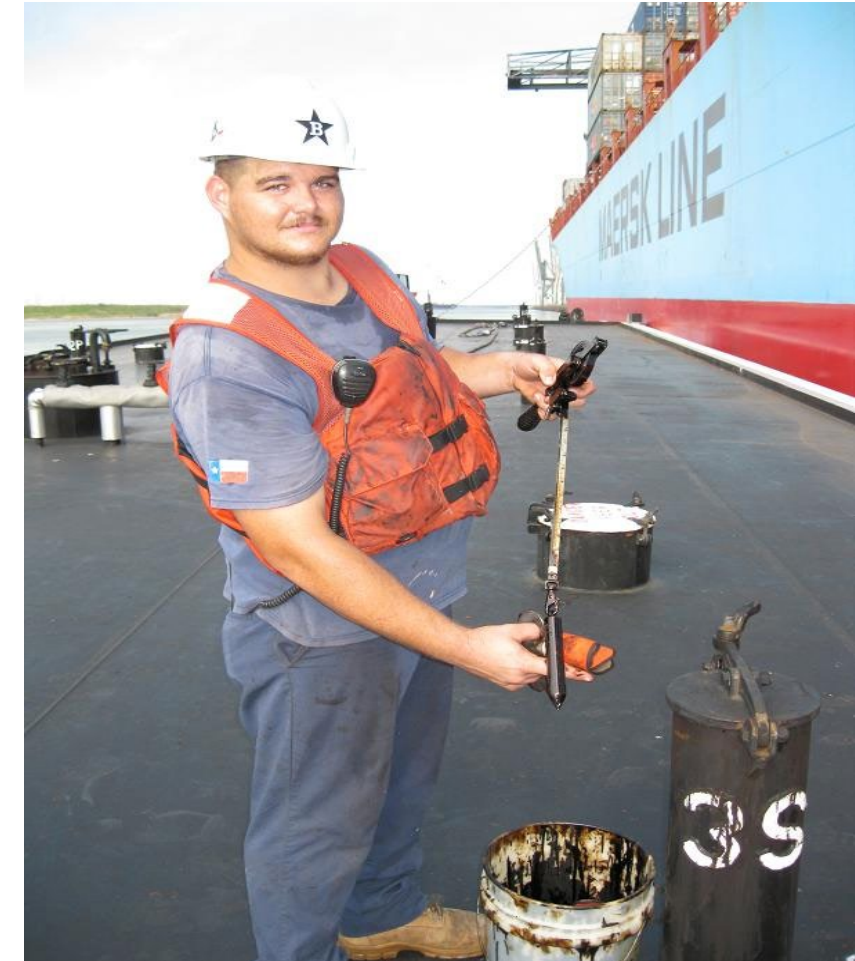
# Indirect Benefits of Sigmafine

- Improving & sustaining meter reliability

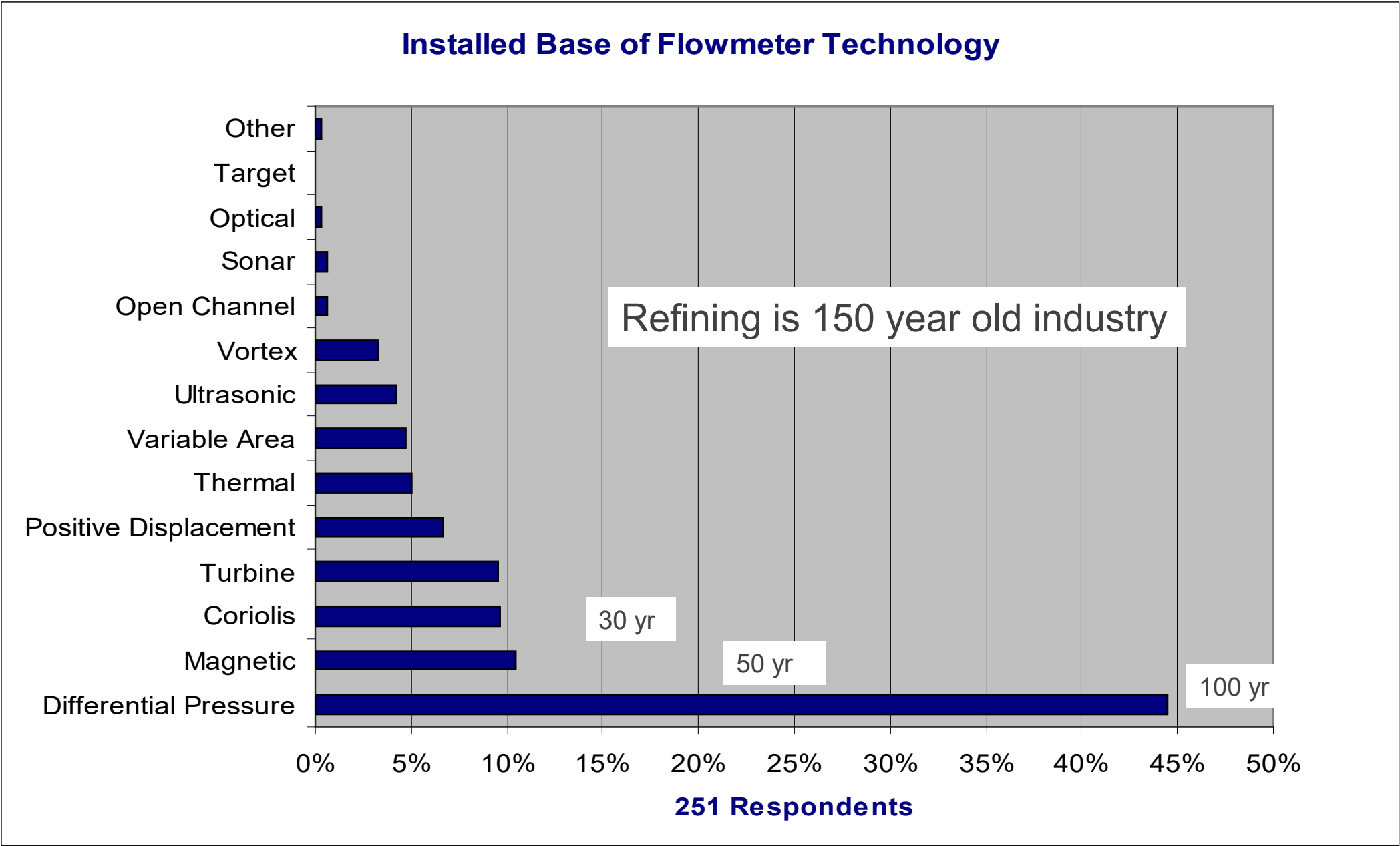


# Custody Measurement Types

- Mass and Volumetric Flow Meters
- Automatic Tank Gauges (ATG)
- Marine Vessel Gauging
- Manual Gauging
- Truck and Rail Car Outages
- Weigh Scales



# Distribution of Flowmeter Technology



# Historical Practice for Mass Balance Meters – Use Volumetric Technologies

## Orifice dP Meters for Process Applications

### Advantages

- Greatest application flexibility
- Low purchase price
  - Independent of line size
  - Cost effective for larger line sizes

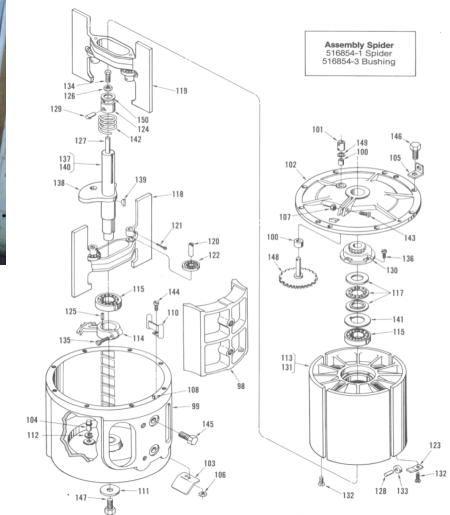
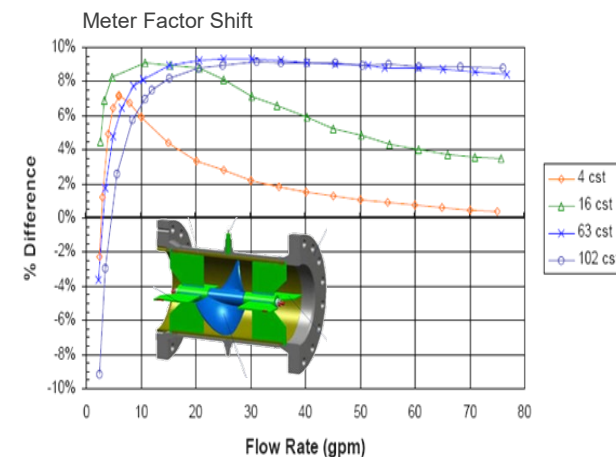
### Limitations

- Poor accuracy when uncompensated, 1-5%
- Moderate accuracy when compensated: 0.5-1.5%
  - Having a **known fluid density** is the key to achieving this accuracy
- Accuracy degraded by orifice plate wear, difficult to detect
- Impulse lines can plug



## Mechanical Meters for Custody Transfer Applications

- Metering performance affected by fluid properties
- Extensive moving/wearing parts
  - High maintenance
  - Meter factor shift
- **NEED** to be frequently checked and adjusted



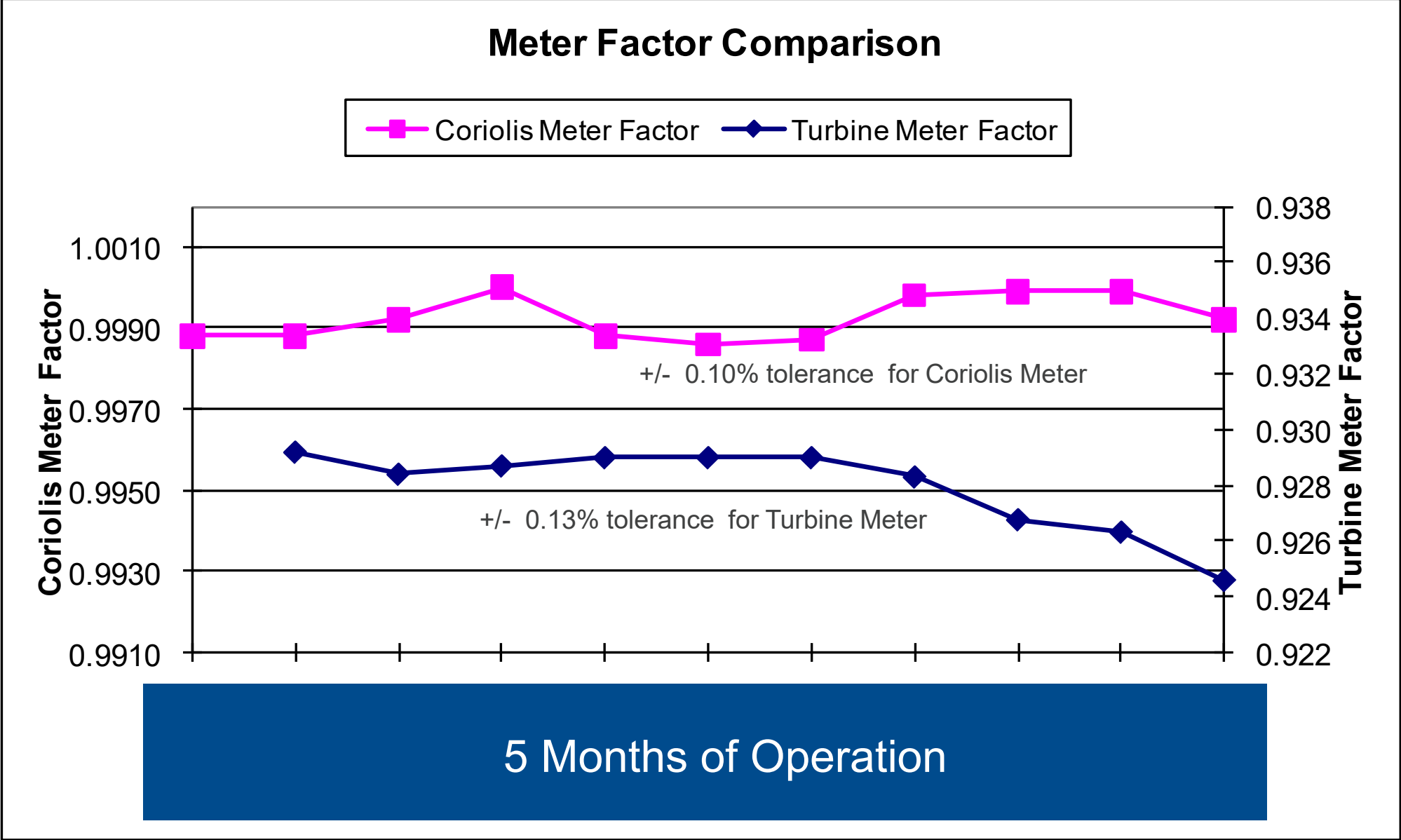
# Coriolis Meters Eliminate The Largest Sources of Measurement Error in Mass Balance and Custody Transfer Applications

- **Direct Mass and Density Measurement**
  - Not affected by changes in composition, viscosity, temperature, pressure, conductivity
- **Rangeability**
  - 20:1 for custody
  - 100:1 for non-custody
- **Measurement accuracy**
  - At 20:1 turndown:
    - Mass Flow Rate:  $\pm 0.1$  (optional 0.05 %)
    - Volume Flow Rate:  $\pm 0.1\%$  (optional 0.05%)
- **No flow conditioning or straight runs required**
  - Not dependent on flow profile
- **Measures difficult and/or viscous fluids**
  - Liquid asphalt and molten sulfur
- **Bi-directional Measurement**
- **Low Maintenance**
  - No moving parts
- **Two-Phase Flow Indication**
  - Provides notification of the fluid being single phase, moderate entrainment, and severe entrainment
- **Smart Meter Verification (SMV)**
  - In-situation testing of meter integrity – tube stiffness, sensor components, transmitter electronics
  - Extend calibration cycles



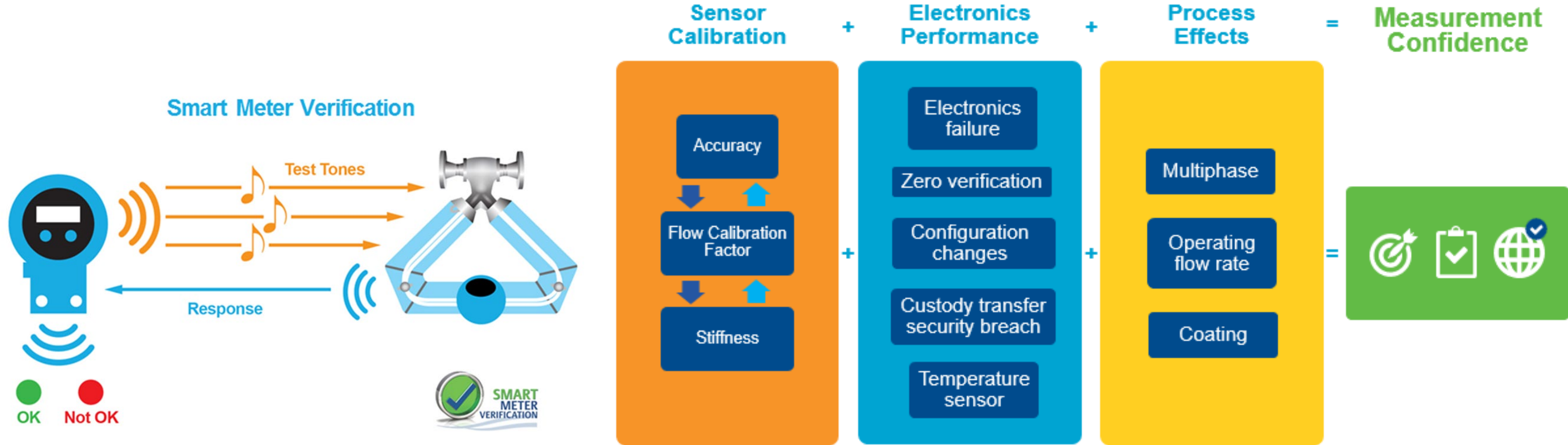


# Long Term Meter Factor Stability



*Results of proving a CMF300 and 4" Turbine meters with 18" Brooks Compact Prover on LPG in refinery in Brazil .*

# Smart Meter Verification Delivers Confidence in Measurement



# Standards for Coriolis Meters

**Manual of Petroleum  
Measurement Standards  
Chapter 5—Metering**

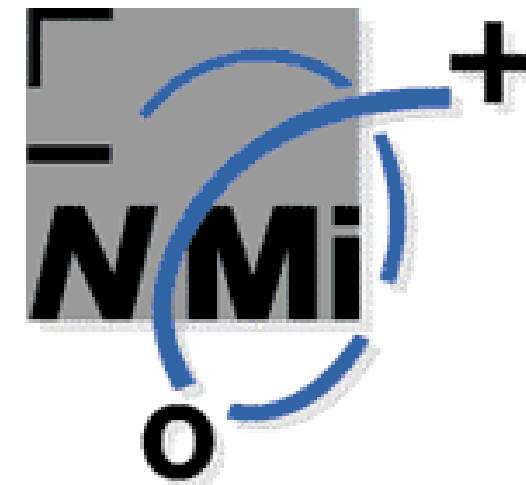
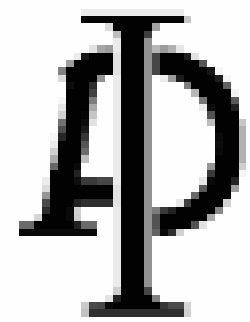
**Section 6—Measurement of Liquid  
Hydrocarbons by Coriolis Meters**

Measurement Coordination

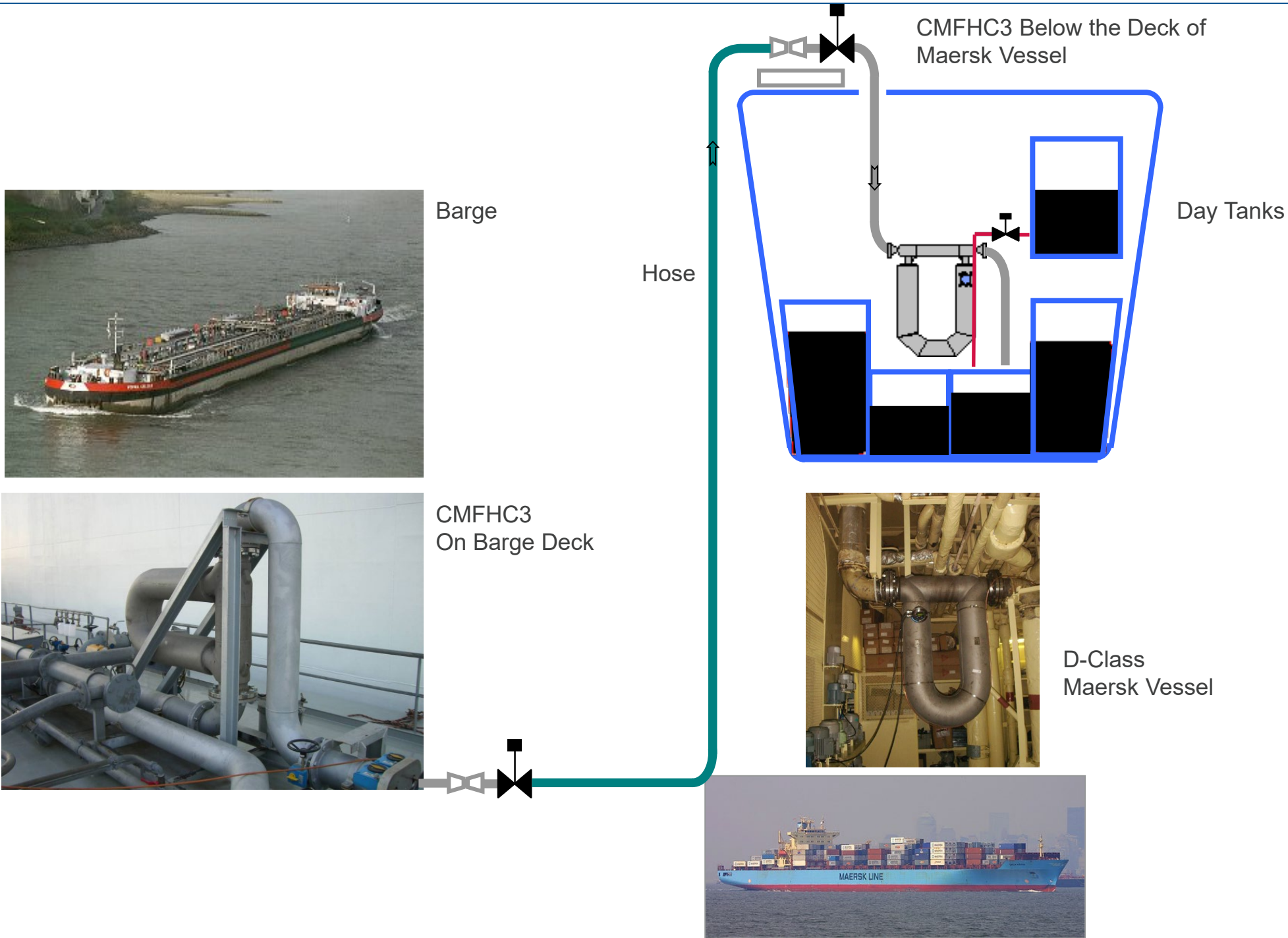
FIRST EDITION, OCTOBER 2002



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Get The Job  
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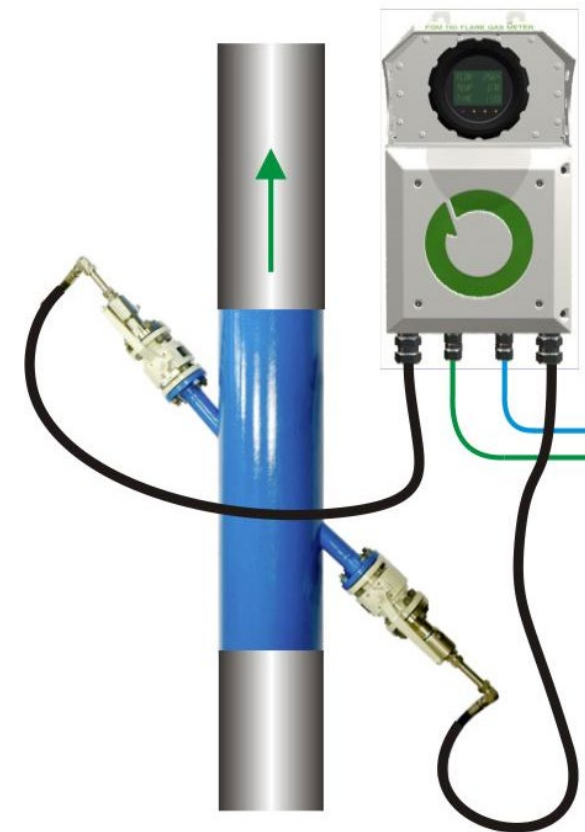
# Example: Tanker Lightering using Coriolis



# Common Sources of Error for Refinery Mass Balance Flare Measurement

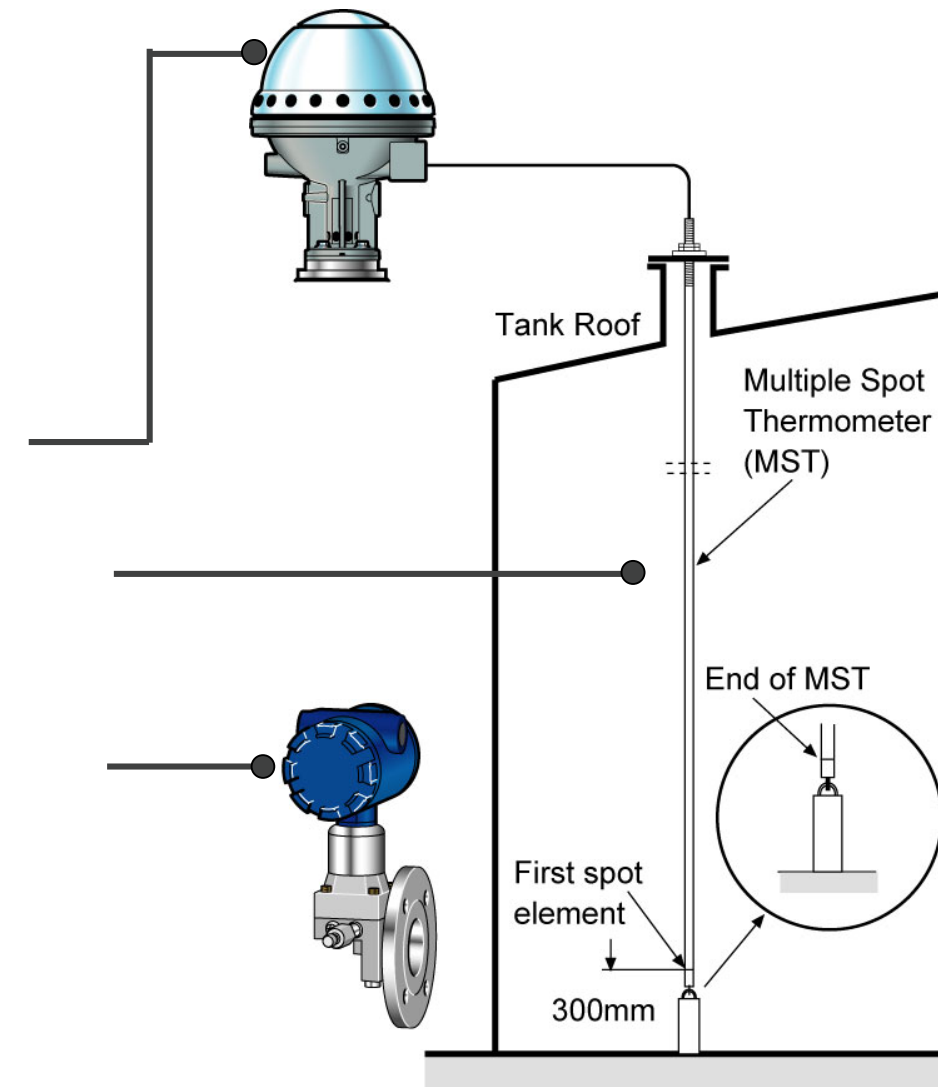
## Flare

- Losses through flare are typically the largest source of identifiable loss
- Measurement challenges:
  - Wide turndown requirements
  - Widely changing compositions
  - Very low gas pressure
  - Fully developed flow profile at low end difficult
- Uncertainty is often above 10% at the low end but technology advances can significantly improve that performance
- Measurement technology:
  - Ultrasonic meters + Gas composition analysis either by lab sampling, GC or Mass Spectrometry
  - Technology enhancements for ultrasonic meters resulting in improved accuracy
    - MW calculations using sound speed of the gas
    - Correction factors from computational fluid dynamics

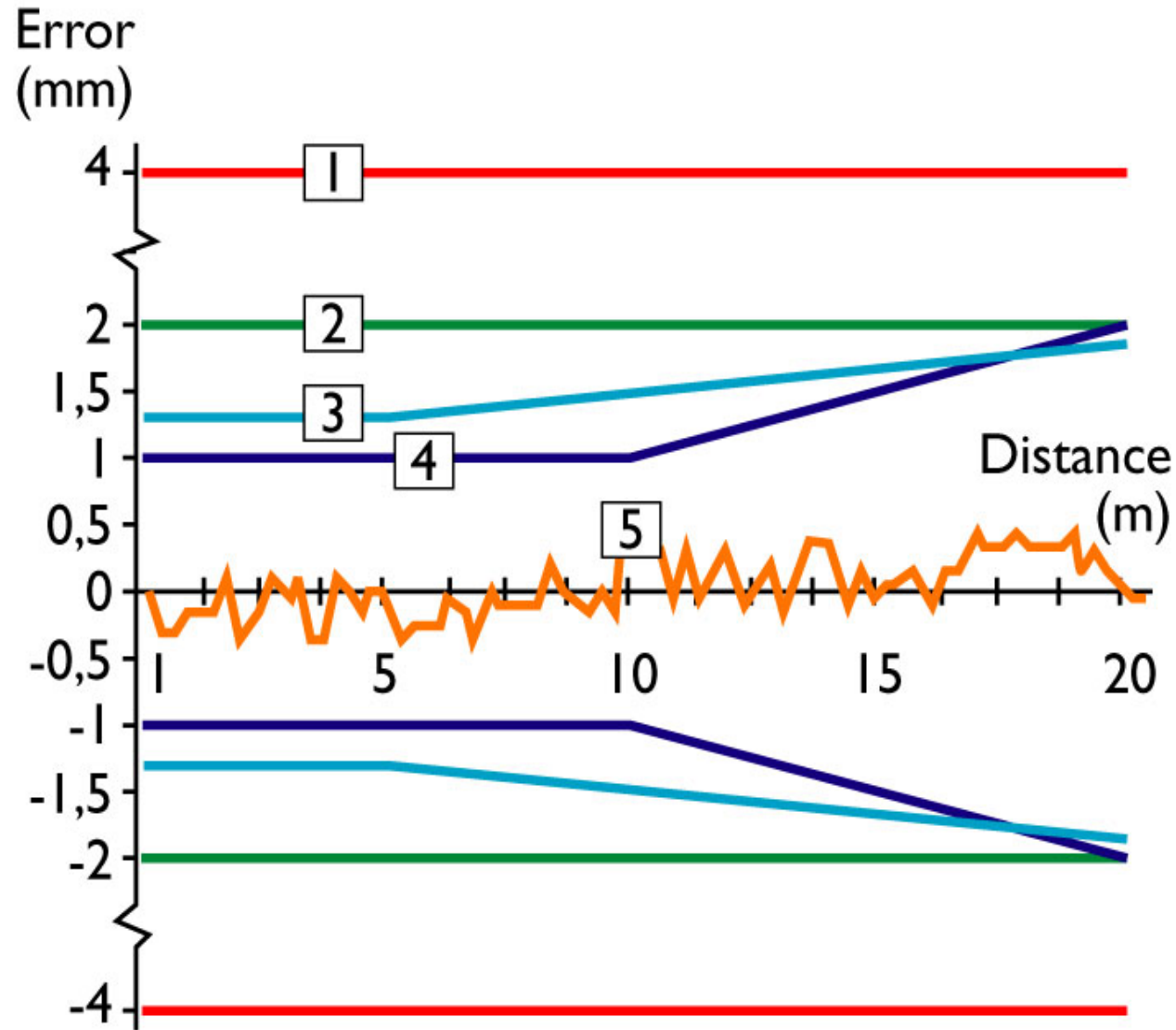


# Custody Transfer and Inventory Tracking – ATG (Radar)

- For the calculation of a transferred quantity the tank gauging system requires:
  - Level, at start and end of transfer
  - Average product temperature, at start and end of transfer
  - Density (or API gravity), at start and end of transfer.
  - Base Sediment & Water
  - Tank Strapping Table



# Accuracy of Automatic Tank Gauging



1 API  $\pm 3/16''$  (4 mm)

2 PTB, Germany

3 NMI, Netherlands

4 OIML, International

5 TankRadar

**Manual of Petroleum  
Measurement Standards  
Chapter 3—Tank Gauging**

**Section 1B—Standard Practice for Level  
Measurement of Liquid  
Hydrocarbons in Stationary  
Tanks by Automatic Tank  
Gauging**

## APPENDIX B—ACCURACY REQUIREMENTS FOR ATG (See Note)

Requirement	Custody Transfer	Inventory
Factory calibration	1 mm ( $1/16$ inch)	3 mm ( $1/8$ inch)
Effect of installation	3 mm ( $1/8$ inch)	n.a.
Initial verification	4 mm ( $3/16$ inch)	25 mm (1 inch)
Subsequent verification	4 mm ( $3/16$ inch)	25 mm (1 inch)
Frequency of verification	monthly	quarterly

Note: This table is for reference only. Please refer to the entire document.

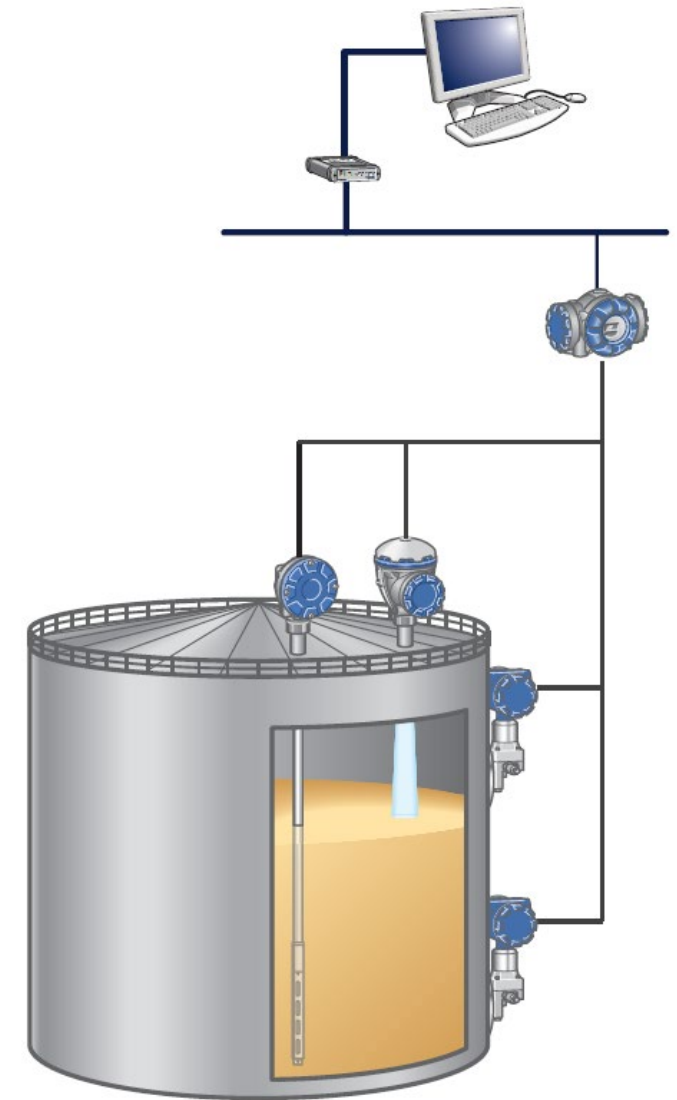
American Petroleum Institute  
1220 L Street, Northwest  
Washington, D.C. 20005



# Uncertainty of Tank Volumes and Mass is highly dependent on instrumentation and maintenance of the tank

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- Tank Gauging System Installation Method
- Uncertainty in Tank Capacity Table
  - Calibration method
  - Maintenance of strapping table
- Uncertainty in Average Product Temperature
  - Multi-spot
- Uncertainty in Density Measurement
  - Manual sampling (sampling procedure and laboratory)
  - Automatic (precision of the pressure transducer)
  - Stratification of fluid in the tank











# How to Improve Mass Balances

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- **Evaluate your current closure of your mass balances**
  - How does your refinery wide balance compare to your target or expected benchmarks?
  - Are there some process units that are more difficult to close?
- **Use Sigmafine to identify measurement issues**
  - KPI's to evaluate current systems and help to prioritize
- **Critical balance points to prioritize**
  - Crude import
  - Crude charge to the crude unit
  - Conversion unit feed rates
  - Primary products for accurate yield data
  - Unconverted bottoms
- **Perform an audit of prioritized measurements**
  - Understand contributions to measurement uncertainty and the overall accuracy and possible biases

# Key Takeaways

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-  Need to understand where there are missing or inaccurate measurements through the use of Sigmafine
-  Using traditional technology in mass balance applications result in inaccuracies
-  Accurate data is needed to make better operational decisions that in return result in better reconciliation, reducing losses, process optimization, and savings
-  Emerson combined with Sigmafine have the technologies and expertise to help you improve your mass balances

A photograph of an industrial refinery or chemical plant. The scene is dominated by a complex network of green metal scaffolding, walkways, and numerous large, white insulated pipes. In the background, several tall, silver cylindrical chimneys or distillation columns rise against a clear blue sky. The entire image is overlaid with a semi-transparent blue triangle that points from the top-left towards the bottom-right. The text 'Thank You' is positioned on the left side of this blue area, and the 'EMERSON' logo is in the bottom right corner.

Thank You

**EMERSON**