A New Look at the Pipeline Variable Uncertainties and Their Effects on Leak Detection Sensitivity

API/AOPL project within PRCI: PL-1-2

2014 Government/Industry Pipeline R&D Forum

August 6 - 7, 2014 | Rosemont, IL

Discussion Topics

- Research Objectives and Deliverables
- Team
- Methodology
- Current Status
- Upcoming Activities

Key Messages

- Executive Summary, new API 1149 technical report, Software Manual, and Software Tool
- More statistics involved
- 1st-2 Documents to API in Spring
- Software Design and Testing

Desired Outcomes/Decisions

- Report Out Status of Project initiatives and activities
- Focus on the being proactive and assist in industry Leak Detection Performance Initiatives.

Background

- **Research Objectives**
  - **A new comprehensive revision, technical report of API's 1149 publication is coming soon**
    - Due to a number of gaps, shortcomings, and recent technological developments, engineering uncertainty factors, and operational requirements.
    - Cover the complete range of CPM methods in current, practical use
    - Extensions to Highly Volatile Liquids (HVL) and gases
    - Alignment of the definitions and approach to uncertainty with those used systematically in instrument and measurement.
      - ASME Validation and Verification Procedure (V&V) # 20 (2009)
      - API Manual of Petroleum Measurement Standards (2013)
    - Recognition of the nonlinear and strongly time-dependent nature of certain engineering factors

The 1993 version of API 1149 was good, but had its gaps and shortcomings.

Background

- **Research Objectives**
    - Inclusion, in detail, of a number of engineering factors that occur regularly in pipeline operations, and SCADA factors
- **Deliverables**
  - **Produce two documents for the new revision**
    - Executive Summary Document
      - Provides a brief description of the algorithm that is used.
    - Technical Report version of the Algorithm
      - Allows for a understanding of the new procedures in detail.
  - **Produce an off-line software tool to be used by Operators to conduct leak detection performance capability studies before committing to improvements**
    - Packaged software application, includes detailed documentation, and performs all the steps in the Technical Report automatically.

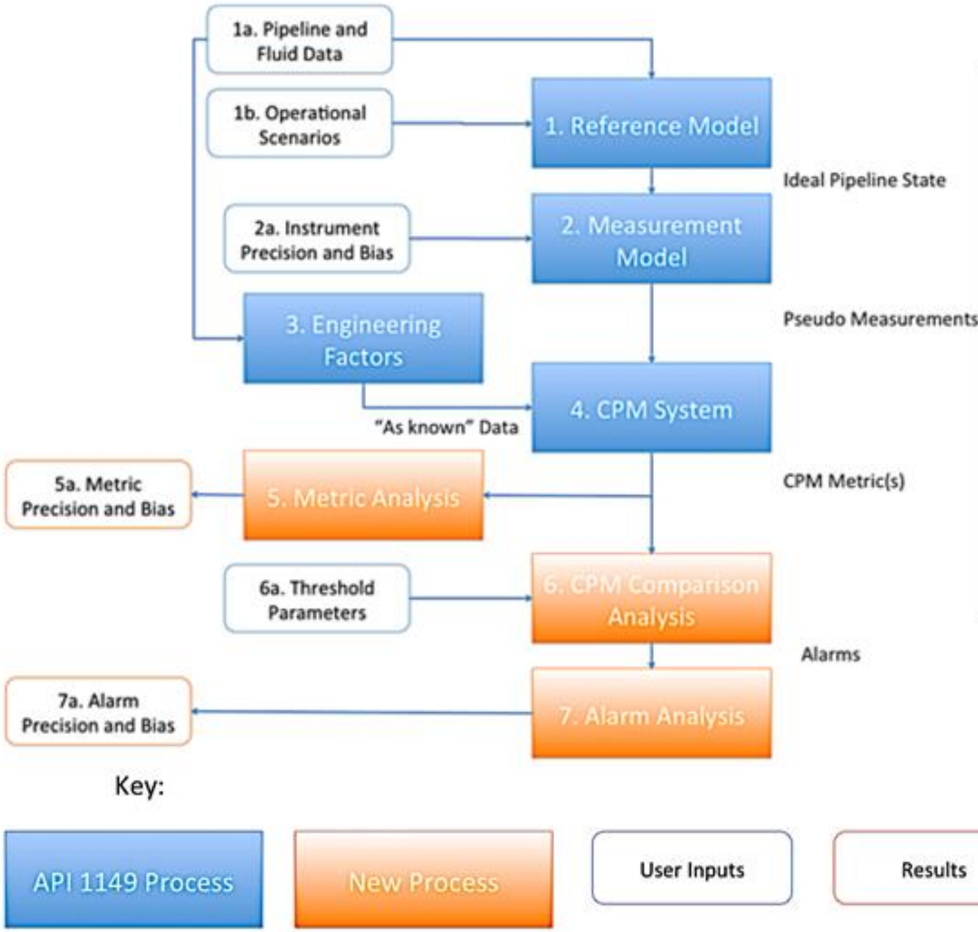
The new version of API 1149 will have several documents, and accompanied software tool.

Project Team

Person	Organization	Role
Karen Simon	API Cybernetics	API Lead
Michael Pearson	AOPL / Magellan LP	AOPL Lead
Carrie Greaney	**PRCI**	Project Manager (PM)
Nikos Salmatanis	**Chevron Pipe Line**	Project Team Lead
David Shaw	**Technical Toolboxes Inc.**	Consultant Technical PM
Kunal Dutta-Roy	**Technical Toolboxes Inc.**	Consultant SME Professional Pipeline Engineering
Jon Van Reet	**Plains All-American Pipeline**	Team Member -- Active
Brandon Zumar	**Enterprise Products**	Team Member -- Active
Daniel Hung	**Enbridge**	Team Member -- Active
Daniel Cochran	**TransCanada**	Team Member -- Active
David Alzheimer	**ConocoPhillips**	Team Member -- Active
David Shotwell	ExxonMobil Pipeline	Team Member
Bruce Wilkerson	Marathon	Team Member
Renan Baptista	PetroBras	Team Member
John Hayward	Shell Pipeline	Team Member
Michael Wheeler	BP Pipeline	Team Member
Jeff Sutherland	GE	Team Member
Mark Piazza	Colonial Pipeline	Team Member
Scott Collier	Buckeye Pipeline	Team Member
Michael Crump	Energy Transfer Parners	Team Member
Carlo Agapito	Williams	Team Member

A project initiative out of API/AOPL, ambassador R&D project through PRCI, industry technical led by Chevron.

Overview of the Process



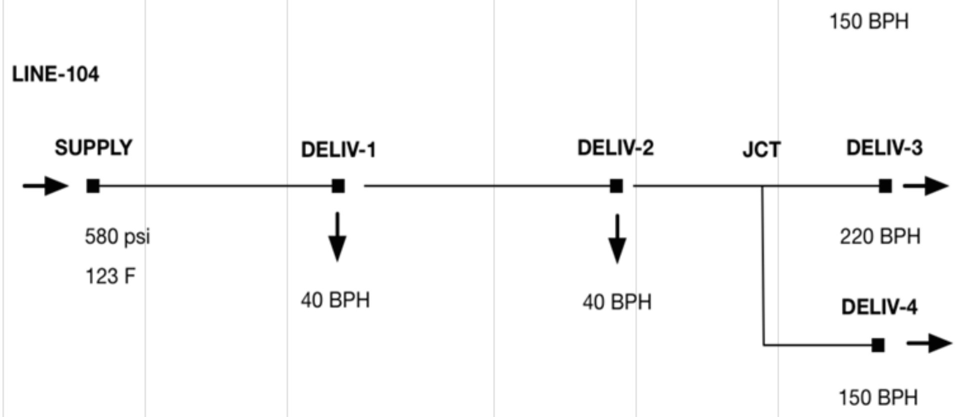
Cross-Reference against 1993 API 1149:

A. <u>Assemble data</u>: Pipeline and Fluid Data – configuration, product density, bulk modulus, etc.
B. <u>Obtain line fill rate of change</u> due to P, T: Use of Reference Model
C. Obtain line fill rate of change due to other Engineering Factors
D. <u>Compute line fill uncertainty</u>: CPM System
E. <u>Consider multiple segments</u>: Repeat 2 – 4
F. <u>Compute line fill change on time window</u>: Metric Analysis
G. Compute time response: Comparison
H. Compute alarm potential: Alarm Analysis

Still pre-determining the leak detection sensitivity for a given pipeline configuration, operation and instrumentation.

Assemble the Basic Pipeline Configuration

Model Control File:	TNETConfig.txt	(File)
Input Data Set:	TestData\Line104	(Folder)



Pipeline Configuration Data:	TNETConfig.csv	(Sketched Above)
Units of Measurement (US Oilfield)	FieldUnits.csv	
Source/Sink Config	TNETbatch.csv	
Elevation Survey	elevProfile.txt	
Heat Transfer Data	HeatXferData.txt	(Not used)
Equipment Curves	EquipCurve.txt	(Not used)
Equipment Data	EquipData.csv	(Not used)
Pipe Data	pipeLibrary.txt	(Not used)
Operating State	TNETscenario.csv	
Fluid Data	FluidData.txt	(Not used)
Viscosity Data	VisCurve.txt	(Not used)
Environmental Data	Environment.txt	(Not used)

See pipeCube Input Reference Manual v2014-04-05

- **Network Configuration via a configuration file**
- **Equipment Devices**
- **Sources and Sinks (Externals)**
- **Profile Lines (used for defining elevation profile and linefill)**
- **Elevation Profile**
- **Fluid Properties and Batching**
- **Input data via SCADA**
- **Unit Conversion**

811 Know what's below. Call before you dig.

The basic pipeline configuration for analysis. *Still in development.*

Methodology

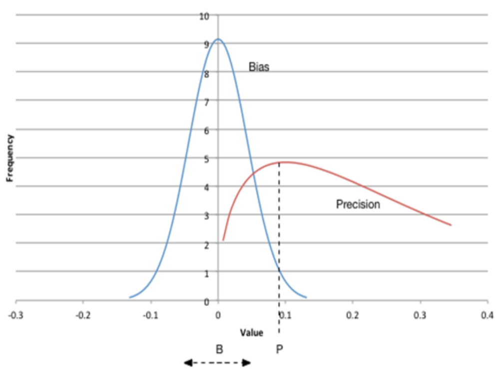
- **A pseudo pipeline is built using the Reference Model (RM)**
  - Calculates the Reference physical state of the pipeline.
  - The purpose of this reference physical state is to allow an estimate of the bias and precision due to assumptions in the CPM method beyond the effects of instrument uncertainty on the CPM method.

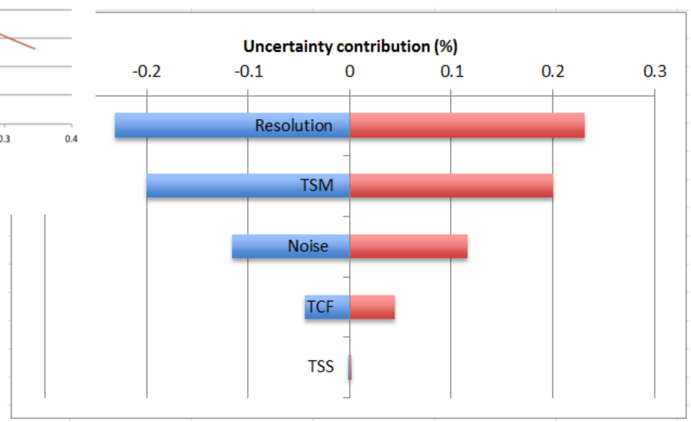
$$U_S = U_{input} + U_{model} + U_{num}$$

The Reference Model will be basis of comparison for you CPM Model.

Methodology

Measurement	*Spread "B"*		*Precision "P"*		
Flow In	0.24%		0.01%		(Percent)
Flow Out	0.24%		0.01%		(Percent)
Pressure In	4.125		0		(PSI)
Pressure Out	4.125		0		(PSI)
Temperature In	1.3		0		(F)
Temperature Out	1.3		0		(F)



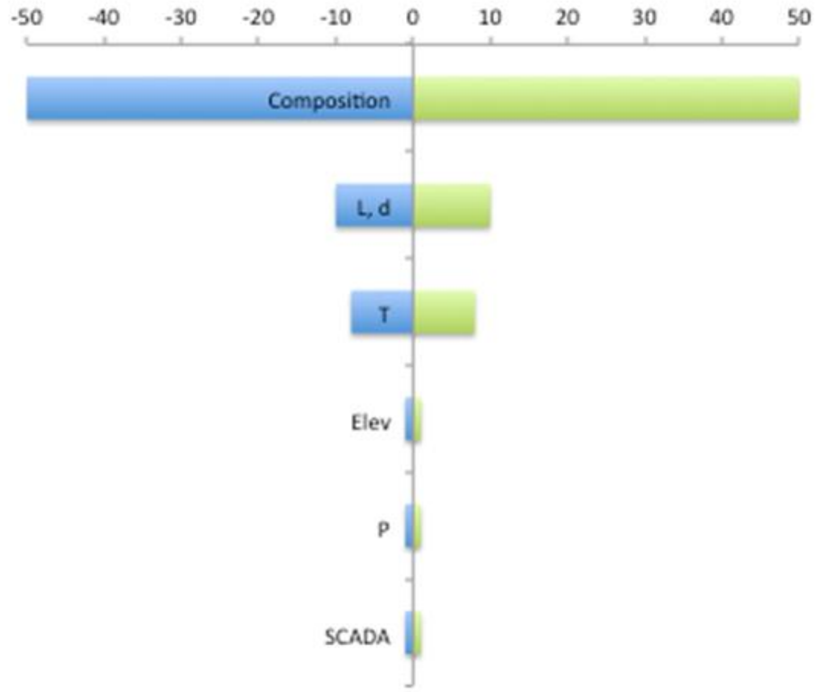


- **Measurement Model**
  - This requires statistics of the bias and precision for each of the meters and instruments used by the LD technique, as defined by the 2013 MPMS.
  - It also takes into account the most important SCADA system uncertainties.
  - This generates a set of pseudo measurements with known uncertainty properties for input to the CPM system

A calculation of Bias and Precision will be carried through the Process.

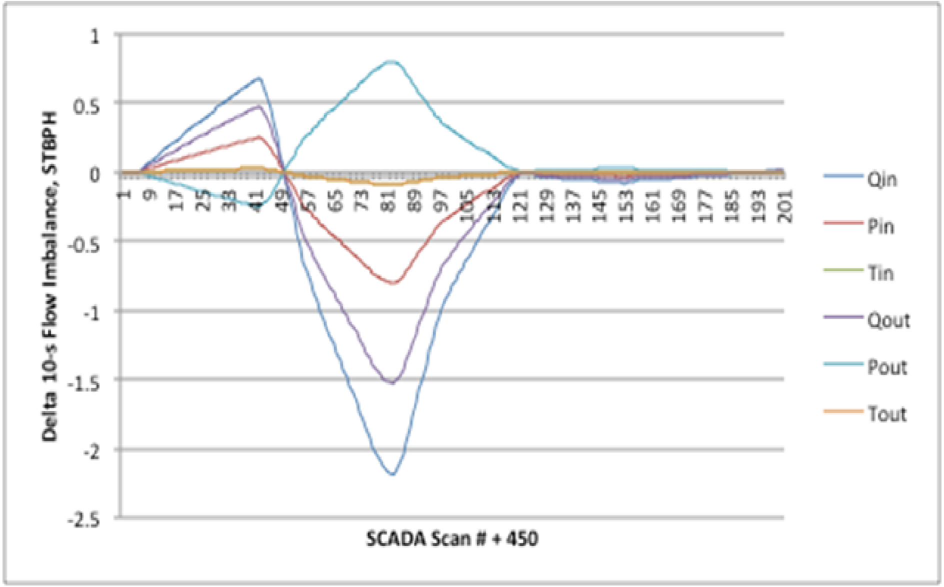
Methodology

- **Engineering Factor Effects**
  - Any number of Engineering Factors can be considered while running the RM in order to assess their effects on the physical pipeline state, and therefore on the CPM System.



There will be several Tornado diagrams to show the effects each factor on the overall Uncertainty of the CPM model.

Methodology

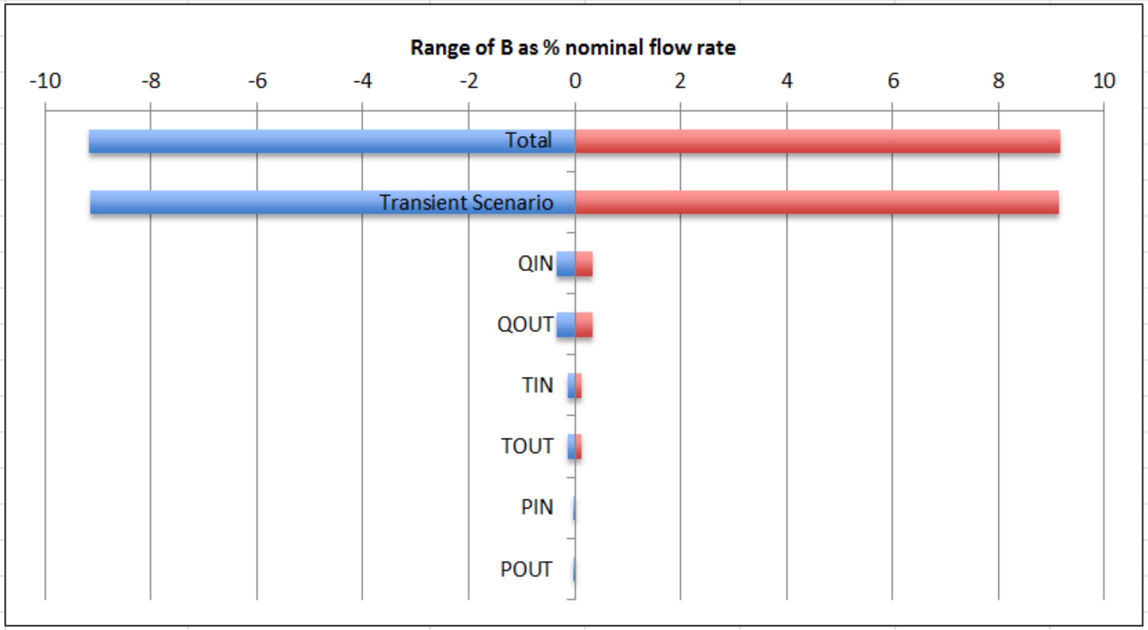


- **CPM Metric**
  - The CPM System is run using the measurement and configuration data that includes introduced errors with known statistical properties and computes its CPM Metric.
  - Will indicate some level of leak due to the introduced errors, even when there is none. (Likelihood of a leak)

The CPM System calculations will be used for comparative purposes.

Methodology

- **Metric Analysis**
  - The CPM System is run repeatedly, using a sampling of potential inputs and engineering factors, in a Monte Carlo approach.
  - Each time that it is run, a sample Metric is produced and Metric Statistics are developed.



Another overall Tornado diagram is produced of the overall model (the integrated comparisons).

Methodology

Inputs						Imbalance +/- B as % of Q_{ref}
QIN	*PIN*	*TIN*	*QOUT*	*POUT*	*TOUT*	
1657	700	111	1657	120	90	0.00
1657 + 0.24%	Ref	Ref	Ref	Ref	Ref	0.24%
Ref	700 + 4.125	Ref	Ref	Ref	Ref	0.00889%
Ref	Ref	111 + 1.30	Ref	Ref	Ref	0.09713%
Ref	Ref	Ref	1657 + 0.24%	Ref	Ref	0.24%
Ref	Ref	Ref	Ref	700 + 4.125	Ref	0.00889%
Ref	Ref	Ref	Ref	Ref	111 + 1.30	0.09713%
					Total R.M.S. "B"	0.366%

- **CPM Comparison Analysis**
  - This final comparison represents the total uncertainty in the CPM System itself.
    - Quantifies how small and how quickly a leak can be detected, given all the factors analyzed.
  - The Metric is potentially compared in several ways against a Threshold.

Quantifies how small and how quickly a leak can be detected, given all the factors analyzed.

Current Status

- **Completed: Design, Frameworks, and Literature Review**
- **In Final Review**
  - API 1149 update Executive Summary (Back to Industry EOW August 8th)
  - API 1149 update Document (detailed description) (Back to Industry EOW August 8th)
  - Technical Committee 5 Operator Test Cases, to be included in Appendix.

Milestone	Estimated Completion Date
0. Project Signature	7/17/2012
1. Kick Off Meeting	9/4/2012
2. Literature Review	12/21/2012
3. Algorithm Development	12/1/2013
4. Algorithm Testing	9/1/2014
5. API 1149 Document	9/1/2014
6. Software Design	10/1/2014
7. Software Testing	12/1/2014
8. Software Delivery	3/1/2015
9. Final Report	4/1/2015
Totals	

Software Tool Specification is commencing and verified with Operator datasets. Finalized documents to API Sept. 2014.

Consultant and Vendors Comments

- **Consultant Comments (examples)**
  - The process of taking recorded data and using it to develop the statistical inputs to the Reference Model should be developed in more detail.
  - I know good technical writing when I see it and this document is a good example of that.
- **Vendor Comments (examples)**
  - The implementation of this method becomes unfeasible on more complex networks that include hundreds of transmitters that need multi hour simulation runs on them for a variety of operating conditions.
  - We reviewed the document and did not have material comments that we felt would add to your document.

Wide range of comments, but most are being addressed in the document; and followed up with the authors.

Upcoming Activities

Milestone	Estimated Completion Date
0. Project Signature	7/17/2012
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8. Software Delivery	3/1/2015
9. Final Report	4/1/2015
Totals	

- **In Current Development:**
  - Finalize Software Tool specification and design
  - Closing out the design of the output report to Users
- **Upcoming Activities**
  - Software Tool development
  - Software Tool documentation and validation
  - Results rollout activities

You can still pre-determining the leak detection sensitivity for a given pipeline configuration, operation and instrumentation.

Thank You

Decisions Today, Ensure Integrity Tomorrow