

# **85th Annual International School of Hydrocarbon Measurement 2010**

**Oklahoma City, Oklahoma, USA  
11-13 May 2010**

**Volume 1 of 2**

**ISBN: 978-1-61738-590-2**

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2010) by the International School of Hydrocarbon Measurement  
All rights reserved.

Printed by Curran Associates, Inc. (2010)

For permission requests, please contact the International School of Hydrocarbon Measurement  
at the address below.

International School of Hydrocarbon Measurement  
1700 Asp Avenue  
Norman, Oklahoma 73072-6400

Phone: (405) 325-1217  
Fax: (405) 325-1388

lcrowly@ou.edu

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2634  
Email: curran@proceedings.com  
Web: www.proceedings.com

# Table of Contents

These proceedings are printed directly from manuscripts provided by the authors. These papers express the findings and opinions of the authors and do not necessarily represent the findings and opinions of the International School of Hydrocarbon Measurement (ISHM). The inclusion of a manuscript does not imply endorsement or acceptance of a product therein. Furthermore, the material contained in this publication is for the exclusive use of ISHM. Any reuse of this information outside the School without the expressed written consent of ISHM is strictly prohibited.

## 1000 Gas Measurement

1010	<b>Basics of High Pressure Measuring and Regulating Station Design</b>	<b>3</b>
	Rusty Woomer, El Paso Pipeline	
1040	<b>Compressibility of Natural Gas</b>	<b>11</b>
	Jeffrey Savidge, Consulting Services	
1050	<b>Coping with Changing Flow Requirements at Existing Meter Stations</b>	<b>28</b>
	James Doyle, Atmos Energy	
1060	<b>Design of Distribution Metering and Regulating Stations</b>	<b>31</b>
	Eddie Collins, Oklahoma Natural Gas Company	
1070	<b>Determination of Leakage and Unaccounted for Gas</b>	<b>36</b>
	David Wofford, Atlas Pipeline	
1090	<b>Effects and Control of Pulsation in Gas Measurement</b>	<b>49</b>
	Ed Bowles, Southwest Research Institute	
1100	<b>Effects of Abnormal Conditions on Accuracy of Orifice Measurement</b>	<b>65</b>
	Dean Graves, Devon Energy	
1140	<b>Fundamentals of Gas Measurement I</b>	<b>72</b>
	Douglas Dodds, Spectra Energy	
1150	<b>Fundamentals of Gas Measurement II</b>	<b>78</b>
	Jerry Paul Smith, Retired	
1160	<b>Fundamentals of Gas Measurement III</b>	<b>83</b>
	Jerry Paul Smith, Retired	

1170	<b>Fundamentals of Gas Turbine Meters</b>	<b>89</b>
	Wayland Sligh, TGMG, INC	
1180	<b>Fundamentals of Orifice Meter Chart Recorders</b>	<b>95</b>
	Dave Cofer, Thurmond-McGlothlin Inc	
1190	<b>Installation and Operation Errors in Gas Measurement</b>	<b>97</b>
	Ed Bowles, Southwest Research	
1195	<b>Low Pressure Gas Measurement</b>	<b>113</b>
	John Lansing, SICK - Maihak	
1200	<b>Mass Meters for Gas Measurement</b>	<b>125</b>
	Stan Calame, Emerson Process Management Karl Stappert, Emerson Process Management	
1210	<b>Measurement Station Inspection Documentation Program and Guide</b>	<b>143</b>
	Bob Rau,	
1220	<b>Multipath Ultrasonic Flow Meters for Gas Measurement</b>	<b>145</b>
	Eric Thompson, SICK MAIHAK Ed Bowles, Southwest Research Institute	
1250	<b>Orifice Fittings and Meter Tubes</b>	<b>164</b>
	Arthur Farve, The Measurement Company	
1270	<b>Orifice Meters - Operation and Maintenance</b>	<b>170</b>
	Scott Smith, Thurmond-McGlothlin, Inc.	
1290	<b>Problems Unique in Offshore Gas Measurement</b>	<b>174</b>
	David Wofford, Atlas Pipeline	
1310	<b>Thermometry in Gas Measurement</b>	<b>179</b>
	Dean Weber, EnCana	
1320	<b>Wet Gas Measurement</b>	<b>184</b>
	Richard Stevens, CEESI	
1330	<b>Flow Conditioners for Natural Gas Measurement</b>	<b>197</b>
	Dave Beitel, Davis & Davis Company Blaine Sawchuk, Canada Pipeline Accessories Co. Ltd.	
1340	<b>Contaminant Accumulation Effect on Gas Ultrasonic Flow Meters</b>	<b>231</b>
	Charles Derr, Daniel Measurement and Control	

Tina Newsome, Daniel Measurement and Control

1355	<a href="#">Measurement and Regulation Operation of a LDC</a>	250
	Joe Sargent, Sourcegas	

## 2000 Liquid Measurement

2010	<a href="#">Application of Densitometers to Liquid Measurement</a>	259
	Marsha Yon, Micro Motion	
2020	<a href="#">Application of Turbine Meters in Liquid Measurement</a>	264
	Noelle George, Plains	
	Mike Bridgforth, Cherokee Measurement	
2030	<a href="#">Automated Truck Loading Systems</a>	271
	Shoyeb Hasanali, Emerson Process Management	
2050	<a href="#">Calculation of Liquid Petroleum Quantities</a>	279
	Peter Kosewicz, University of Texas - PETEX	
2075	<a href="#">Crude Oil Blending</a>	289
	Harry James, Gibson Energy ULC	
2080	<a href="#">Crude Oil Gathering by Truck Metering versus Manual Gauging</a>	293
	J. W. Sulton, Micro Motion	
2090	<a href="#">Design, Operation and Maintenance of LACT Units</a>	298
	Miles Chaney, Plains Pipeline	
2110	<a href="#">Displacement Meters for Liquid Measurement</a>	302
	Thomas Rogers, Brodie International	
2120	<a href="#">Effects of Flow Conditioning on Liquid Measurement</a>	N/A
	Blaine Sawchuk, Canada Pipeline Accessories Co. Ltd.	
2130	<a href="#">Effects of Petroleum Properties on Pipeline Measurement</a>	343
	Jim Smith, FMC Technologies	
2140	<a href="#">Measurement of Dense Phase Fluids</a>	352
	Galen Cotton, Applied Metrology	

2150	<a href="#">Evaporation Loss Measurement from Storage Tanks</a>	357
	Warren Parr, KinderMorgan	
2160	<a href="#">Fundamentals of Liquid Measurement I - Physical Properties</a>	363
	Dave Beitel, Davis & Davis Company	
2170	<a href="#">Fundamentals of Liquid Measurement II - Static</a>	372
	Douglas Arrick, Shell Pipeline	
2180	<a href="#">Fundamentals of Liquid Measurement III - Dynamic</a>	379
	Peter W. Kosewicz, University of Texas PETEX	
2190	<a href="#">Fundamentals of Liquid Turbine Meters</a>	389
	Mitch Reckner, FMC Technologies	
2202	<a href="#">Helical Turbine Meters for Liquid Measurement</a>	399
	Mitch Reckner, FMC Technologies	
	Josh Rose, FMC	
2205	<a href="#">Installation and Operation of Densitometers</a>	406
	Paul Mullen, Enterprise	
2220	<a href="#">Liquid Measurement Field Surveys</a>	411
	Chris Levy, Shell Pipeline	
2230	<a href="#">Liquid Measurement Station Design</a>	418
	Al O' Dowd, Daniel Measurement	
2240	<a href="#">Marine Crude Oil Terminal Measurement Systems</a>	423
	Harold Osborn, Measurement, Pipeline and Storage Solutions	
2250	<a href="#">Mass Measurement of Natural Gas Liquid Mixtures</a>	430
	Eric Estrada, Targa Resources	
2260	<a href="#">Mass Meters for Liquid Measurement</a>	434
	Jason Casilio, FMC Measurement Solutions	
2270	<a href="#">Measurement Accuracy and Sources of Error in Tank Gauging</a>	441
	C. Stewart Ash, BP Pipelines (North America) Inc.	
2280	<a href="#">Shrinkage Losses Resulting from Liquid Hydrocarbon Mixing</a>	447
	Harry James, Gibson Energy ULC	
2285	<a href="#">Measurement of Cryogenic LNG</a>	454

Michael Scott, Qatar Gas / RAS Gas

2290	<a href="#">Measurement Methods for Liquid Storage Tanks</a>	471
	Robert Arias, Cape Inc.	
2310	<a href="#">Measurement of Petroleum on board Marine Vessels</a>	485
	Jack Szallai, Orion	
2330	<a href="#">Orifice Meters for Liquid Measurement</a>	492
	Fred Van Orsdol, SPL	
2340	<a href="#">Pycnometer Installation, Operation and Calibration</a>	498
	Bob Armbruster, Enterprise Products	
2350	<a href="#">Resolving Liquid Measurement Differences</a>	503
	Jim Godbold, Marathon Oil	
2360	<a href="#">Statistical Control of Meter Factors - A Simplified Approach</a>	507
	Dan Comstock, The University of Texas (PETEX)	
2380	<a href="#">Troubleshooting Liquid Pipeline Losses and Gain</a>	513
	Michael Plasczyk, Shell Pipeline Joe Rasmussen, Colonial Pipeline Company	
2400	<a href="#">Ultrasonic Meters for Liquid Measurement</a>	528
	Daniel Hackett, Daniel Measurement & Controls	
2410	<a href="#">Viscosity and its Application in Liquid Hydrocarbon Measurement</a>	539
	Gary Rothrock, Micro Motion	
2415	<a href="#">Measuring High Viscosity Liquids with Flow Meters</a>	546
	Chris Laird, Cameron - Measurement Systems	
2420	<a href="#">Proving Liquid Meters with Microprocessor Based Pulse Outputs</a>	553
	Galen Cotton, Applied Metrology	
2440	<a href="#">Accuracy Diagnostics of Liquid Ultrasonic Flow Meters</a>	559
	Herman Chris Sokol, Krohne Patrick Abshire, ExxonMobil Pipeline Company	
2450	<a href="#">Offshore Liquid FPSO Measurement Systems</a>	564
	Terry Cousins, Cameron - Measurement Systems	
2460	<a href="#">Application in Liquid Measurement Using Clamp-On Ultrasonic Technology</a>	573

Tim Guest, Flexim

2470	<a href="#">Measurement of Liquefied Petroleum Gas</a>	582
	Brent Palmer, Enterprise Products	
2480	<a href="#">Viscosity Compensation of Helical Turbine Meters</a>	590
	Jim Smith, FMC Technologies	

## 3000 Electronic Measuring and Related Equipment

3010	<a href="#">Advanced Application of Flow Computers and Telemetry Systems</a>	599
	Sami Halilah, Dynamic Flow Computers	
3020	<a href="#">Application of Flow Computers for Gas Measurement and Control</a>	607
	Tim Jones, Cameron - Measurement Systems	
3030	<a href="#">Applications of Portable Computers and Software</a>	617
	B.J. Walker, ABB Inc.	
3050	<a href="#">Basic Application of Flow Computers and Telemetry Systems</a>	628
	Jerry Van Staaldune, Emerson	
3060	<a href="#">Basic Electronics for the Field Technician</a>	634
	Stan Canfield, Williams	
3070	<a href="#">SCADA Systems</a>	641
	Darin Molone, Chesapeake Midstream	
3080	<a href="#">Communication Systems for Gas Measurement Data</a>	645
	Ben Hamilton, J-W Measurement Company	
3110	<a href="#">Economics of Electronic Gas Measurement</a>	652
	Shawn Kriger, ABB	
3115	<a href="#">Production Equipment Effects on Gas Measurement</a>	657
	David Pulley, J-W Measurement	
3120	<a href="#">Effects of Cathodic Protection and Induced Signals on Pipeline Measurement</a>	663
	Peter P. Jakubenas, FMC Technologies, Inc.	



3125	<a href="#">Ethernet for SCADA Systems</a>	669
	Ben Hamilton, J-W Measurement Company	
3140	<a href="#">On-line Computers for Custody Transfer</a>	673
	Casey Hodges, CEESI	
3150	<a href="#">Real-Time Electronic Gas Measurement</a>	679
	Tommy Mitchell, ABB Totalflow	
3155	<a href="#">Spread Spectrum Systems for EFM and SCADA</a>	684
	Jim Gardner, Freewave Technologies	
3160	<a href="#">Smart Transmitter Selection, Calibration and Installation</a>	689
	Leon Black, ABB	
3170	<a href="#">Testing; Maintenance and Operation of Electronic Flow Computers for the Gas Industry</a>	697
	Steve Stark, Stark & Associates, Inc.	
3180	<a href="#">Transient Lightning Protection for Electronic Measurement Devices</a>	703
	Dan McCreery, MTL	
3200	<a href="#">Host Gas Measurement Audit Trail data Handling and Maintenance Techniques</a>	713
	Ed Smyth, ABB, Inc.	

## 4000 Calibration, Proving and Testing

4020	<a href="#">Calibration of Liquid Provers</a>	725
	Ron Harris, Meter Engineers Inc	
4040	<a href="#">Design, Calibration and Operation of Field Standard Test Measures</a>	734
	Sherry Sheckels, NIST	
4050	<a href="#">Effective Use of Deadweight Tester</a>	742
	Scott Crone, Product Line Manager - AMETEK Calibration Instruments	
4055	<a href="#">Flow Calibrating Ultrasonic Gas Meters</a>	748
	Joel Clancy, Vice President CEESIowa	
4060	<a href="#">Guide to Troubleshooting Problems with Liquid Meters and Provers</a>	758

	Jerry Upton, Measurement Man	
4070	<b>In-Situ (On-Site) Gas Meter Proving</b> Ed Bowles, Southwest Research Institute	<b>763</b>
4080	<b>LACT Unit Proving - The Role of the Witness</b> Bynum Vincent, Linco - A Cameron Company	<b>773</b>
4090	<b>Liquid Flow Provers</b> David Seiler, Emerson Daniel	<b>781</b>
4095	<b>Liquid Meter Proving Techniques</b> Peter P. Jakubenas, FMC Technologies, Inc.	<b>787</b>
4100	<b>Operation and Problems Associated with Prover Detector Switches</b> Warren Parr, KinderMorgan	<b>795</b>
4110	<b>Operational Experience with Small Volume Provers</b> Kevin Fields, Coastal Flow Liquid Measurement, Inc.	<b>801</b>
4130	<b>Proving Coriolis Flow Meters</b> Steve Whitman, Coastal Flow	<b>804</b>
4140	<b>Theory and Application of Pulse Interpolation to Prover Systems</b> David Seiler, Emerson Daniel	<b>810</b>
4150	<b>Verification / Calibration Of Devices Used In Liquid Measurement And Implications Of How Mercury Issues Will Impact These Processes</b> Anne Brackett, W. L. Walker Co., Inc.	<b>817</b>
4160	<b>Witnessing Orifice Meter Verification / Calibration</b> Olen Douglass, Thurmond-Mcglathin Inc.	<b>822</b>
4170	<b>Improving Flow Measurements with Improved Calibration &amp; Data Handling Procedures</b> Michael Perez, Flow-Cal, Inc.	<b>825</b>
4180	<b>Proving Liquid Ultrasonic Meters</b> Mike Scott, C&W Meter Services, Inc.	<b>835</b>

## 5000 Energy, Quality, and Sampling

5010	<b>Auditing Gas Laboratories</b>	843
	John Renfrow, Unit Petroleum Corporation	
5020	<b>BTU Analysis Using a Gas Chromatograph</b>	846
	J.W. Bowen, Mercury Instruments	
5030	<b>BTU Determination of Natural Gas Using a Portable Chromatograph</b>	853
	Burt Reed, ABB Inc. Totalflow Division	
5040	<b>Chromatograph Applications and Problems from the User's Standpoint</b>	860
	Fred Ryel, Cherokee Measurement & Controls	
5050	<b>Chromatograph Maintenance and Troubleshooting</b>	863
	Shane Hale, Daniel Industries	
5060	<b>Chromatographic Analysis of Natural Gas Liquids</b>	869
	Timothy Beary, LDH Energy Olefins, LLC	
5080	<b>Crude Quality - What is Involved and Why Its Important</b>	875
	Patti Edens, Shell Pipeline	
5090	<b>Determination of H2S and Total Sulfur in Natural Gas</b>	878
	Sam Miller, SpectraSensors Inc.	
5100	<b>Determination of Water Vapor Content in Natural Gas</b>	882
	Sam Miller, SpectraSensors Inc.	
5110	<b>Determination of Hydrocarbon Dew Point in Natural Gas</b>	886
	Jack Herring, Michell Instruments, Inc. Noelle George, Plains Pipeline	
5115	<b>Hydrocarbon Dew Point Effects on Gas Flow Measurement</b>	892
	Fred Van Orsdol, SPL	
5120	<b>DOT Requirements for the Transportation of Sample Containers</b>	899
	David Fish, Welker	
5130	<b>Energy Measurement using Flow Computers and Chromatography</b>	902
	Burt Reed, ABB Inc. Totalflow Division	
5140	<b>Energy Measurement Using Ultrasonic Meters and Gas Chromatography</b>	910
	Charles Derr, Daniel Measurement and Control Dave Beitel, Davis & Davis Company	

5150	<b>Energy Measurement Utilizing On-Line Chromatographs</b>	<b>919</b>
	David Hailey,	
5160	<b>Field and Laboratory Testing of Sediment and Water in Crude Oil</b>	<b>925</b>
	Jane Williams, University of Texas-PETEX	
5170	<b>Fundamentals of Gas Chromatography</b>	<b>929</b>
	Shane Hale, Daniel Gas Chromatographs	
5190	<b>Heat Quantity Calculation relating to Water Vapor in Natural Gas</b>	<b>937</b>
	Ed Bowles, Southwest Research Institute	
5235	<b>On-line Water Measurement Devices in Liquid Service</b>	<b>946</b>
	Kim Mohajer	
5260	<b>Sampling and Conditioning of Natural Gas Containing Entrained Liquids</b>	<b>950</b>
	Josh Welker, Welker, Inc.	
5265	<b>Sample Conditioning and Contaminant Removal for Water Vapor Determination</b>	<b>952</b>
	Brad Massey, Southern Star Central Gas Pipeline	
5280	<b>Techniques of Gas Composite Sampling</b>	<b>959</b>
	Paul McNeely, Welker	
5290	<b>Techniques of Gas Spot Sampling</b>	<b>963</b>
	Shannon Bromley, A+ Corporation	
5300	<b>Determination of Hydrocarbon Dewpoint using a Gas Chromatograph</b>	<b>973</b>
	Shane Hale, Daniel Gas Chromatographs	
5310	<b>Fundamentals of Sampling Natural Gas for BTU Determination</b>	<b>984</b>
	Justin Harvey, A+ Corporation	
5320	<b>Moisture Measurement Using Laser Spectroscopy</b>	<b>993</b>
	Sam Miller, SpectraSensors Inc.	
5330	<b>Reducing Measurement Uncertainty in Process Gas Quality Measurements</b>	<b>1000</b>
	Darin George, Southwest Research Institute	
5340	<b>CO2 Determination of Natural Gas Streams</b>	<b>1008</b>
	Charlie Cook, Interlock Sales and Marketing	
5345		<b>1012</b>

## Considerations in Sampling Wet, High Pressure, or Supercritical Natural Gas

Shannon M Bromley, A+ Corporation, LLC

5350 **Flare Measurement Practices** 1019

John Chitty, SICK

5400 **Micro Gas Chromatography for Liquid Petroleum Gas's** 1026

Alejandro Amarin, DCG Partnership 1 Ltd.

Louis D'Agostaro, DCG Partnership 1 Ltd.

Yvonne Diersche, DCG Partnership 1 Ltd.

Alejandro Gonzalez, DCG Partnership 1 Ltd

## 6000 Series Control and Regulation

6010 **Causes and Cures of Regulator Instability** 1035

Bill Earney, Earney Eng. LLC

6020 **Controlling Surges in Liquid Pipelines** 1040

Clay Carroll, SPX

6090 **Over Pressure Protection Methods** 1046

Craig Lam, Dresser Inc

6100 **Prevention of Freezing in Measurement and Regulating Stations** 1052

Steve Palmitier, Welker Engineering

6110 **Selection, Sizing and Operation of Control Valves for Gases and Liquids** 1057

Ross Turbiville, Emerson Process Management Fisher Valve Division

6130 **Flow Meter Installation Effects** 1064

Terry Cousins, Cameron - Measurement Systems

Christopher Laird, Cameron Measurement Systems

## 7000 Accounting, Calculations and Industry Standards

7010 **Allocation Measurement (API MPMS Chapter 20)** 1089

Mark Brown, SPL Incorporated

7020	<a href="#">Orifice Meter Primary Elements Standards</a>	1092
	Jerry Blankenship, Daniel Measurement and Control	
7030	<a href="#">Auditing Electronic Gas Measurement per API Chapter 21</a>	1097
	Danyelle Miller, J-W Measurement Company	
7040	<a href="#">Auditing Gas Measurement and Accounting Systems</a>	1101
	Steve Stark, Stark & Associates, Inc.	
7050	<a href="#">Auditing Liquid Measurement</a>	1105
	Ed Saccomanno, Motiva	
7100	<a href="#">Measurement Information Management Systems</a>	1110
	Chris Levy, Shell Pipeline Company LP	
7110	<a href="#">Overall Measurement Accuracy</a>	1119
	Paul LaNasa	
7170	<a href="#">Sarbanes-Oxley Act and its Impact on Measurement</a>	1126
	Lisa Walker, DCP Midstream	
7180	<a href="#">API MPMS Chapter 22 Testing Protocol for Differential Pressure Flow Measurement Devices</a>	1131
	Casey Hodges, CEESI	
7300	<a href="#">Overview of GPA 2172/API 14.5 Revision</a>	1139
	Don Sextro, Targa Resources	

## 8000 Miscellaneous

8020	<a href="#">Calibration Using Portable Digital Pressure Indicators</a>	1147
	Noelle George, Plains	
	Leo Buckon, Meriam Process Technologies	
8025	<a href="#">Intrinsic Safety with Surge Protection in the Hydrocarbon Industry</a>	1153
	Dan McCreery, MTL	
8040	<a href="#">DOT Qualification Training for Measurement and Control Technicians</a>	1165
	David Wofford, Atlas Pipeline	
8065	<a href="#">Interface Detection in Liquid Pipelines</a>	1170

Vicky Garza, KAM CONTROLS, INC.

8110	<a href="#">Multiphase Flow Measurement</a>	1174
	Richard Steven, CEESI	
8120	<a href="#">Odorization in Natural Gas</a>	1186
	Ken Parrott, k2controls, Inc.	
8132	<a href="#">Orifice Meter Tube Dimensional Tolerances</a>	1194
	Ken Embry, JW Operating Company	
8140	<a href="#">Program for Training a Gas Measurement Technician</a>	1199
	Eric Kelner, Letton-Hall Group	
8160	<a href="#">The Effects of Additives on Metering in Liquid Pipelines</a>	1201
	Harry James, Gibson Energt ULC	
8200	<a href="#">Meter Selection</a>	1206
	Robert Fritz, Regency Energy Partners	
8210	<a href="#">Cone Meters for Liquid and Gas Measurement</a>	1214
	Philip Lawrence, Cameron Measurement Systems	
8220	<a href="#">Measurement Scene Investigations</a>	1231
	Chris Spriggs, Oklahoma Natural Gas	