

84th Annual International School of Hydrocarbon Measurement 2009

**Oklahoma City, Oklahoma, USA
12 – 14 May 2009**

Volume 1 of 2

ISBN: 978-1-61567-144-1

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© (2009) by the International School of Hydrocarbon Measurement
All rights reserved.

Printed by Curran Associates, Inc. (2009)

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

VOLUME 1

1000 GAS MEASUREMENT

Basics of High Pressure Measuring and Regulating Station Design	1
<i>E. D. Woomer</i>	
Compressibility of Natural Gas	9
<i>Jeffrey L. Savidge</i>	
Coping with Changing Flow Requirements at Existing Meter Stations	25
<i>James M. Doyle</i>	
Design of Distribution Metering and Regulating Stations	28
<i>Edgar Wallace Collins</i>	
Determination of Leakage and Unaccounted for Gas	34
<i>David Wofford</i>	
Effects and Control of Pulsation in Gas Measurement	47
<i>Robert J. McKee, Ray G. Durke</i>	
Effects of Abnormal Conditions on Accuracy of Orifice Measurement	61
<i>Dean Graves</i>	
Fundamentals of Gas Measurement I	68
<i>Douglas E. Dodds</i>	
Fundamentals of Gas Measurement II	74
<i>Jerry Paul Smith</i>	
Fundamentals of Gas Measurement III	79
<i>James W. Keating</i>	
Fundamentals of Gas Turbine Meters	85
<i>Tom Hudson</i>	
Fundamentals of Orifice Meter Chart Recorders	91
<i>David Cofer</i>	
Installation and Operation Errors in Gas Measurement	93
<i>Thomas B. Morrow, Edgar B. Bowles Jr.</i>	
Mass Meters for Gas Measurement	108
<i>Karl Stappert</i>	
Measurement Station Inspection Program and Guide	126
<i>Robert J. Rau</i>	
Verifying GUSM Accuracy and Stability Using Advanced Diagnostic Control Limits	128
<i>Martin Schleback</i>	
Orifice Fittings and Meter Tubes	142
<i>Darren Schwarz</i>	
Orifice Meters - Operation and Maintenance	147
<i>Scott Smith</i>	
Problems Unique in Offshore Gas Measurement	151
<i>David Wofford</i>	
Thermometry in Gas Measurement	156
<i>Stephen T. Stark</i>	
Wet Gas Measurement	163
<i>Philip A. Lawrence</i>	
Flow Conditioners for Natural Gas Measurement	179
<i>James E. Gallagher</i>	

2000 LIQUID MEASUREMENT

Application of Densitometers to Liquid Measurement	193
<i>Ray N. Adcock</i>	
Application of Turbine Meters in Liquid Measurement	199
<i>David Seiler</i>	

Calculation of Liquid Petroleum Quantities	206
<i>Peter W. Kosewicz</i>	
Calibration of Storage Tanks	216
<i>Dan Comstock</i>	
Crude Oil Blending	221
<i>Kevin B. Macdougall</i>	
Crude Oil Gathering by Truck Metering versus Manual Gauging	225
<i>J. W. Sulton</i>	
Design, Operation and Maintenance of LACT Units	230
<i>Miles Chaney</i>	
Displacement Meters for Liquid Measurement	234
<i>Tome Piskorski</i>	
Effects of Flow Conditioning on Liquid Measurement	244
<i>James E. Gallagher</i>	
Effects of Petroleum Properties on Pipeline Measurement	253
<i>Jim Smith</i>	
Measurement of Dense Phase Fluids	262
<i>Ron Labus, Galen Cotton</i>	
Fundamentals of Liquid Measurement I - Physical Properties	267
<i>David Beitel</i>	
Fundamentals of Liquid Measurement II - Static	276
<i>Doug Arrick</i>	
Fundamentals of Liquid Measurement III - Dynamic	283
<i>Peter W. Kosewicz</i>	
Fundamentals of Liquid Turbine Meters	293
<i>David Seiler</i>	
Gauging, Testing and Running of Lease Tanks	298
<i>Jane Williams</i>	
Helical Turbine Meters for Liquid Measurement	301
<i>Glen Wilson</i>	
Installation and Operation of Densitometers	309
<i>Don Sextro</i>	
Liquid Measurement Field Surveys	314
<i>Christopher Levy</i>	
Liquid Measurement Station Design	321
<i>Kevin J. Tansey</i>	
Marine Crude Oil Terminal Measurement Systems	332
<i>Harold E. Osborn</i>	
Mass Measurement of Natural Gas Liquid Mixtures	339
<i>Eric Estrada</i>	
Mass Meters for Liquid Measurement	343
<i>Marsha Yon</i>	
Measurement Accuracy and Sources of Error in Tank Gauging	347
<i>C. Stewart Ash</i>	
Shrinkage Losses Resulting from Liquid Hydrocarbon Mixing	353
<i>J. H. James</i>	
Measurement of Cryogenic LNG	360
<i>Gregor Brown</i>	
Measurement Methods for Liquid Storage Tanks	374
<i>Robert Arias</i>	
Measurement of Petroleum on board Marine Vessels	388
<i>John A. Szallai</i>	
Resolving Liquid Measurement Differences	395
<i>Herbert H. Garland</i>	
Statistical Control of Meter Factors - A Simplified Approach	398
<i>Dan Comstock</i>	
Troubleshooting Liquid Pipeline Losses and Gain	405
<i>Joseph T. Rasmussen, Michael R. Plasczyk</i>	
Ultrasonic Meters for Liquid Measurement	420
<i>Sid Douglass</i>	
Viscosity and its Application in Liquid Hydrocarbon Measurement	428
<i>Gary Rothrock</i>	

Measuring High Viscosity Liquids with Flow Meters	435
<i>Raymond J. Kalivoda</i>	
Proving Liquid Meters with Microprocessor Based Pulse Outputs	446
<i>Galen Cotton</i>	
Proving Liquid Ultrasonic Meters	452
<i>Galen Cotton</i>	
Accuracy Diagnostics of Liquid Ultrasonic Flow Meters	468
<i>Joshua W. Rose</i>	
Accuracy Diagnostics of Liquid Ultrasonic Flow Meters	473
<i>Christopher B. Laird</i>	
Offshore Liquid FPSO Measurement Systems	481
<i>Cameron Caldon</i>	
Application in Liquid Measurement Using Clamp-On Ultrasonic Technology	490
<i>C. Tim Guest</i>	

3000 ELECTRONIC MEASURING AND RELATED EQUIPMENT

Advanced Application of Flow Computers and Telemetry Systems	499
<i>Shawn Kriger</i>	
Application of Flow Computers for Gas Measurement and Control	506
<i>Jerry Van Staalduine</i>	
Applications of Portable Computers and Software	513
<i>Trey Thee, B. J. Walker</i>	
Basic Applications of Telemetry Systems	524
<i>Tommy Mitchell</i>	
Basic Electronics for the Field Technician	531
<i>Dale Gary, David Nichols</i>	
SCADA Systems	538
<i>Ed Smyth</i>	

VOLUME 2

Communication Systems for Gas Measurement Data	545
<i>Ben Hamilton</i>	
Economics of Electronic Gas Measurement	552
<i>Jason Orf</i>	
Production Equipment Effects on Gas Measurement	556
<i>David Pulley</i>	
Effects of Cathodic Protection and Induced Signals on Pipeline Measurement	564
<i>Peter P. Jakubenas</i>	
Ethernet for SCADA Systems	570
<i>David Crandall</i>	
On-line Computers for Custody Transfer	576
<i>Mark Godfrey</i>	
Real Time Electronic Gas Measurement	587
<i>Jim Griffith</i>	
Spread Spectrum Systems for EFM and SCADA	592
<i>Jim Gardner</i>	
Smart Transmitter Selection, Calibration and Installation	597
<i>Leon Black</i>	
Testing, Maintenance and Operation of Electronic Flow Computers for the Gas Industry	605
<i>Stephen T. Stark</i>	
Transient Lightning Protection for Electronic Measurement Devices	611
<i>Dan McCreery</i>	

4000 CALIBRATION, PROVING AND TESTING

Calibration of Liquid Provers	621
<i>William R. Young Jr.</i>	

Design, Calibration and Operation of Field Standard Test Measures	630
<i>Sherry Sheckels</i>	
Effective Use of Deadweight Tester	638
<i>Roger Thomas</i>	
Flow Calibrating Ultrasonic Gas Meters	645
<i>Joel Clancy</i>	
Guide to Troubleshooting Problems with Liquid Meters and Provers	655
<i>Jerry Upton</i>	
In-Situ (On-Site) Gas Meter Proving	660
<i>Edgar B. Bowles Jr.</i>	
LACT Unit Proving - The Role of the Witness	670
<i>Art Casias, Terry Ridley</i>	
Liquid Flow Provers	674
<i>Ruud Bos</i>	
Liquid Meter Proving Techniques	682
<i>Peter P. Jakubenas</i>	
Operation and Problems Associated with Prover Detector Switches	690
<i>Warren A. Parr Jr.</i>	
Operational Experience with Small Volume Provers	696
<i>Steve Whitman</i>	
Proving Coriolis Flow Meters	701
<i>Marsha Yon</i>	
Theory and Application of Pulse Interpolation to Prover Systems	707
<i>David Seiler</i>	
Verification / Calibration of Devices used in Liquid Measurement	714
<i>Anne Walker Brackett</i>	
Witnessing Orifice Meter Verification / Calibration	719
<i>Olen Douglass</i>	
Improving Flow Measurements with Improved Calibration & Data Handling Procedures	722
<i>Duane Harris</i>	

5000 ENERGY, QUALITY AND SAMPLING

Auditing Gas Laboratories	731
<i>Joe Landes</i>	
BTU Analysis Using a Gas Chromatograph	734
<i>James W. Bowen</i>	
Chromatograph Applications and Problems from the User's Standpoint	741
<i>Fred Ryel</i>	
Chromatograph Maintenance and Troubleshooting	745
<i>Shane Hale</i>	
Chromatographic Analysis of Natural Gas Liquids	751
<i>Darville Dee Orr Jr.</i>	
Determination of H₂S and Total Sulfur in Natural Gas	756
<i>Thomas Y. Tramel</i>	
Determination of Water Vapor Content in Natural Gas	760
<i>Murray Fraser, Charlie Cook</i>	
Determination of Hydrocarbon Dew Point in Natural Gas	774
<i>Andy Benton</i>	
Determination of Hydrocarbon Dew Point in Natural Gas	785
<i>Ray N. Adcock</i>	
Hydrocarbon Dew Point Effects on Gas Flow Measurement	790
<i>Fred Van Orsdol</i>	
DOT Requirements for the Transportation of Sample Containers	797
<i>David J. Fish</i>	
Energy Measurement using Flow Computers and Chromatography	800
<i>Burt Reed</i>	
Energy Measurement Utilizing On-Line Chromatographs	807
<i>Derrill Meyer</i>	
Field and Laboratory Testing of Sediment and Water in Crude Oil	811
<i>Del J. Major</i>	

Fundamentals of Gas Chromatography	817
<i>Derrill Meyer</i>	
Heat Quantity Calculation Relating to Water Vapor in Natural Gas	826
<i>Edgar B. Bowles Jr., Darin L. George</i>	
Measurement of Liquefied Petroleum Gas	835
<i>Fred Van Orsdol</i>	
On-line Water Measurement Devices in Liquid Service	839
<i>Kim Mohajer</i>	
Sampling and Conditioning of Natural Gas Containing Entrained Liquids	843
<i>Donald P. Mayeaux</i>	
Sample Conditioning and Contaminant Removal for Water Vapor Determination	852
<i>Brad Massey</i>	
Techniques of Gas Composite Sampling	859
<i>Phil Rutledge</i>	
Techniques of Gas Spot Sampling	863
<i>David J. Fish</i>	
Determination of Hydrocarbon Dewpoint Using a Gas Chromatograph	875
<i>Shane Hale</i>	
Fundamentals of Sampling Natural Gas for BTU Determination	887
<i>Donald P. Mayeaux</i>	
Moisture Measurement Using Laser Spectroscopy	896
<i>Samuel C. Miller</i>	
CO₂ Determination of Natural Gas Streams	903
<i>Charlie Cook</i>	
Considerations in Sampling Wet, High Pressure, or Supercritical Natural Gas	907
<i>Donald P. Mayeaux</i>	
Flare Measurement Practices	914
<i>Curtis Gulaga</i>	

6000 SERIES CONTROL AND REGULATION

Causes and Cures of Regulator Instability	921
<i>William H. Earney</i>	
Controlling Surges in Liquid Pipelines	926
<i>Ron Kennedy</i>	
Fundamentals of Pressure Regulators	932
<i>Thomas Weyer</i>	
Over Pressure Protection Methods	940
<i>Thomas Weyer</i>	
Prevention of Freezing in Measurement and Regulating Stations	946
<i>Tom Fay</i>	
Selection, Sizing and Operation of Control Valves for Gases and Liquids	949
<i>Ross Turbiville</i>	
Turbulence and Its Effect in Measuring and Regulating Stations	956
<i>Mike McKay</i>	

7000 ACCOUNTING, CALCULATIONS AND INDUSTRY STANDARDS

Allocation Measurement (API MPMS Chapter 20.1)	963
<i>Jeffrey L. Savidge</i>	
Orifice Meter Primary Elements Standards	981
<i>Jerry Blankenship</i>	
Auditing Electronic Gas Measurement per API Chapter 21.1	986
<i>John Renfrow</i>	
Auditing Gas Measurement and Accounting Systems	990
<i>Stephen T. Stark</i>	
Auditing Liquid Measurement	995
<i>Linda A. Larson</i>	
Overall Measurement Accuracy	1000
<i>Casey Hodges</i>	

Sarbanes-Oxley Act and its Impact on Measurement	1006
<i>Lisa Walker</i>	
API MPMS Chapter 22.2 Testing Protocol for Differential Pressure Flow Measurement Devices	1011
<i>Casey Hodges</i>	
Overview of AGA 7 Revision	1019
<i>Angela Floyd</i>	
Overview of AGA 9 Revision	1024
<i>John Lansing</i>	
Overview of GPA 2172/API 14.5 Revision	1036
<i>Don Sextro</i>	

8000 MISCELLANEOUS

Calibration Using Portable Digital Pressure Indicators	1041
<i>Leo J. Buckon</i>	
Combining Intrinsic Safety with Surge Protection in the Hydrocarbon Industry	1047
<i>Don Long</i>	
Development of Orifice Meter Standards (Past, Present, Future)	1055
<i>Jane Williams</i>	
DOT Qualification Training for Measurement and Control Technicians	1061
<i>J. Shiflet</i>	
Interface Detection in Liquid Pipelines	1064
<i>Vicky Garza</i>	
Multiphase Flow Measurement	1067
<i>Richard Steven</i>	
Odorization in Natural Gas	1079
<i>Kenneth S. Parrott</i>	
Orifice Meter Tube Dimensional Tolerances	1087
<i>Ken Embry</i>	
Program for Training a Gas Measurement Technician	1092
<i>Allen N. Chandler</i>	
The Effects of Additives on Metering in Liquid Pipelines	1096
<i>Joseph T. Rasmussen</i>	
Meter Selection	1101
<i>Harvey Stockman</i>	
Cone Meters for Liquid and Gas Measurement	1108
<i>Philip A. Lawrence</i>	
Measurement Scene Investigations	1123
<i>Chris Spriggs</i>	
Author Index	