Training Natural Gas Orifice Measurement Technicians

Meeting the Demand

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Introduction

With the unparalleled ramp-up in domestic shale plays and the U.S. reaching record levels of oil and gas production, the petroleum industry is facing significant resource limitations. Among these are broad staffing challenges, including a high demand for natural gas measurement technicians qualified to install and maintain measurement stations. Training personnel on basic natural gas meter inspection and calibration can be accomplished within a relatively short period of time. However, knowing how to work safely in a natural gas production or pipeline environment, troubleshoot advanced measurement and communication problems, and evaluate sources of excessive "Lost and Un-Accounted For" (LUAF) gas volumes requires years of experience. This paper will examine the basic recruiting and educational requirements for an orifice meter technician, including training in measurement fundamentals, electronic gas measurement (EGM) inspection and calibration, witness testing, communications, gas sampling, and basic oilfield safety.

Recruiting Measurement Personnel

Finding personnel suited for field measurement work is an especially challenging task for Human Resources, even in times of lower demand. Technicians usually work alone, cover large geographical areas, spend a substantial amount of time driving, and must be able to work outside in often challenging weather conditions. They also must have above-average mechanical and computer skills, the ability to lift heavy objects, a developed talent and aptitude to think quickly on their feet, a strong focus and commitment to be safety minded, and a good driving record. Recruits with past oilfield experience are, of course, good candidates because of their general oilfield knowledge, but qualified personnel from outside of the industry should still be considered.

The military is an excellent source of qualified personnel for our industry. These candidates already meet most of the baseline job requirements, only lacking specialized oil and gas training. Working outdoors, occasional overnight travel, and not being in potentially life-threatening situations are generally very appealing attributes to many of our veterans. More importantly, there is an abundance of veterans with mechanical and communications training anxious to find a job in which those skills can be utilized. While there is a widespread patriotic obligation to help those who have served our country find a job, there is also a practical business advantage associated with recruiting from this pool of candidates.

In addition to ex-military personnel, we recommend recruiting candidates to our industry who have a two-year associate's degree or trade school certification, at a minimum, with areas of concentration which include instrumentation, electronics, information technologies, and/or general science curricula. Due to the increasing requirements for field measurement personnel to work with flow computers, telemetry, oilfield automation etc., advanced education and training are an important prerequisite. Recently, many community colleges have begun offering two-year petroleum technology programs that enable students to gain training and potentially earn an associate's degree or formal certification. These programs generally focus on lease operations and equipment maintenance, and often include introductory training in hydrocarbon measurement.

Gas Measurement Basics

Most measurement departments are comprised of a centralized flow data processing center, chromatography lab, and field services department (See Figure 1). The job requirements vary department-by-department, yet they're all vitally dependent on

one another and have naturally overlapping responsibilities. While it takes years to become an expert in any one functional area, it's essential that all groups are familiar with common measurement industry concepts, terms, and definitions. As a result, training all new employees in gas measurement must begin with an introduction to petroleum industry fundamentals and the language unique to our industry, including an overview of the principles and standards to which we adhere…such as those from the American Gas Association (AGA) American Petroleum Institute (API), Gas Processor Association (GPA), etc. See the Glossary of Terms below for definitions of some common industry measurement terms.

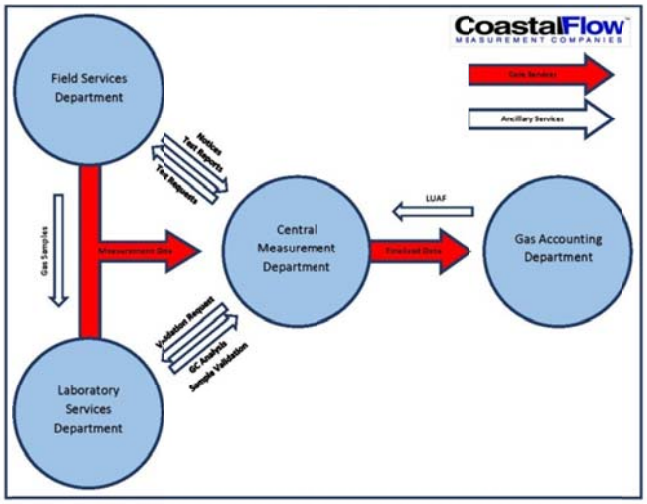

Figure 1: Integrated Measurement Model

While gas measurement can involve somewhat complex math and science, the function of an orifice meter station is mechanically fairly simple. It consists of primary and secondary devices, with or without communications, and has essentially no moving parts (See Figure 2). The primary device is a straight section of pipe (known as a *meter run*) machined to strict tolerances for length, smoothness, roundness, etc., and which contains a fitting that permits an orifice plate to be installed concentrically and perpendicular to the pipe. When a gas stream passes through the orifice a pressure drop is created which is measured in inches of water. The secondary device, for purposes of EGM, measures the flowing gas temperature, absolute pressure, and differential pressure across the orifice plate, and then calculates a raw volume based on these flowing conditions. To avoid altering the developed flow profile, the thermowell, where the flowing temperature is sensed, is generally installed in the downstream section of the meter run along with a sample probe.

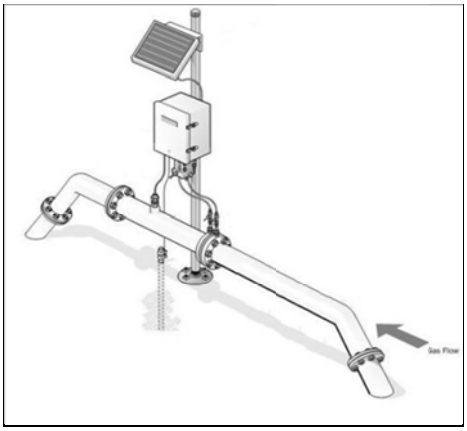

Figure 2: Orifice Meter Station

The field technician, at a minimum, must be able to oversee the installation of a meter station according to industry standards (e.g., AGA Committee Report No. 3, Part 2); configure the flow computer with the characteristics and calculation requirements specified by contract and/or company policy; verify and adjust the calibration of the transducers measuring flowing pressure, differential pressure, and temperature; obtain a representative gas sample and conduct gas quality tests; and document these test and sample procedures for the central processing center. An overview of the basic field service training requirements of a measurement technician follows.

<u>EGM Orifice Meter Installation and Configuration:</u>
Many sources of measurement error can be avoided by following proper industry standards and practices for the installation of orifice measurement stations. AGA Committee Report No. 3, Part No. 2, outlines the design, installation, and operation of measurement stations. When adhered to, this standard provides for minimum measurement uncertainty as long as operational conditions don't adversely impact or interfere with measurement and routine maintenance is provided. Accordingly, measurement technicians should be trained to verify that a meter station meets the applicable design standards, supervise the meter installation, and program the flow computer to calculate volumes according to company policy. Additional tasks which a measurement technician should be trained

to perform upon initial installation of the measurement station include:

- Verify the meter station and orifice plate are not installed backwards;
- Select a proper seal ring for the orifice plate;
- Verify the meter run is installed with the flange taps on top of the fitting in a vertical position…if operationally possible;
- Make sure that the gauge lines connecting the primary device to the secondary device have no liquid traps or contribute to gauge line error;
- Test for leaks in all connections and fittings;
- Initiate new service without over-ranging the measurement equipment;
- Verify that high-frequency pulsation is not causing adverse measurement conditions and inaccuracies; and
- Obtain a representative gas sample as soon as possible for laboratory analysis.

EGM Orifice Meter Inspection and Calibration: Orifice meters are very seldom "proved" while under flowing conditions. Typically, they are taken out of service and the technician uses test equipment with certified standards to verify that the differential transducer, pressure transducer, and temperature element are calibrated according to acceptable tolerances for error and transmitting equivalent values to the flow computer. When testing indicates that the equipment is out of calibration, the technician must be trained to re-calibrate the device to the manufacturer's specifications using calibration devices traceable to industry accepted standards, usually those from the National Institute of Standards and Technology (NIST).

While AGA Committee Report No. 3, Parts 1-4, provide the standards for producing accurate and accountable measurement results, these standards do not provide measurement policy or standard operating procedures (SOPs), all of which are necessary components of a functional, cost-effective measurement operation. Most companies in the U.S. recognize and implement the testing and calibration requirements developed for EGM according to API Chapter 21.1.8 and Chapter 22.2. Accordingly, technicians must be knowledgeable about these standards regardless of whether more or less stringent testing procedures are required by specific company policies.

Additional meter technician responsibilities may include conducting gas quality tests for water vapor content, H_2S, CO_2, etc.; inspecting the meter station and orifice plate; verifying the meter's volume and energy calculations; determining flow error due to calibration; and preparing a meter inspection and calibration report.

Obtaining a Representative Gas Sample: Natural gas sampling is a critical link in the chain of events that is necessary to produce accurate and accountable gas measurement and analytical results. Measurement technicians must be trained to obtain natural gas samples using GPA and API approved techniques for "spot" and/or "composite" sampling. To obtain samples representative of the gas stream at the time of a test, precautions should be taken, including the following:

- The sample cylinder must be free of any impurities that might contaminate the gas sample;
- The sample cylinder should be adequately purged before capturing a sample;
- The sample should be taken with a sample probe which is installed vertically in the center-third of the pipeline;
- The sample valve should be opened and purged to clear any debris before a sample cylinder is connected so that the sample is not contaminated; and
- The sample cylinder needs to be maintained at a higher temperature than the pipeline to prevent issues with liquid condensation during the purge process for both spot and composite samples, and during the entire sampling process for spot samples.

After samples are obtained in the field, they are transported to the analytical laboratory by a variety of means. Because gas samples are classified as hazardous materials, the Department of Transportation (DOT) regulates their transportation. Technicians who handle hazardous materials to any degree must be trained and very familiar with DOT regulations for such samples.

Documentation: Many technicians still complete hardcopy meter inspection and calibration reports and then distribute the results to the data validation and editing center. However, more advanced technologies are available in today's measurement world which permits test report data to be electron-

ically uploaded directly into the central measurement software system. This seamless integration of measurement functionality allows for the auto-validation of meter characteristics, auto-calculation of flow error due to calibration error, more accurate editing, and faster data processing. As a result, the technician must be adept at using computers, transferring files, and managing data. See Figure 3 for an example of a typical electronically-prepared meter inspection and calibration report.

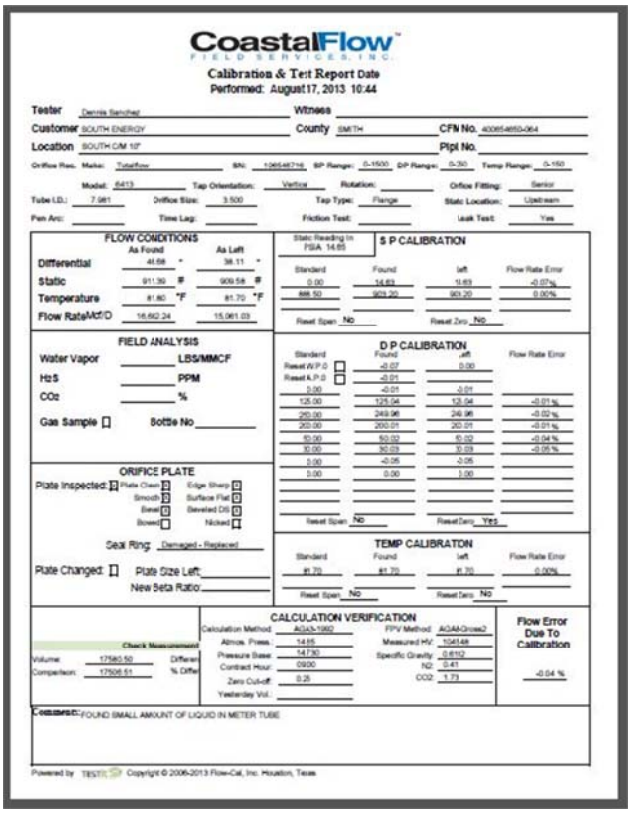
CoastalFlow
FIELD SERVICES, INC.
Calibration & Test Report Date
Performed: August 17, 2013 10:44
Tester Dennis Sanchez Witness
Customer SOUTH ENERGY County SMITH CFN No. 400654650-064
Location SOUTH O/M 10" Pipl No.
Orifice Run: Make: TotalFlow SN: 100548748 SP Range: 0-1500 DP Range: 0-30 Temp Range: 0-150
Model: 5413 Tap Orientation: Vertical Rotation: Orifice Fitting: Senior
Tube I.D.: 7.981 Orifice Size: 3.500 Tap Type: Flange Static Location: Upstream
Pen Arc: Time Lag: Friction Test: Leak Test: Yes
FLOW CONDITIONS
As Found As Left
Differential 41.66 " 38.11 "
Static 911.39 # 909.58 #
Temperature 81.60 °F 81.70 °F
Flow Rate Mcf/D 16,662.24 15,061.03
Static Reading In PSIA 14.65
S P CALIBRATION
Standard Found left Flow Rate Error
0.00 14.63 14.63 -0.07%
888.50 903.20 903.20 0.00%
Reset Span: No Reset Zero: No
FIELD ANALYSIS
Water Vapor LBS/MMCF
H2S PPM
CO2 %
Gas Sample Bottle No
D P CALIBRATION
Standard Found left Flow Rate Error
Reset W.P.0
Reset A.P.0
0.00 +0.07 0.00
0.00 +0.01 -0.01
125.00 125.04 123.94 -0.01 %
250.00 249.96 248.96 -0.02 %
200.00 200.01 200.01 -0.01 %
50.00 50.02 50.02 +0.04 %
30.00 30.03 30.03 +0.05 %
0.00 -0.05 -0.05
0.00 0.00 1.00
Reset Span: No Reset Zero: Yes
ORIFICE PLATE
Plate Inspected: Plate Clean Edge Sharp
Smooth Surface Flat
Bevel Beveled DS
Bored Nicked
Seal Ring: Damaged - Replaced
Plate Changed: Plate Size Left:
New Beta Ratio:
TEMP CALIBRATON
Standard Found left Flow Rate Error
81.70 81.70 81.70 0.00%
Reset Span: No Reset Zero: No
CALCULATION VERIFICATION
Calculation Method: AGA3-1992 FPV Method: AGA8-Gross2
Atmos. Press.: 14.65 Measured HV: 1041.49
Pressure Base: 14.730 Specific Gravity: 0.6102
Contract Hour: 0900 N2: 0.41
Zero Cut-off: 0.25 CO2: 1.73
Yesterday Vol.:
Flow Error Due To Calibration
-0.04 %
Comment: FOUND SMALL AMOUNT OF LIQUID IN METER TUBE
Powered by TESTER Copyright © 2006-2013 Flow-Cal, Inc. Houston, Texas

Figure 3: Calibration and Test Report

Witness Meter Inspection and Calibration

Witness testing, a traditional provision of most gas sales contracts, allows a representative of a non-measuring party to witness the inspection, calibration, and gas sampling procedures performed at the custody transfer point by the measuring party. As a result, the witness technician must be trained to verify and document that these procedures are properly conducted within the provisions of the gas sales contract. This is an essential check and balance between buyers and sellers of natural gas which requires professional courtesy and respect between the parties.

Communications

Due to the expansion of wellhead automation within the developing *digital oilfield*, measurement stations are increasingly equipped with advanced communications for automated Remote Data Retrieval (RDR) or Supervisory Control and Data Acquisition (SCADA). As a result, technicians must have basic knowledge of communications to be able to fully execute their day-to-day responsibilities. Most RDR and SCADA systems are designed to perform collection of measurement data for downstream data management. Currently, missing data resulting from failed communications is one of the most common and persistent problems in measurement. Technicians must be trained to troubleshoot basic communication problems…and to perform manual data collection from flow computers and similar devices whenever communications problems arise, to eliminate the need to estimate missing flow data.

Basic Oilfield Safety

With the oil and gas industry booming in many regions throughout the U.S., especially with the phenomenal growth associated with the major shale plays, our industry is hiring and training thousands of new employees every year. With large numbers of inexperienced personnel joining our ranks, the need for safety training is at an all-time high. The following are just a few of the important guidelines and reminders to help keep the oilfield safe for everyone:

- The roadways throughout the oilfields are filled with heavy traffic and dangerous conditions so it's imperative to drive safely, obey traffic signs, always wear a seat belt, and not use cell phones while behind the wheel to talk, text, or e-mail;
- Enter hazardous areas (e.g., drilling, production, or pipeline locations) with caution. Locate a wind sock or flag and know which direction should be used for evacuation in case of an emergency;
- Watch your step; lots of accidents occur as the result of simply tripping, stumbling, or slipping;

- Utilize proper "Lockout/Tagout" of pressure isolation points (valves), if required; be aware of and avoid the hazards associated with pressurized gas;
- Use the right tools for the job;
- Wear proper clothing and safety apparel; and
- Make safety a lifestyle, not a job.

There are no shortcuts when it comes to safety and these reminders are just some of the guidelines which must be part of the daily routine to stay safe at work and home.

Closing

In order to produce accurate and accountable natural gas measurement results, technicians responsible for maintaining the physical equipment and executing the SOPs in the field must be thoroughly trained and equipped to perform these basic duties in accordance with company policies, legal contracts, as well as local, state, and federal regulations. On average, it takes approximately one year to train a technician to work independently in basic orifice measurement. During that time, the technician should be closely mentored by a senior-level measurement specialist until requisite measurement skills, including work safety, can be certified by management.

Most companies provide in-house measurement training according to specific company policies and/or use third-party service companies. However, specialized training by equipment manufacturers is also widely available and serves as an excellent source of advanced measurement and communications training...especially for those technicians who demonstrate an aptitude for the technology and embrace greater challenges. In addition, many industry organizations and associations sponsor well respected hydrocarbon measurement schools and trade shows which are available throughout the United States, with most offering advanced education in all aspects of measurement. These associations provide excellent, low-cost resources for ongoing training in leading technologies that continue to both challenge and improve our industry.

Hydrocarbon measurement is the primary cash register for an industry that generates over one trillion dollars annually for our economy and it offers some of the most stable jobs available in the oilfield. Fulfilling the demand for candidates who meet the basic requirements of an orifice measurement technician continues to be a challenge, but this also provides an excellent opportunity for applicants who possess a strong work ethic and willingness to learn a job skill that, literally, counts.

"Training is everything. The peach was once a bitter almond; cauliflower is nothing but cabbage with a college education." ~ Mark Twain

Glossary of Terms

Absolute Pressure: Pressure above that of a perfect-vacuum; the sum of gauge and atmospheric pressure (designated by psia).

Atmospheric Pressure: Force per unit area created by the weight of Earth's atmosphere; atmospheric pressure at sea level is 14.696 pounds per square inch.

Beta Ratio: The measured bore diameter of an orifice plate divided by the internal diameter of the meter tube; this ratio should be in the range of 0.20 to 0.60 for minimum uncertainty in measurement.

Contract Hour: The time designated by a gas sales contract for the beginning of a new twenty-four hour measurement period.

Full Stream: Well stream gas that has not had separable liquids removed, such as water, oil, and condensates; when full stream gas is measured through an orifice meter, excessive error can be introduced.

Gauge Pressure: Measurement of the amount that the pressure is greater than atmospheric pressure. (designated by psig).

Pressure Base: Standard used for determination of gas volumes; volumes are measured at operating pressure and then converted to the appropriate base pressure volumes. Generally, the base pressure value is defined by a legal document for the state in which the gas is produced.

Primary Element: Describes the basic type of flow meter used in gas measurement, including orifice, Coriolis, and ultrasonic; for an orifice type of element, the primary device consists of the meter tube, orifice fitting, and orifice plate.

Secondary Element: A device that senses and records data, such as (but not limited to) static pressure, temperature, differential pressure, relative density and other variables, that are used in volume determinations.

Supercompressibility Factor: A factor used in a volume measurement calculation to correct for deviation from the ideal gas law.

Resources

1. AGA Standard No. 3 Part 1, "Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids: General Equations and Uncertainty Guidelines," American Gas Association, 400 North Capital St., Washington, DC, 2012. DOI: XQ1201, www.aga.org.

2. AGA Standard No. 3 Part 2, "Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids: Specification and Installation Requirements," American Gas Association, 400 North Capital St., Washington, DC, 2000. DOI: XQ0002, www.aga.org.

3. AGA Standard No. 3 Part 3, "Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids: Natural Gas Applications," American Gas Association, 400 North Capital St., Washington, DC, 1992. DOI: XQ9210, www.aga.org.

4. AGA Standard No. 3 Part 4, "Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids: Background, Development, Implementation Procedure, and Subroutine Documentation for Empirical Flange-Tapped Discharge Coefficient Equation," American Gas Association, 400 North Capital St., Washington, DC, 2012. DOI: XQ9211, www.aga.org.

5. API Standard 21.1, "Flow Measurement Using Electronic Metering Systems: Electronic Gas Measurement," American Petroleum Institute, 1220 L St., Washington, DC, 2013. DOI: H30730, www.api.org.

6. API Standard 22.2, "Flow Measurement Using Electronic Metering Systems: Testing Protocols—Differential Pressure Flow Measurement Devices," American Petroleum Institute, 1220 L St., Washington, DC, 2005. DOI: H220201, www.api.org.

7. GPA Standard 2261-00, "Analysis for Natural Gas and similar Gaseous Mixtures by Gas Chromatography," Gas Processors Association, www.gpaglobal.org.

8. National Institute of Standards and Technology, N.p., n.d. Web. 12 Nov. 2013, www.nist.gov/calibrations/.

Measurement Schools

International School of Hydrocarbon Measurement
www.ishm.info

American School of Gas Measurement Technology
www.asgmt.com

Appalachian Gas Measurement Short Course
www.agmsc.org

Corpus Christi Area Measurement Society
www.ccams.info

Midwest Measurement Society
www.midwestmeasurementsociety.org

Colleges with Petroleum Technology Programs

Kilgore College
Kilgore, Texas

Navarro College
Corsicana, Texas

Nicholls State University
Thibodaux, Louisiana

North Central Texas College
Bowie, Texas

Odessa College
Odessa, Texas

Panola College
Carthage, Texas

Western Texas College
Snyder, Texas