Western Gas Measurement Short Course

FUNDAMENTALS OF ELECTRONIC FLOW METER DESIGN, APPLICATION & IMPLEMENTATION

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Introduction

Electronic flow measurement in the natural gas industry has advanced considerably over the last 30 years as applications for upstream, midstream, and downstream gas measurement technologies have become more complex. This paper is a brief overview of the design, application, and implementation parameters to consider when designing an Electronic Flow Measurement (EFM) system.

Industry Sectors

The major sectors of the natural gas industry are often referred to as upstream, midstream, and downstream. *Upstream* refers to the search for and recovery of natural gas and is sometimes called *exploration and production*, or E&P. *Midstream* refers to the transportation of natural gas in pipelines as a way to move it to from production to distribution. *Downstream* refers to the final delivery or distribution of the natural gas to homes, businesses, and industries.

As gas flows from production (upstream), transportation (midstream), and distribution (downstream), it can be bought and sold at least four times. This is referred to as custody transfer of the gas. The buying and selling transaction is based on calculated gas volume. This requires high-accuracy digital resolution and speed, and requires that the electronic flow metering devices comply with industry-accepted measurement standards. These standards are issued by the American Gas Association (AGA) and the American Petroleum Institute (API) in the U.S. Other world areas may have their own set of standards that companies must comply with.

Components of Electronic Flow Metering

The API 21.1 document "Manual of Petroleum Measurement Standards – Flow Measurement Using Electronic Metering Systems" describes natural gas flow measurement in the following terms: *primary devices*, *secondary devices*, and *tertiary devices*. In this paper, primary devices are referred to as metering devices, secondary devices are referred to as transmitters, and tertiary devices are referred to as flow computers.

Many other components support the operation of an electronic flow metering installation. These include—but are not limited to—gas chromatographs, power systems, communication systems, historical data editing systems, and host systems. This paper also discusses those components.

Metering Devices

Metering devices include orifice, turbine, rotary, or diaphragm meters that are mounted directly on the pipe and have direct contact with the gas being measured.

Orifice meters are commonly used for applications where liquids, sand, paraffin, or other foreign materials are mixed with the gas. A producing well can bring a lot of material to the metering device. Orifice meters can generally handle these worst case conditions. Turbine meters and positive displacement meters can be used where there is little or no foreign material mixed with the gas.

Ultrasonic meters are becoming increasingly popular for natural gas measurement. They generate sound waves along transverse sections of a single spool section of pipe. The signals are monitored and when there is flow in the pipe, the sound signals sent through the gas are delayed and the meter measures the delay. By measuring this delay precisely, the meter can determine the velocity of the gas and thus the flow rate. Ultrasonic meters are very cost effective when measuring large volumes of gas that vary in flow rate.

Downstream measurement is different from upstream and midstream in that the meters are located at private homes or companies. Whereas home usage of gas is low volume, manufacturers or power plants can use significant volumes of gas. Downstream metering systems must address these wide-ranging needs. Positive displacement meters are typically used in these applications. This type of meter generates a pulse output that represents a portion of the flow and sends the pulses to a flow computer for accumulation and calculation of a finished volume.

Transmitters

Transmitters convert raw measurements into electronic signals or data and can include flowing static pressure transmitters, temperature flowing transmitters, differential pressure, relative density, and other variables from the metering device.

Orifice measurement requires three inputs from the gas stream: differential pressure, static pressure, and temperature. Differential pressure devices are often integrated with static pressure devices and are called multi-variable transmitters or sensors. Flowing temperature is measured using an RTD (Resistance Temperature Detector). For turbine meters, ultrasonic meters, and positive displacement meters, only the static pressure and flowing temperature are required.

Flow Computers

Flow computers are programmed to calculate flow within specific limits. They receive information directly from the metering devices and/or transmitters.

There are many flow computing choices for the upstream or production sector. Classification by hazardous or non-hazardous service is a critical selection criteria. Class 1 Division 2 hazardous service means that natural gas may be present in the area surrounding the flow computer, such as a flow computer that is located a specified distance from the metering device or flange of the pipe.

Class 1 Division 1 hazardous service occurs were the flow computer is mounted directly on the meter run along with the primary device. This is a more stringent hazardous service where natural gas is always present. It is important that products for this service classification are both explosion-proof and intrinsically safe in design. Explosion-proof means that if natural gas enters the device and ignites, the explosion is contained within its enclosure.

All flow computers for natural gas metering store historical flow data that consists of specific measurement parameters. In the U.S., the parameters are dictated by a governing agency in a standards document such as API chapter 21.1. This comprehensive document describes the methodologies used to meet minimum standards in all aspects of today's gas flow computers.

Most companies are concerned with the security of their process information. This is especially true at remote sites where most flow computers are installed and for devices that have a keypad or other type of user interface mounted permanently to them. A flow computer should restrict access to data and configuration parameters through the use of user IDs and passwords. Additionally, it should maintain an audit trail of who logged in, when, and the parameters that were accessed or changed.

Midstream metering systems usually handle a much greater volume of natural gas flow than the upstream production wells. In general, they are located in more populated areas and require additional safety measures to prevent damage to life and property.

The typical flow computer for downstream applications is known as a corrector and consists of built-in pressure and temperature transmitters, or transducers, along with a pulse-input device known a totalizer. The totalizer counts the number of rotations coming from the positive displacement gas meter and the count can be read off the mechanical display. The flow computers have the ability to communicate over phone lines or radio back to a host SCADA system. Once the specific application is known, the user can choose the type of corrector to mount to the meter.

Gas Chromatographs

Sometimes it is important to monitor the quality or chemical composition of the gas, which is especially true in midstream applications. This can be accomplished by a sampling system and a natural gas chromatograph. The sampling system typically operates on either a timed or volume basis. If based on volume, the flow computer sends a digital contact closure to the sampler which samples the gas and keeps it in an enclosed cylinder to be analyzed later.

A gas chromatograph analyzes the gas sample and provides the specific gravity of the gas and its full analysis to the flow computer to be used in the gas volume calculations. Understanding the composition and known volume of the gas in the pipeline is critical to moving large volumes. Once the flow computer collects this data, it must be sent to the host system for accounting purposes.

Solar/Battery Systems

Power requirements for electronic flow metering have declined significantly over the years. Today’s devices benefit from technologies that have been derived from consumer products such as cell phones, PDAs, IPods, and other low power consuming electronics. The advent of improved battery system technologies and solar panels has also added to longer field autonomy.

Once the flow computer, communications system, and external transmitter power requirements are known, the solar panel and battery requirements can be addressed. The autonomy of a system is based on the number of days the system must communicate to the host when solar energy is low, or if the solar panels are stolen or destroyed. Typically, 14 days of autonomy is sufficient for most regions of the world except for far-northern latitudes, where additional days of autonomy may be required.

Communication Systems

Radio systems bring the data generated by a flow computer quickly and efficiently back to a regional or corporate office where it is used by many departments to ensure steady production and accurate accounting.

Traditional two-way data radio systems must be licensed by the FCC in the U.S. By contrast, spread-spectrum radio systems use frequency switching technology that allows multi-radio systems to co-exist in the same frequency spectrum. You get good radio distances without the hassle of registering the radios. Because licensing requirements can vary by country, it is important to know the rules in advance of selecting a radio technology to use.

Properly designed and oriented antenna systems are essential to reliable data transmission. The height and design of the antenna are important to assure a good signal path between the central and remote locations. Antenna system design is a function of many factors including distance, terrain, and the radio frequency used.

Radio systems and satellite transponders can consume up to 90 percent or more of the power available at a site. Power cycling the radio can significantly reduce this consumption. Power cycle radio systems remove radio power down until it is needed and can significantly reduce battery/solar equipment cost for the site. Some systems do this by synchronizing the host polling cycle to the flow computer's clock, which powers up the radio for no more than a few seconds during each polling cycle.

Historical Data Editing Systems

Flow computers for natural gas metering are required to store historical flow data as specified in API chapter 21.1 or similar standards. This comprehensive document contains sections that describe the methodologies used to meet minimum standards in all aspects of gas flow computers.

For historical data editing, the parameters listed in the standards document are used to recalculate the flow over a period of time. Why would we want to recalculate flow volumes? Perhaps to correct errors that may occur due to field operations errors. For example, the size of an orifice plate may have been incorrectly entered into the flow calculations and it is necessary to re-calculate the flow based on the correct orifice size. These editing systems allow users to change the final totals and keep complete audit trails to assure who and what parameter was changed.

Most flow computers are designed to meet the minimum requirement of data storage. Once the data is collected from the flow computer, via radio or manually, it can then be moved to a personal computer that contains an editing software program.

Host SCADA Systems

Natural gas measurement systems must have a means to collect data remotely from metering sites. Generally, a host Supervisory Control and Data Acquisition (SCADA) system does this using a PC-based program that resides in the corporate office or in the field office.

The host SCADA system contains polling software that communicates to each remote location. These systems typically communicate to the flow computer at least once an hour to ensure the processes are running at the site and to retrieve process information.

Protocols are the means by which flow computers communicate with one another or to the host system. The most common protocol in use today is Modbus, a simple single-layer protocol developed in the early 1980’s. In the past 12 years or so, the former Enron Corporation developed a means of transferring data with Modbus, known as Enron Modbus. By using a common protocol, most flow computer suppliers can communicate to any common host system.

The host SCADA system must be designed to poll the flow computer on an interval that best meets the needs of the corporation. Polling too often can deplete the battery/solar system of the flow computer; not polling often enough can result in increased response time to fix any on-site problems.

Host SCADA systems for the upstream sector play an important role in reducing costs and maintaining safety in field operations. Flow computer manufacturers supply simple packages that poll their products and provide editing capability in one software bundle. It is important to know who will use the data once it is retrieved from the production sites.

Host SCADA systems for the midstream sector typically poll the data from large customer sites very quickly. This helps in balancing the pipeline pressures and flows. Pipeline modeling software packages that look for early signs of problems in the integrity of the pipeline are often standard in these systems and are crucial in maintaining a high level of integrity for midstream measurement.

Host SCADA systems for the downstream sector typically use automatic meter reading software to gather data through phone lines and or through very short wireless applications.

Other Considerations

Safety is always an issue when dealing with a flammable product such as natural gas. After installing the SCADA host, engineers must make sure all of the data collected on site is properly sent back to the host system. This process, if pre-tested back at the staging area, should not take much time.

Another issue is training the field operations personnel. This has to be well-planned and executed in a timely fashion. If training not done effectively, then the success of the project can be at risk.

Summary

The wide range of applications in the upstream, midstream, and downstream industry sectors determine the type of meter, flow computer, radio, host and power/solar system requirements. Understanding the fundamentals of electronic meter design is important to integrating these technologies to ensure a successful outcome.

Figures

Typical Metering Devices

Typical Transmitters

Typical Radios

Typical Flow Computers