Application of Flow Computers for Gas Measurement and Control

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Executive summary

Flow Computer installations can be very complex and careful consideration of all parameters will help ensure a successful installation.

This white paper:

- Defines the electronic Gas Flow Computer,
- Outlines various flow computer application types,
- Highlights a typical flow computer installation, and
- Explains in detail, power systems, wireless instrumentation and remote I/O, remote communications, data collection and calibration practices.
Introduction: What is an Electronic Gas Flow Computer?

Overview

Electronic gas flow computers are microprocessor-based computing devices used to measure and control natural gas streams. There are a variety of configurations available from dedicated (integrated) single board computers to PLC-based multi-run (hybrid) systems.

Flow computers perform the following functions:

- Compute volumetric flow of measured fluid
- Log measured and computed data
- Transmit real time and historical data to a central location
- Perform automated control of the site based on measured values

Historical data is collected and saved in accordance to guidelines set forth by the API (American Petroleum Institute) Ch 21.1. Flow computers that do not adhere to these guidelines are not suitable for custody transfer and should not be used for physical measurement applications.

The physical configuration of a flow computer consists of an I/O subsystem with a computational engine and data storage section. Most flow computers are “Flash” memory-based such that the firmware can be updated to accommodate the application and any future requirements. A communications section allows operational and custody transfer data to be transmitted to a central location. All of these features together make a flexible system to meet the needs of each measuring application.
Flow Computer Applications

There are numerous applications for the measurement of gas along its way from the well to the burner tip. Since applications vary significantly, flow computers need to be easily configured and flexible in I/O and communications. Computers used at the wellhead differ significantly than those used in the transmission and distribution systems.

Expandable inputs and outputs, as well as flexible communications, are critical in assuring that the flow computer will be suitable for an application. Today’s flow computers are very flexible in their configurations; in many cases the flow computer application can be updated remotely to accommodate site-specific requirements of measurement and control. As requirements change, the flow computer must be able to be reconfigured to meet the ever-changing demands of flow measurement and control.

Location types include the following applications:

Wellhead Measurement and Control
Combination ‘measurement and control’ application incorporating safety systems to shut the well in the event of a problem. Additionally, well flow optimisation like plunger lift, can be incorporated to improve the production and life of the well.

Compressor Fuel Gas
Meter to measure the fuel consumption of the compressor or any device in the field that uses natural gas-like boilers or heaters, etc. The information is used in allocating cost-of-operations of fuel-consuming devices. The data is also useful in determining the operational efficiency of the device.

Re-Injection
Flow computer used to measure and control the re-injection of gas at a wellhead for the purpose of deliquifying a gas well. These computers typically incorporate a flow or pressure controller to maintain a set point for operation. The measured gas is subtracted from the total gas produced so the user can determine the net gas produced from a well after reinjection. The volume rate is also used as the process variable for the control of the flow for the re-injection rate. As the volume rate changes, the PID controller adjusts the flow rate to maintain a steady flow under varying conditions. The output of the PID controller can be analog or digital depending on the type of control element used.

Check Meter
Meter station in line with another flow computer, used to check the accuracy and performance of the other meter. Check meters often share a meter tube or primary element with the compared meter. In some cases they will be completely independent systems. Discrepancies between meters and check meters are a method of determining proper operation of a flow computer site. Properly configured meters should agree to within a small percentage of error in comparison.
Sales Meter
Meter located at the point where flow is going from the gathering system to the pipeline system. This is where the gas changes custody between the seller and the buyer. This meter should equal the sum of all the gathering system meters upstream. Sales meters generally handle large volumes of gas and in many cases are installed after the gas is dehydrated and compressed to go into high pressure transmission lines.

Transmission Station
High pressure transmission meter to measure large volumes of gas that may require a special metering element like an ultrasonic meter and direct chromatograph inputs. These sites can involve ‘multiple meter run tube switching’ and are typically designed to operate over a very wide range of flows. Transmission meters can be used for custody transfer, leak detection and load monitoring applications. Most transmission stations can’t be shutdown, requiring equipment that can be serviced while gas is flowing and therefore can’t be stopped.

In-Plant Metering
In-plant meters vary depending on the application. In gas processing plants and industrial applications, gas flow is measured going into and out of the plant and different processes. Applications include fuel consumption and energy management, as well as blending and process control. Numerous types of installations are needed to meet the requirements of in-plant applications.

Distribution Metering
These applications can vary significantly, from residential, to large industrial users. Flow computers in this market segment are usually used on the larger industrial customers to correct for pressure and temperature fluctuations. These meters can telemeter volume data back to the gas distribution company for load distribution and billing.
Typical Flow Computer Installation

Regardless of the application, careful consideration of the installation is required to insure proper performance and safety. With the flexibility of the flow computer in mind, the user will need to decide the metering specifics, power considerations and remote communications. If additional monitoring points and control are required, provisions will have to be made to incorporate features like additional I/O, power and communications bandwidth.

There are two main types of flow computer designs:

- Integrated models that include an integral multi-variable sensor to allow the DP & Pressure inputs from the meter run to be plumbed directly to the computer.

- Hybrid models that use separate MV sensors and communicate to the flow computer electronics via serial or Ethernet communications. Hybrid systems can generally support multiple flow runs in a single set of electronics. Hybrid models tend to be bigger installations and will generally operate multiple wells complete with tank monitoring and alarming systems for safety shutdowns.

The primary flow element (orifice plate, etc.) will dictate the flow range and turndown of the measurement system. The MV sensor or transmitter has to match the pipeline pressure to avoid damage to the measuring element. Proper I/O will be required to accommodate the additional measurements such as tubing & casing pressure, tank levels and other possible measurements at the well location. In some cases, the additional I/O is connected wirelessly, making the installation quick and simple. Wireless I/O can be operated with both integrated and hybrid flow computers.

Power Systems

Since most metering stations are remote, and electric power is rarely required for a gas well to operate, most stations are solar-powered. One or more solar panels are used with a solar charge controller connected to a battery for the power system.

Some integrated flow computer designs have an internal charge controller circuit optimised for the charging of a battery which is installed within the electronics enclosure. These self-contained systems are quick and easy to install but are limited in capability.

Hybrid systems on the other hand will generally have a battery and solar systems independent of the flow computer. It is very important to size the solar system, accounting for location, power requirements of the flow computer and related equipment, and days of autonomy (operation without sunlight) for operation. Poorly designed solar systems will result in loss of data and possible safety issues, not to mention lost and unaccounted-for production.
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Wireless Instrumentation and Remote I/O

Wireless Instrumentation offers expandability for integrated and hybrid-type flow computers. The ability to add instruments (without the need to run wire) and have extended I/O is allowing many users to make measurements that would otherwise not be made. Wireless instrumentation does not add to the burden of the flow computer solar system and eliminates physical limitations of I/O and wiring. Most wireless instruments are battery-powered and are optimised for very long battery life of up to 5 years or more. More sophisticated wireless sensors use technology that can provide rapid reading updates, transmitting data only after a change occurs; thus maintaining responses like traditional hard-wired sensors, but having long battery life.

Wireless I/O is a technology that allows the user to use wired sensors and connect them to a remote system that reads the signals and transmits that data back to the flow computer. Most remote I/O systems require battery and solar panels to provide power for these remote measurements. In remote I/O applications it is not uncommon to have 2 or 3 solar panels located on a well pad to support the remote points.

Both technologies offer features and benefits that extend the capability of any flow computer.
Remote Communications

The ability to accommodate remote communications is a very important requirement for most flow computer applications. Being able to monitor and control a well remotely is a necessity for many applications.

Urban wells located near homes and businesses need to be monitored for safety and environmental reasons. Remote wells may be un-accessible for long periods of time and in many cases the sheer quantity of wells to be monitored can only be done efficiently using remote communications.

Data is communicated via serial or Ethernet communication links. Operational or SCADA data, as well as historical, is needed back at the central location. Consideration for the type and amount of data and the frequency of readings is needed to determine the best way to communicate with the flow computer. Communications can be by private radio networks, cellular networks or satellite communications.

Communication media can be either:

- Serial: commonly used when only a central host is polling the flow computer data, or

- Ethernet: used when multiple systems need to access the flow computer at the same time. Ethernet supports multiple connections to the flow computer with Ethernet protocols managing data flow. Typically, multiple systems continuously poll the flow computer in this mode.
Data Collection

The primary function of the flow computer is to measure and store data for accounting purposes. The historical data stored in the flow computer memory is saved such that it is unalterable by the user, and is transported in a format to guarantee the integrity of the data back at the host. Since this information is for custody transfer purposes, great care is needed to maintain integrity of the data for accurate billing purposes. API guidelines regulate how this data is stored and transported. In the event of lost or inaccurate data, gas editing software is used to help recreate accurate data so billing can be produced. Errors in data can come from improper configuration of the flow computer such as incorrect orifice plate size or bad gas composition values. Lost or missing data can be caused by communication failures or loss of power at the flow computer.

It is possible to collect the volume information from the computer manually (i.e. physically going to the computer, connecting to a com port with a computer, uploading data and then saving to hard drive) or by remote communications. Either method is acceptable by the API. Again, due to the volume of wells in many areas, remote communication is the only reasonable method for collecting data. By contract most sites have to be collected every month.

Calibration

Calibration verification is the only method for determining the accuracy and performance of the flow computer. Many high quality meters hold their calibration for long periods of time without drift or degrading of the measured signals. Typically meters are calibrated at no less than 1-year intervals but some sites, due to contractual obligations, are tested every month or every quarter year. Calibration consists of testing the zero-shift and span accuracy of the pressure and differential pressure inputs (for orifice measurement applications), and RTD accuracy, with an offset being applied if there are any errors. Additionally, because bent or worn orifice plates degrade the overall measurement accuracy of a flow computer installation, the orifice plate should be inspected for wear and dimensional accuracy. The site should also be inspected for leaks or plugged tubing which will introduce measurement errors.

It is critical to use calibration equipment that is considerably more accurate than the sensor to be calibrated. You would not want to use a calibration device of 0.1% accuracy to test a flow computer sensor that is 0.075% accurate. In most cases a deadweight tester or PK tester will have the required accuracy to test the DP measurement device. A digital pressure calibrator of sufficient accuracy can be used for testing the pressure sensor of the MV sensor.

Calibration test equipment itself should be periodically tested to ensure accuracy in accordance with calibration accuracy specifications.
Conclusion

Many factors need to be considered in designing and implementing a flow computer installation including:

- Proper selection and mechanical construction of the primary measurement element dictates the capacity and turndown of the site.

- Consideration for automation and control will determine the I/O and computational power required for the installation.

- Configuration of the control logic must be implemented to allow the system to provide measurement and control.

Flow computer installations can be very complex and careful consideration of all parameters will help ensure a successful installation.