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APPLICATION OF FLOW COMPUTERS FOR GAS MEASUREMENT AND CONTROL

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Introduction

Flow computers are microprocessor controlled CPUs specifically designed to measure and regulate the transfer of a fluid from one point to another. They are an essential part of electronic fluid flow measurement, and are usually installed in various remote locations throughout the production, transmission and distribution segments of the gas industry. The function of a flow computer is fourfold: collect measurement data, calculate and store measurement data, transmit stored measurement data to a host system, and execute control requirements. In addition to measurement data, the event log, audit trail, and alarm information are also collected, stored, and subsequently transmitted to a host system in accordance with API Ch 21.1 – Flow Measurement Using Electronic Metering Systems. All of these flow computer functions are controlled by on-board firmware, independently or in conjunction with inputs from Host systems. It is this on-board firmware, and associated Host software, that allows the user to maximize the flow computer's versatility and efficiency.

Measurement and Control Station

There are several factors that must be considered in order to achieve safe and dependable measurement with accurate and stable pressure regulation. Site location, construction costs, future load increases, operation and maintenance requirements and costs, effects of government regulations, and environmental impacts are just a few factors that must be considered.
Improper application or installation of a gas measurement and control station can cause several serious problems. The most frequent and obvious problem is customer-billing inaccuracies. The most costly problem is negligence involved with safety related issues that could potentially result in disaster. Another less obvious, yet major problem, created by improper design or assembly, is the introduction of incorrect information into the control decision-making process.

Since measurement and control stations are generally installed in remote locations, power consumption is of the utmost importance. Because the availability of power is often limited in these remote locations, the measurement and control equipment must be capable of being reliably powered by batteries and solar arrays.

The measurement and control equipment used for gas flow measurement and regulation typically falls into three categories: the flow computer (and its peripheral input and output devices), the power system, and the communication equipment. **Figure 1** shows an example of a simple solar powered gas flow measurement installation with communications.

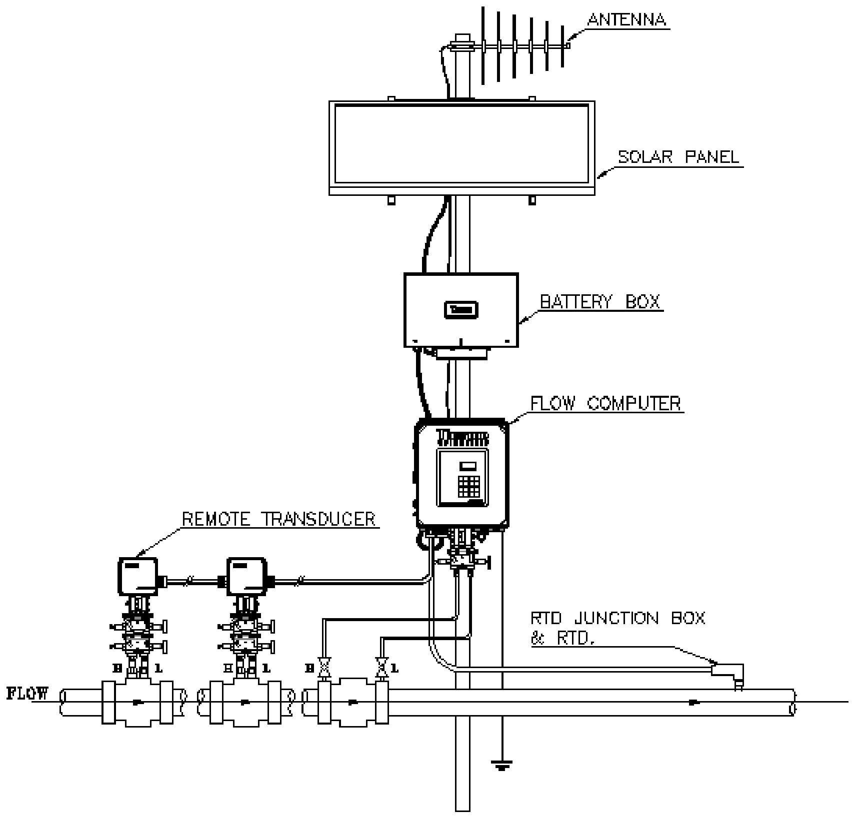

Figure 1

Flow computer devices usually control or indicate flow conditions. A typical battery powered flow computer used in the gas industry consists of numerous low power components assembled together to provide accurate and dependable measurement of a transported gas in a safe manner. These components are usually mounted on a single printed circuit board design and include power supply circuitry, microprocessor circuitry, various input and output circuitry, analog to digital conversion (A/D) circuitry, firmware memory circuitry and data memory circuitry, RS232 or RS485 communication circuitry, display circuitry, and lightning and surge protection circuitry.

There are also various peripheral devices used in conjunction with flow computers. These peripheral devices include items such as sensing devices (e.g., pressure and temperature transmitters, turbine meters, PD meters, etc.), communication devices (e.g., modems, radios and cellular telephones), and output control devices (e.g., valve actuators, samplers, odorizers, etc.). Most of these peripheral devices can be powered by the flow computer's power source. When devices are powered in this manner, they should be considered part of the flow computer system. The most desirable flow computer system is one in which all the peripheral devices, along with the flow computer and solar power system, utilize a single enclosure design in order to simplify installation and reduce installed costs.

Unlike basic computers, a flow computer is designed to support multiple inputs and outputs, as well as various communication channels of varying types (i.e RS-232, RS-485, Ethernet etc). Since a flow computer system usually handles several requirements, the number of inputs and outputs, along with the expandability of the flow computer system, are very important.

Input types can be analog, discrete, pulse inputs or serial signals and come from various peripheral devices. These devices include pressure and temperature transmitters, pulses from turbine and PD meters, densitometers, gas quality data, and valve status indicators. Whatever the input device, its purpose is to provide measurement and/or decision making information to the flow computer.

Outputs can also be analog, discrete, or serial signals controlling various peripheral devices such as gas samplers, valve actuators, emergency shutdown devices, and alarms. The most useful outputs are proportional outputs and proportional integral and derivative (PID) feedback control loops. Output communication ports are typically RS232/RS485, USB and Ethernet connections. They provide communication capabilities with a local interface unit via a direct wired connector or a Host system via a communication device such as a radio. The Ethernet connection allows the flow computer to connect directly to an existing network and provides high rates of communication for data retrieval and control commands. In addition, communication ports allow for communication with various peripheral devices such as chromatographs, smart transmitters, flow elements or other control devices out in the field.

Power Systems

A primary concern when designing a flow computer system for remote operation is power consumption. Each component requires a certain amount of electrical current and voltage in order to function. This is the power consumption of the component and is defined by the equation $P = I * V$ (i.e., power equals current times voltage). The amount of power consumed varies with many parameters. One example of this is the length of time that a component is in a dynamic or static state (powered up or not). In general, ultra-low voltage components (usually ultra-low current) and power cycling design techniques are used to reduce the overall power consumption of a system.

Peripheral devices typically consume the largest part of the overall power budget of a flow computer system. Many of the primary sensing devices (e.g., pressure and temperature transmitters) are available in low power models and should be used whenever possible to further minimize system power consumption. Communication devices, when part of the flow computer system, can vary significantly in power consumption. Modems typically consume very little power. Radios, on the other hand, can be the single most power-hungry devices in a flow computer system. The amount of power consumed by a radio is directly dependent upon the amount of time it is in the transmit mode (which typically consumes about 15 to 20 times more power than when the unit is in the stand-by mode).

Output control devices that require a 4-20 mA analog signal from the flow computer is another source of power drain in a system. This type of output signal is required when using PID control loops. Since most of these peripheral devices receive their power from the flow computer's power source, they can generally make use of the power-cycle design of the flow computer. Power cycling, however, is usually not an alternative in PID applications due to the requirement for continuous control. Use of stepper motors, that consume power only when valve movement is required, can reduce the power usage of a system dramatically, but the control valve must support this option.

Power can be supplied to a flow computer system by different means: AC power (i.e., AC battery charger), a non-rechargeable battery, or solar power. Each power source has its own advantages and disadvantages. AC power is usually thought to be the most reliable power source; however, it is not available in many remote locations. Furthermore, even if AC power is available in a remote location, it is prone to occasional outages, especially in these remote locations. Therefore, an appropriately sized backup power system must be incorporated to ensure continuing operation when these power outages occur. When considering the initial installed costs (which can be quite high if AC power lines are not in the immediate vicinity of the installation site) along with the costs associated with a backup power system, AC power becomes a very costly way of providing the needed reliable power. A non-rechargeable battery is a very economical solution when considering just the initial installed costs. However, the ongoing costs associated with periodic battery replacement can be quite extensive.

Another area of concern with using non-rechargeable batteries is system reliability. Even though the flow computer can send a low battery alarm to the host system (if the flow computer system has some type of communication device installed), other activities still must occur in a timely fashion. Field technicians must have replacement batteries available in order to get to the installation site, and replace the battery before it ceases to provide adequate power to the flow computer system. Solar power systems generated power from arrays of photovoltaic cells. These devices convert radiant energy, such as sunlight, into electrical energy. Solar power is usually the best method to provide power to flow computers mounted in remote locations; however, the solar power system requirement is perhaps the most underestimated item in the design of a flow computer system installation.

There are several factors that need careful consideration when sizing a solar power system: the amount of available sunlight and ambient temperatures at the installation site, as well as the total load current and operating time requirements of the flow computer system. Additional factors include, solar array inefficiencies and de-rated battery capacity of the solar power system must be considered in order to compensate for worst-case conditions.

It is the oversight, or neglect, of the latter two factors that causes many solar power systems to be unreliable. The amount of available sunlight in a particular location is critical to a solar power system. The available sunlight in a general geographic location can be determined by using "Insolation Maps". These maps show the worst-case (i.e., winter time) average solar radiation hours per day. The daily solar radiation hours are used to calculate solar system capacity. Though Insolation Maps do not guarantee the solar radiation hours indicated, they are widely accepted and used as the standard for solar energy calculations. However, due to geographic variations and installation specifications, each site must be evaluated individually.

Ambient temperatures affect storage battery life, mostly at colder temperatures. Storage batteries provide power at night and during periods of limited sunlight. The number of days that a battery can supply ample power without sunlight is referred to as its reserve time, or autonomy. The required autonomy of a solar power system should consider the time it will take to fully recharge the battery under normal load conditions.

Total load current and operating time requirements of a flow computer system, the solar array inefficiencies, and de-rated battery capacity of the solar power system are often difficult to determine. Because there are many variables to consider when estimating worst-case conditions, these estimations are usually determined by a team of qualified persons who are very knowledgeable of the system's installed operating conditions. When sized properly, solar power systems can be a cost effective, reliable means of supplying power to a flow computer system. However, the reliability of a solar power system is frequently questioned by some flow computer system installation designers. This is usually based on their past negative experiences with solar power installations. Unfortunately, poor reliability of a solar power system is usually due to poor installation design. Most unsuccessful solar power systems result from design flaws, such as inadequate sizing of the solar array or the battery.

Communications

Communication devices the link the RTU to the Host system and is an essential part of a gas measurement and control station. These are as vital to a smooth running flow computer station as the nervous system is to a healthy human being. Communication capability is what makes supervisory control and data acquisition (SCADA) possible.

SCADA systems are specialized control systems used to monitor and control facilities, such as a gas measurement station. These systems make extensive use of remote communications devices to link the flow computer with a Host system. Information, such as gas measurement data, passes in both directions between the flow computer and Host system through the communication device. Supervisory control data passes from the host system to the flow computer. The reliability of the communication system is crucial. There are several types of communication devices that can be selected for a gas measurement station. The most common types of communication devices are hard line telephone modems, cellular telephones, radios and satellite. Site location can be the most important element when selecting the best communication device for a particular station.

Telephone line modems are still being used if an elaborate radio system is not already in the field. However, telephone lines must be available to make use of a telephone line modem. When selecting a modem, several items need to be taken into consideration.

Lightning is an inevitable occurrence so lightning protection on a modem's input is essential. Telephone lines can transport damaging power surges from lightning strikes within a radius of many miles from the flow computer station. If the modem selected does not have on-board lightning protection, then an external surge suppressor should be utilized. Because ambient temperatures fluctuate in a remote installation, the operating temperature range of the modem is an important consideration. Most modems are designed to operate in an office type environment. Reliability problems occur when these modems are exposed to environments where temperatures are not controlled. An industrial grade modem is essential for these demanding remote applications.

With the advance in communication technologies in recent years, radios (a general term for wireless communication device) are presently the most popular communication device for flow computer stations. There are several types of radio communication systems available to choose from when selecting a radio for a flow computer station. The most commonly used are license radios and spread-spectrum radios. The growing disadvantage with license radios is the licensing requirement. Not only has obtaining a license become very time consuming, but an even bigger problem is that in many areas all of the licenses have already been issued. This is a major problem with new installation that a license cannot be obtained.

Spread Spectrum Radio is the most commonly used device out in the field today. The term “spread spectrum” has been around for a long time. The military has been using spread spectrum techniques to increase the difficultly for its enemies to intercept or jam these wireless communication systems. The techniques that provide a low probability of detection also provide the desirable benefits to solve spectrum congestion problems. A spread spectrum radio system provides several benefits to the overall communication system:

- Inherent interference rejection capacity and resistance to multi-path fading
- Low power to meet the FCC requirements
- No licenses required
- Secure communication
- Easy implementation of repeaters
- Low cost

Because of the flexibility of spread spectrum radios, it is feasible to use them together with other types of communication equipment to solve many communication network problems or to improve the efficiency of the system as a whole. For example, a spread spectrum radio network can be added to the backend of a licensed radio or an Ethernet connection to extend the range of the current communication network. Today, many radios have Ethernet connection as an option to allow easy interface to a network.

Flow Measurement and Control

Flow measurement information provided to the electronic gas measurement system by the flow computer must be as accurate as required for custody transfer applications. Accuracy is not only governed by the quality of the sensing devices, but also dependent upon the equations being executed by the flow computer. The American Gas Association (AGA) and American Petroleum Institute (API) provide standards for these equations. API Chapter 21.1 provides the algorithms for all aspects of natural gas measurement for custody transfer. This includes calibration algorithms, calculation methods, historical record content, audit trail considerations as well as installation issues.

Control decisions are executed by the flow computer based either on a pre-programmed sequence of events or direct commands from the host system. Plunger lift, gas nomination, valve control, PID control, tank gauging, odorization and chemical injection are just a few advanced control functions offered by today’s flow computers.

Conclusion

Though flow computers have been used successfully for many years, in just the last few years, tremendous advances in technology have been made to enhance their performance and reliability.

Today, flow computers can be used for many measuring, controlling, and regulating applications. The power of a flow computer resides in its flexibility. A flexible flow computer can be made to perform nearly all of a gas measurement station's requirements given the right combination of hardware and software.