INTRODUCTION

A common requirement for gas transmission pipeline systems is to provide a pipeline control system to remotely monitor and operate the pipeline from a central location. This paper presents an overview of the main components of a pipeline control system:

1. Field Instruments, Analyzers and Actuators
2. Controllers
3. Telecommunications
4. SCADA systems
5. Advanced Pipeline Applications

SCADA is an acronym for Supervisory Control and Data Acquisition. A Supervisory Control system is a system that has the ability and intelligence to perform controls with minimal supervision and a Data Acquisition system has the ability to gather data. They are commonly used in the gas, oil, electric and water transmission and distribution industries where facilities are spread out over a large area.

Telemetry can be defined as the process of where data from a measured device is being transmitted to a distant location by any variety of media, e.g., radio, telephone, etc.

PIPELINE CONTROL SYSTEMS

The primary functions of a complete pipeline control system include data acquisition, reporting, operator control, pump/compressor control, valve control, nominations, scheduling, custody transfer, imbalance measurement, billing, pipeline modeling, batch tracking (for liquid pipelines only), pump/compressor optimization and leak detection. Nominations are monthly (or daily) bids by customers for available capacity. Imbalances occur when a customer of the pipeline delivers or receives an amount that is different from the nomination.

The key physical variables measured at many locations by field instruments include pressure, temperature, BTU content, gas composition, flow rate, pump/compressor status and valve status. Due to the remote location of many measurement points, transmitters and controllers can be solar powered with battery back-up if conventional power is not available.

Communications can be by leased line, fiber optic line, radio, microwave, satellite or any combination. Some of the primary functions such as pipeline modeling, batch tracking and leak detection are handled by advanced application software.

FIELD INSTRUMENTS, ANALYZERS AND ACTUATORS

Field instruments and analyzers provide the means to measure and convert a measured variable into a signal that can be understood by a digital controller.

Analog instruments typically measure temperature, flow rate and pressure. Digital instruments typically measure On/Off signals such as a tank high level limit switch, motor running, etc. Pulse signals are generated by electronic pulses or contact closure signals with frequency proportional to the measured variable. Pulses are used to represent an incremental measurement such as flow rate.

Actuators or output devices can be driven by three types of output signal from a controller. Analog actuators use an analog output signal to control variables such as flow rate, pressure, etc. Digital outputs are useful for absolute actions such as opening a valve, launching a pig, etc. Pulse outputs are often used as hand-off signals to other controllers.

Gas and BTU analyzers are complex instruments that determine gas components.

CONTROLLERS (PLC, RTU, FLOW COMPUTER)

Controllers are devices designed to be placed close to the sensors and actuators. Nearly all modern controllers are microprocessor based with a high level data communications interface for connection back to a SCADA system and low level connections for field devices such as transmitters, switches, actuators, etc. Today most low level connections are either voltage or current based, but the trend is towards smart sensors and actuators that communicate using serial data busses.

The function of the controller is to:

- Periodically read the input signals and convert into an internal numeric format
- Control the output signals to the correct value
- Perform calculations and algorithms
- Send and receive data from an external computing system
Three types of controllers are used on pipeline systems: PLCs, RTUs and Flow Computers. PLCs are used at sites where conventional power is available (i.e., 24 volt dc or 110 volt ac); RTUs are found in remote locations where solar power is used (i.e., 12 volt dc and less than 2 watts); and Flow Computers are used specifically for flow measurement.

**PROGRAMMABLE LOGIC CONTROLLERS (PLC)**

Typically PLCs are appropriate in situations where solar power is not required and difficult communications requirements are not an issue. PLCs are widely used in all control business segments and are a low cost versatile solution.

**RTU CONTROLLERS**

An RTU is required at remote sites where conventional power is not available, difficult communications requirements exist or industry specific algorithms and processing are required.

Most RTUs are very small compared with PLCs and are designed to handle a small number of I/O, mount in harsh environments and be quick and simple to engineer.

A large pipeline SCADA system can communicate with thousands of RTUs.

**FLOW COMPUTERS**

Flow computers are similar to RTUs, being designed to handle a small number of I/O and mount in difficult environments. The main differentiation with RTUs is that flow computers are purpose built for flow measurement and control and have a large number of built in algorithms and applications specific to flow measurement and control such as AGA flow calculations, custody transfer, meter proving, etc.

**TELECOMMUNICATIONS**

The telecommunications system is a critical component of pipeline control systems. There are several common methods including leased lines, dial-up public service telephone (PSTN) lines, fiber optic lines, satellite, microwave and radio. For new pipeline construction, fiber optic lines, leased lines and satellite systems are most common. Radios are commonly used for gathering systems in onshore oil and gas production areas. Occasionally, a system involves combinations of two or more telecommunication methods.

A number of design considerations go into the selection of telecommunication methods:

- **Short haul vs long haul** – Radios can communicate about 25 miles. Beyond that, repeaters are needed.
- **New construction vs retrofit** – It is easy to lay fiber optic lines while laying new pipe.
- **Availability of leased lines and public telephone lines.**
- **Availability of radio frequencies for licensing** – Radio communications fall into frequency ranges of 360-512 mHz and 928-960 mHz with bandwidths of 12.5 to 25 kHz. Speeds range from 9.6 to 384 kbps. The time required to obtain a license must also be considered.
- **Availability and cost of satellite space for long distance.**
- **Terrain** – This governs the height and location of radio and microwave towers.
- **Requirements for voice and/or video communications** in addition to data.
- **Capital cost vs operating cost.**

**SCADA SYSTEM**

Pipelines require a control system which is very different from other types of control systems. A SCADA system is designed for low speed, limited bandwidth communications over long distances while a typical DCS system is designed for high speed, unlimited bandwidth communications inside a plant. In a SCADA system, data is transferred in small packets. Constant data such as controller ID data are stored in the central database, not in the field controller. Operating data is stored in controllers for intermittent polling and communications are minimized by designing controllers to report by exception for a change of status. Communication links must be verified with each report and the sequence of events is often recorded in the controllers so that history can be re-established if communication links are interrupted.

The Data Acquisition part of the SCADA system is responsible for collecting data from the field and storing in a database where it is available to other functions on the system. Each item of data is generally called a point or a tag and SCADA systems can be very large, collecting data from hundreds of thousands of points many times each day. A standard requirement of pipeline control systems is the collection of large amounts of historical information about each point.

The Human Machine Interface (HMI) is responsible for much of the Supervisory Control part of the SCADA system. This is where an operator can call up graphic displays showing the current values of the point database and send changes to field devices.

**ADVANCED PIPELINE APPLICATIONS**

A large number of applications can be run on a SCADA system to provide the pipeline owner with higher levels of optimization, safety and efficiency than possible with human control.
Some examples are: Leak Detection, Shut-in Leak Detection, Leak Location, Batch Scheduling, Batch Tracking, Composition Tracking, DRA Tracking (Drag Reducing Agent), Product Distribution, Inventory Analysis, Allocation, Nomination, Pig Scheduling & Tracking, Training Simulator, Look-Ahead, Survival Time, Predictive Modeling, Pump Optimization (among stations), Compressor Optimization (among stations), Scenario Study, Pipeline Efficiency, Forecast of Demand, Dual/Redundant System, Service Modem, Condensate Detection/Location, Multi-Phase Modeling, GIS System (Geographical Information System).

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