CONTROL
For the Process Industries

FIELD BUS FOR TANK FARM AUTOMATION

Today's tank farm gauging system can use ASi, Profibus, and Ethernet to cost-effectively replace antiquated proprietary communications networks and integrate instrumentation with control systems

Aging wiring, increased requirements, and cost-effective new approaches make this a good time to consider updating level gauge systems.

By: Craig Schiro

Unless the primary operator of a tank farm is a terminal, the tank field is typically considered an operating cost to be minimized rather than an investment opportunity. In petrochemical facilities, tank farms are often last in investment priorities.

Equipment infrastructure (e.g., wiring, level measurement devices, electrical gauging apparatus) in many facilities is more than 30 years old. At least one refinery still manually gauges its tanks and has no automatic tank gauging system.

Often, management attention is not focused on this area of the facility until costly overfills raise awareness and upgrade investments become a priority. Continued overfills are a safety liability, environmental hazard, and generally a public relations disaster.

Also, pressures to reduce operating costs are driving dismantling of many storage tanks. Blending directly to pipelines is becoming common practice in the petrochemical industry.

These and other reasons are leading to investments in tank farm automation, but upgrade costs can be significant as tank fields cover great expanses of real estate compared to typical process operating units. In one refinery, the conduit and wiring system stretched for more than 26 miles and involved nearly 1,000 tank level instruments. The replacement project took several years to construct and place in service. Using the most appropriate technologies can help control costs.

Aging Wiring – A Target of National Inquiry

Most cable manufacturers publish the expected life of their products to be 40 years. This is based on the expected life of the wire insulation. Aging wiring systems on airplanes was a recent target of national inquiry. A June 3, 2000, Houston Chronicle article concluded, "Aging wiring is an issue of national concern that extends beyond aviation."

That article also quoted Ed Block, a former Defense Logistics Agency wiring expert who is on the FAA panel studying airliner wiring, as saying, "There is a crying need" for the government to tackle what he described as a ticking time bomb of a public safety hazard. "For the longest time, I couldn't get any government official to recognize that four-letter word - wire - as a potential safety problem," he said.

In many cases, incremental patches to the tank field have yielded mixed-up wiring systems and one-of-a-kind interfaces to the control systems. Aged systems are often poorly documented and spare parts are hard to get. Some sites are trapped into unsupported communications protocols as the vendor goes out of business or is assimilated via acquisition (Siemens/Texas Instruments, for example).

To accommodate the investment inertia described above, traditional tank gauging companies, such as Saab and L&J Technologies, offer wide communications options for their level measuring elements. Incremental level instrument replacement using versatile communications heads located in the gauge electronics has extended the systems' life at the expense of upgrading the wiring infrastructure. But poor wire quality and lack of controlled power sources are causing operability problems when the 30-year-old systems are called upon to deliver power to drive electronics.

Legacy Gauges and Protocols

Early gauging devices were mechanical float-and-tape devices such as Varec level gauges (Varec has been acquired by EndressHauser). This type of device is still in wide use today. It reports tank level in feet, inches, and sixteenth inches based on revolutions of a shaft tied to the float mechanical motor.

Varec built a mechanical brush absolute encoder to transmit the level back to the control room over a matrix wiring bus that used silicon diodes and a central power source, with a relay-based decoder. Today, these mechanical tank gauges require approximately $1,150 per year in maintenance expenses if the equipment owner chooses to maintain them per the manufacturer's recommendations. Even with this yearly maintenance expense, it is difficult to cost-justify their replacement with radar technology. This is primarily due to the high cost to retrofit a mechanical gauge and replace it with a proper radar installation.

You could say that the first fieldbus systems were the proprietary schemes developed more than 30 years ago to address level gauge resolution and wiring complexity problems. (This was long before today's fieldbus wars arose among the more modern buses competing for control customers.) Tried-and-true 4-20 mA with typical 12-bit DCS analog to digital (A/D) conversion does not offer enough resolution to transmit level for custody transfer. For example, a Saab tank gauge approved for custody transfer has a stated accuracy of +/- 1 mm (0.039 in.). But with the 4-20 mA range set for a 50 ft. tank height, the 4,096-count range of the converter gives output resolution of 50 ft./4,096, or 0.146 in., more than four times the tank gauge error. And that assumes perfectly stable analog calibration.

A simple calculation demonstrates the problem:

MA	Voltage	Tank Height Feet	Feet/Volt
4-20	1-5	50.00	12.50

Typical DCS Analog to Digital Converter Resolution	Resolution	Feet/Count	Inches/Count	Millimeters/Count
12 bit converter	4,096	0.0122	0.1465	3.720

Also, DCS's typically use some of the A/D converter resolution for indicating transmitter problems, so the available counts are fewer than 4,096, further increasing the tank gauge error. Even by using all the counts of the A/D, we wouldn't have enough resolution to measure the storage tank level precisely.

To overcome the resolution problem and reduce the cost and complexity of individual field device-to-control house cable runs, all early storage tank gauging companies were forced to develop their own communications schemes. As no standards existed, many ingenious designs were developed to multi-drop the tank devices off the same signal wiring bus.

A key design consideration was galvanic isolation to prevent lightning from destroying the electronics. Varec's designs evolved from its diode matrix wiring to its mark-space four-wire serial transmission. Enraf used a transformer-coupled scheme including a universal asynchronous receiver transceiver (UART) to transmit Manchester encoded data (serial data and clock signal encoded with the data transmission) back to a data concentrator.

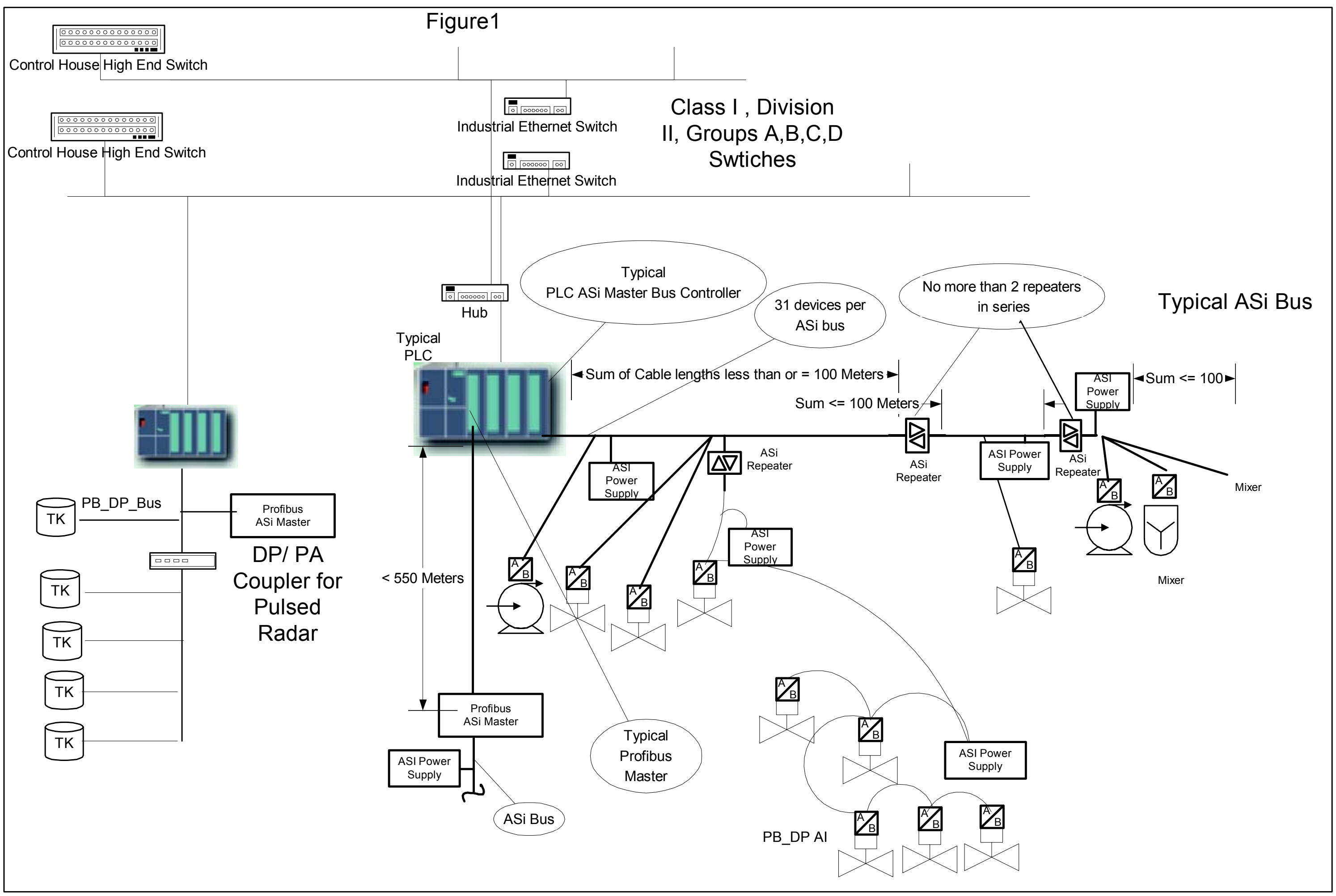
In the early '80's, Texas Instruments designed the first intelligent tank transmitter devices (called IT-160). They used an optically isolated TI-Way high-current drive differential line driver/receive and synchronous serial high-level data link control (HDLC) data bus. This was the first system designed to increase the utilization of the significant tank field wiring investment to support an integrated tank farm automation system. PLCs, in addition to intelligent tank (IT) transmitters, could share the same digital data bus. It was not atypical for literally hundreds of PLCs to share the same field bus with hundreds of TI's IT transmitters. Part of this system included a distributed low-voltage AC power network to provide reliable field power to the devices.

Many new storage tank farm infrastructure upgrades took place in the '80's. New wiring was used to replace ancient complex diode matrix/relay-based systems. Those have wiring that can support the new Profibus or Foundation fieldbus networks. Sadly, there are still too many systems that use the diode matrix systems today.

Enter Fieldbus

Few would argue against the benchmark for reliably measuring level in most storage tank applications being radar gauges, though servo gauges are still used where interface level measurement is required. Radar tank gauge vendors typically use a four-wire system. One pair of wires is used to supply the required power; the other two wires are used to connect the devices to a signal bus. It is interesting to note that the old Varec mechanical gauge had a benefit that costs extra with most new non-mechanical methods for tank gauging devices – an at-grade local indicator, which most tank field operators require.

Two-wire devices are becoming more prevalent and are available from several newcomers to the tank gauge market. Ohmart/Vega, Krohne, and others are putting pressure on the traditional storage tank leaders with two-wire, loop-powered radar gauges. Evolved from process measurement, these devices fit nicely into a modern fieldbus strategy.



Tank farm solution incorporating open-vendor technologies and fieldbuses

These newer devices use pulse radar and are supplied with Foundation fieldbus or Profibus PA protocol. This move opens the door to competing interchangeable storage tank gauge systems, which is good for the tank farm owner as there are more choices.

One thing is becoming clearer each day: all fieldbus wars end at Ethernet. Operators who are still using the 30-plus-year-old electromechanical systems should consider upgrading. Starting over with a clean sheet of paper and designing a tank farm automation system using off-the-shelf components is not hard to do. Better yet, the design can use various open technologies to build an integrated system that interfaces nicely to existing DCS's by using open communication technology such as OLE for Process Control (OPC). Modern systems such as Emerson Process Management's DeltaV can directly interface to the tank field automation systems via Foundation fieldbus or Profibus PA or DP. Siemens' PCS7 control system or S7 line of controllers provides direct interfaces using Profibus PA or DP to the tank gauge instruments.

Profibus PA, AS-I Lead Pack

Profibus has been widely used outside of the U.S. and has a head start on Foundation fieldbus. In the two-wire market, gauging companies such as Ohmart/Vega, Krohne, and Endress+Hauser have Profibus devices available. Foundation fieldbus will be coming (Krohne offers it now). We estimate in two more years, both field buses will be available from multiple sources as gauging vendors work to provide what customers expect.

The tank field has more than just storage tanks to consider. All tanks have other devices that need automation such as pumps, motor-operated valves, and mixers, and analog inputs and outputs for temperature measurements, control valves, etc. In the past, dual wiring systems were required to control and monitor these ancillary components and the many local pneumatic controllers typically found in the tank field. These tasks can now be accomplished with a single fieldbus wiring system.

Two bus standards widely used outside the U.S. are worth considering if you plan to modernize your tank farm: Profibus and AS-i. AS-i, in conjunction with Profibus DP, can be used to easily and cost-effectively integrate motor-operated valves and pumps with tank gauging.

Industrial Ethernet networks using high-temperature, fiber optic switches designed for hazardous locations (Class I, Div. 2, Groups A, B, C, and D) are now widely available. Various controllers can be dropped in the vicinity of a group of tanks or concentration of pumps and valves to meet the farm's automation needs. Why invest in dedicated wiring systems that lock you into vendor A or B's technology, when you can use Ethernet and have a new utility available in the tank farm that's just as important as the power system used to run your pumps and motor operated valves?

Figure 1 shows how AS-i, a two-wire (signal and power) bus, can be used to cost-effectively connect on/off type devices to control systems. AS-i to Profibus connectors allow several AS-i buses to be connected to a Profibus DP network. Profibus DP to PA couplers are used to multi-drop two-wire pulsed radar tank gauges to an inexpensive controller.

An Ethernet backbone (fiber optic in this case) integrates all field devices. Redundancy can be incorporated to satisfy the desired availability and scale of failure. The field network can be easily extended using spread-spectrum radio, with hand-held devices for easy calibration and mobile HMI applications for operations and maintenance personnel.

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