A Guide to Instrumentation for Ethanol Fuel Production

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by Schneider Electric

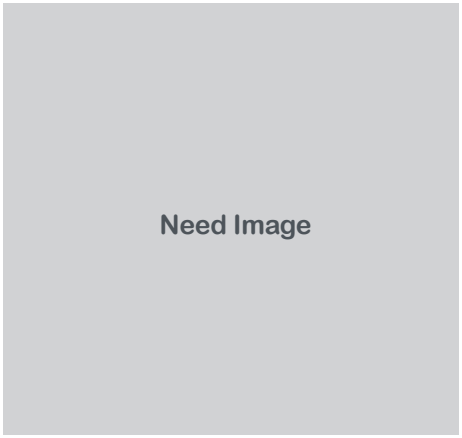
Introduction

Ethanol, the common name for ethyl alcohol, is fuel grade alcohol that is produced through the fermentation of simple carbohydrates by yeasts. Fueled by growing environmental, economic, and national security concerns, U.S. ethanol production capacity has nearly doubled in the past six years, and the Renewable Fuel Association (RFA) projects another doubling of the industry by 2012. Ethanol can be made from renewable feedstock's such as grain sorghum, wheat, barley, potatoes, and sugar cane. In the United States, the majority of the ethanol is produced from corn.

The two main processes to produce ethanol from corn are wet milling and dry milling.

Wet milling is more versatile as it produces a greater variety of products, including starch, corn syrup, and sucralose (such as Splenda®). However, with this versatility come higher costs in mill design, building, and operation. If ethanol is the primary product produced, dry mills offer the advantages of lower construction and operations costs, with improved production efficiency. Of the more than 70 U.S. ethanol plants currently being built, only a few are wet mills.

The efficiency of ethanol production has come a long way during the last 20 years. As more large-scale facilities come on line, ethanol producers are faced with the growing challenge of finding innovative ways to maintain profitability while this market matures. An increasingly accepted solution is process automation to assist ethanol producers in controlling product quality, output, and costs. Because sensing and analytical instrumentation represents what is essentially the eyes and ears of any automation system, careful evaluation of instrumentation, at the design phase can reduce both equipment and operating costs significantly, while improving overall manufacturing effectiveness.



Criteria for Instrument Selection

Although ethanol production is well proven, the need to ramp up to realize the tremendous growth potential elevates the importance of selecting automation technology that is cost effective for the present and easily scalable to the future. Furthermore, this prospect of potentially high demand is giving rise to recently created manufacturing enterprises, which underscores the need for easy to implement solutions, training, and proven vendor support. The following are the top criteria for selecting instrumentation for ethanol production.

- **Price/performance:** Meeting performance specifications at the lowest cost is important in any industry, the fact that ethanol is still not cost-competitive with gasoline, means that producers must keep operating costs low to survive. Although compliance with well-honed standards has placed leading vendors at near parity in baseline performance, vendors are constantly innovating to improve accuracy and reliability of their instruments. In this market, the highest priced products are not necessarily the best performing, so careful attention to required functionality and price can definitely pay off. In addition and discussed in more detail below, technology advances make it more feasible to measure multiple variables with a single instrument, which can contribute further purchasing economies.

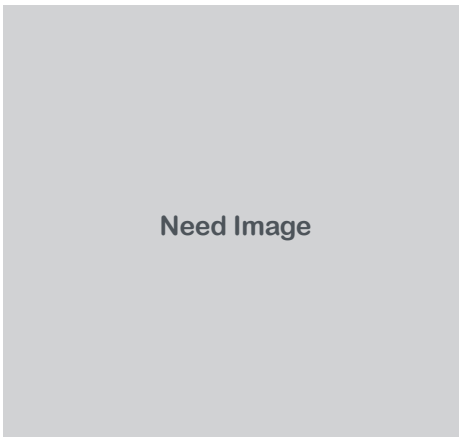
- **Ease of implementation:** Ease of implementation and operation affects both performance and cost of running ethanol operations. Because the industry is still relatively new, finding experienced workers can be a challenge. The less complicated it is to install, configure and use the equipment; the shorter the learning curve is for new workers. Ease of implementation includes mechanical design features that impact installation, as well as ease of configuration and calibration.
- **Maintainability:** Maintenance will be one of the most significant factors contributing to cost of operations. Contributing to reduced maintenance costs are advances in design, materials, and diagnostics. Ethanol production, like most refining processes, requires rugged, robust products that will withstand demanding operating conditions and severe environments. Proper selection of instrumentation is critical to the overall production and success of the plant. Instrumentation that needs continuous maintenance, such as calibration and repair, or replacement can cause production downtime, thus reducing plant yield. Conversely, instrumentation that requires little maintenance time will boost plant production, while reducing replacement and labor costs.
- **Flexibility:** Flexibility is significant because of the rate at which the market is changing, ethanol producers need to be able to obtain the maximum possible use from each sensor they purchase. Careful consideration of these options during the design phase can save thousands of dollars by eliminating the need to purchase individual sensors for different variables and can improve operations by providing process engineers greater flexibility in deploying or repurposing sensors.
- **Scalability:** Closely related to flexibility, producers want to be sure that the systems they install today can grow with them as their businesses expand. This is primarily a consideration for the control system that is installed, as it must include an open architecture that will enable deployment of best of breed devices, but is also a function of the communications protocol used within the instrumentation.
- **Support:** Availability of support is critical because of the relative newness of this industry, combined with technology advances that can result in savings of thousands of dollars, but can also add unnecessary costs if implemented without a clear understanding of the process needs of ethanol production and the workings and benefits of latest technological advances. Helping ethanol producers meet these requirements are a number of tends in sensor design and development, expanded functionality, user access and integration, and vendor support.

Instrumentation Design and Development Trends Impacting

Sensor development and design trends affecting ethanol performance, include improved sensor characterization and compensation for pressure sensors, removal of mechanical linkages between processes and Vortex sensors, and flow-through conductivity designs. Helping to improve performance and reduce maintenance costs are the integration of advanced materials in pH sensors. These applications are discussed in further detail on each of these trends to ethanol production.

Benefits of improved pressure sensor characterization and compensation

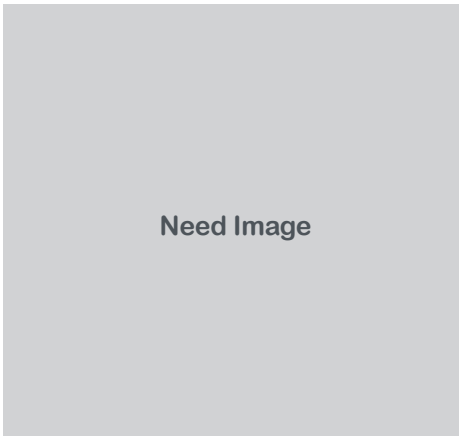
Pressure sensors are used in almost every phase of ethanol production, from fermentation on. Helping meet the ongoing need for accuracy and reliability throughout these phases are improved sensor characterization and compensation. Foxboro® pressure transmitters, for example, apply proprietary innovations in characterization and compensation to achieve accuracy and reliability up to 25% higher than the industry standard in three grades of pressure sensors. The premium performance grade delivers accuracy specification of ±0.025% of span for spans as low as 10% of maximum span (10.1 turndown). When calibrated for spans as low as 1.25% of maximum span (80:1 turndown), the accuracy is better than ±0.050% of span. Improved characterization and compensation provides comparable accuracy and reliability gains in Foxboro multi-range and standard pressure transmitter lines.



Benefits of flow-through conductivity sensing

Flow-through conductivity sensors might be used during the utilities phase to measure changes in conductivity as water flows to the boiler or in chemical storage to monitor changes in caustic tank contents.

Unlike contacting conductivity sensors that require direct contact with fluids, or even electrodeless sensors in which the housing is in contact with the fluid, in flow-through conductivity sensors, the sensor is part of the process line. As such, there is no coating or fouling of sensor elements, elimination the need for frequent line maintenance. Instead of requiring the removal of the sensor for maintenance each week or so, flow-through sensors seldom require removal from the line at all.



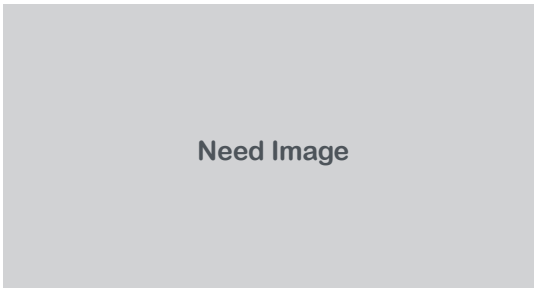
Not only does this save maintenance time, it eliminates the need for recalibration, which might otherwise be needed to return the sensor to the line. In addition, when calibration is required, as part of a routine maintenance for example, the flow-through design enables calibration in less than 10 minutes, simply by inserting a shirt pocket tool into the sensor while the process is running.

Although the initial price of flow-through sensors can be as high as four times the cost of a penetrating sensor, the cost is typically recouped, through savings in labor, within the first six months of operation.

Benefits of eliminating mechanical linkages between Vortex meters and processes

Vortex flow meter might be specified to measure rectifier column reflux, regenerator to pre-heater flow, or alcohol to re-boiler flow during distillation or product to receiver flow during drying.

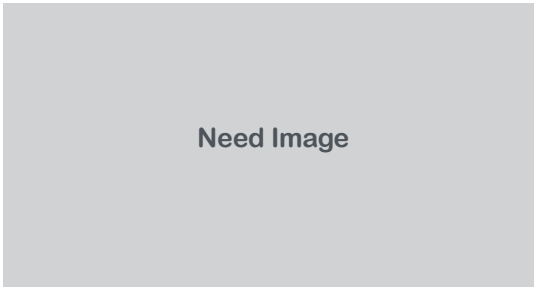
One advance in Vortex flow meter eliminated unreliable mechanical linkages between the process and the sensor. Removing vibrating shedder bars in this way provides greater sensitivity for higher accuracy and wider flow rate measurement capability. It also reduces noise from pipe vibration, enables large ports, which do not clog, and provides an overall simpler, more reliable design.



Benefits of transmitter modular design and mounting options

At every stage of production, sensors must be installed at some point and the less time this takes the sooner the process is up and running. One innovation that simplifies this is rotatable housings in top works pressure transmitter designs. These feature an LCD indicator that can be rotated in the housing for readability with any transmitter installation. The rotatable housings allow ease of installation while offering the versatility to choose electronic module outputs of analog, HART, or FOUNDATION Fieldbus. Since only the module changes and the transmitter remains the unchanged, the investment in pressure transmitters is protected and the transmitter is easily upgradeable to accommodate future needs.

Recent advancements in mounting options further facilitate ease of installation and maintenance. An example is the bi-planer configuration of the bottom works of pressure sensors, which enables easy mounting, tangential venting, and training in any mounting position. This configuration also simplifies sensor replacement, which further reduces maintenance costs.



Another recent innovation is low profile pressure transmitters, which provide greater installation flexibility and are ready retrofit for any vendor's differential pressure or multivariable transmitter. The low profile structure uses a compact sensor body, reducing the overall height of the transmitter and allows use of process covers with process connections facing downward. By accommodating an easy retrofit for any vendor's DP or multivariable transmitter, low profile configurations provide cost savings through reduced installation and maintenance expenses, while minimizing items carried in inventory.

Benefits of using advanced materials in pH probes

The pH measurement is critical to measure slurry tank mix and liquefaction mash early in the process and later when analyzing the water that is going into the boiler. Recent advances in the materials used in the glass probe and used in pH sensors results in significant reductions in maintenance costs, improved accuracy, and reliability. The DolpHin pH sensor from Foxboro, for example, provides superior measurement stability and accuracy, and longer service life in high temperature applications, up to 250 degrees F. The glass increases response speed up to five times and allows longer duty cycles compared to conventional sensors. By switching to pH sensors and incorporating this new technology, one Foxboro customer increased pH sensor life from two weeks to six months. Equipment and maintenance costs were eight times lower than with the previous sensors. The new sensors also provided more accurate pH readings, ensuring that control operators could use the online pH measurements to optimize the efficiency of their process.

Need Image

Expanding device functionality

In addition to improvement in basic sensor design and materials, vendors are expanding the functionality of sensors and enabling a single sensor to manage multiple process variables and multiple phases of a process. New tools simplify integration and management of multiple device protocols within a single system.

Benefits of multivariable measurement

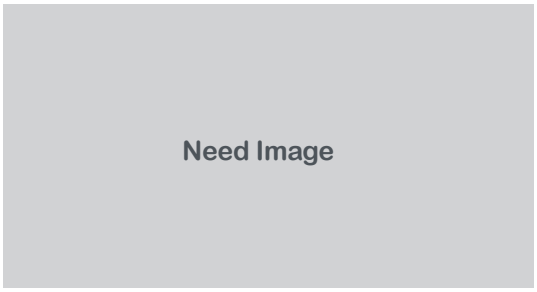
Intelligent multivariable transmitters use polysilicon chip technology to take multiple measurements with a signal transmitter. One from Foxboro, for example, can measure differential and absolute pressures, temperature, flow rate and density. The chip measures absolute pressure, differential pressure, and the temperature of the sensor, while related sensor electronics accept process temperature from external three or four-wire RTDs and calculate flow rate and density from pressure and temperature values.

Multivariable sensing technology has multiple benefits. Most apparent is the cost savings resulting from using one sensor to do the job of two, three or more. This reduces the overall purchase price as well as the costs of installation and maintenance. Compressing measurement in one sensor also improves reliability by reducing the number of potential failure points. Sensors that can measure multiple variables can be deployed almost anywhere in the ethanol process.

A single multivariable transmitter can be used to measure differential and absolute pressures, temperatures, flow rates, and density. Process temperature can also be measured from an external three- or four-wire RTD. In addition to requiring fewer penetrations, multivariable transmitters provide the benefits of reducing the number of transmitters to purchase, increasing reliability with fewer devices, reduced installation costs, improved efficiency, and value for instrumentation investment. Density compensated sensors are another example of a multivariable sensor that can reduce costs and improve uptime. A density compensated level transmitter compensates for density changes caused by pressure and temperature variations. This is ideal for high performance applications and fluids that undergo specific density changes (such as taking level measurements in either open (vented) or closed (pressurized tanks). Density compensated sensors are well suited for high performance applications and fluids with significant density changes.

Benefits of multi-phase measurement

Integration of digital electronics enables accurate measurement of multi-phase flow. When the process material changes state, from liquid to gas for example, as takes place during distillation, traditional Coriolis flow meters are unable to provide accurate measurements until the flow returns to a steady state, either liquid or gas. With digital electronics, the sensors can monitor flow continuously, which eliminates air-induced interruptions or stoppage during two phase flow events such as ethanol load out, enabling batching from empty, eliminating costly rework, reducing downtime, and minimizes product that might otherwise be lost due to the slow response time of conventional Coriolis meters.



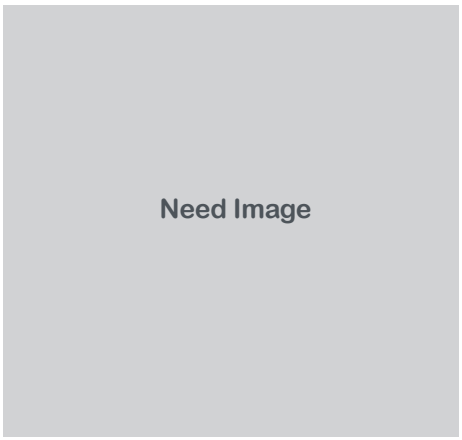
Improved access and integration

Numerous developments now make it easier for users to access and manage their devices. Digital technologies expanded access to their devices for configuration, monitoring, and integration of devices regardless of communications profile.

Benefits of improved access to devices

To realize the full potential of intelligent devices, a group of equipment vendors and end users agreed to the development of a common tool kit that simplifies commissioning, configuration, and maintenance of the devices, regardless of the communications protocol they use.

Without this Field Device Toolkit (FDT) capability, ethanol producers running HART or ProfiBus instruments with the need to take advantage of newer, intelligent devices, for example, risk interoperability with legacy systems unless the select instruments running the same protocol. Likewise, those building new plants and wanting to implement FOUNDATION Fieldbus, for example, might risk interoperability with businesses they may later acquire or with which they may merge in the future. FDT provides a common platform that enables them to obtain flexibility from FDT and provide a common format for accessing and manipulating the unique, device specific data, functions, and graphical user interfaces of most field devices. This information is contained in Device Type Managers (DTM), which each vendor creates in this common format. DTMs are similar to drivers that contain data necessary for managing peripherals such as printers or network cards. DTMs can range from a simple Graphical User Interface (GUI) for setting device parameters to a highly sophisticated application capable of performing complex real-time calculations for diagnosis and maintenance purposes.



Devices which support FDT are easier to implement, easier to integrate and easier to diagnose.

The Foxboro Measurements and Instruments Product Line

With an installed base of field instrumentation in the ethanol industry, Foxboro offers extensive expertise to provide on-target measurement solutions. Foxboro is the leading supplier of instrumentation for both dry and wet milling plants and continues its tradition of the original devices for making on-line, real-time measurement possible. Hallmark Foxboro innovations include pneumatic transmitters, the MagFlow magnetic flowmeter, pneumatic process gas chromatographs, and flow through conductivity sensors. Today, the company offers instrumentation for almost every stage of ethanol production. These complement systems, software, and services to boost economic, safety, and environmental performance. The Foxboro measurement product line includes following product groups:

- **Foxboro pressure transmitters:** Foxboro pressure transmitters combine field-proven, superior performance with application versatility, and rugged dependability. Available with a choice of electronic modules, and mounting configurations – the product line includes the industry's most extensive offerings of multi-range and multivariable instruments, as well as absolute, gauge, and differential pressure, and low power voltage output.
- **Foxboro temperature transmitters:** Built for long-term stability, Foxboro temperature sensors combine microprocessor-based technology to provide high reliability, maximum flexibility, and unmatched intelligence. Products support FOUNDATION Fieldbus, 4-20 mA, HART, or FoxCom Digital Output.
- **Foxboro flow instrumentation:** From vortex and magnetic, to mass flow and digital Coriolis, Foxboro offers a full range of flow products for the accurate measurement of liquid, gas, or steam. Designed to meet even the most demanding applications and accommodate diverse communications protocols, instruments are available in 4-20 mA, HART, FoxCom and FOUNDATION Fieldbus. The product line includes sanitary 3A authorized flow products for food and beverage, dairy, pharmaceutical, and biotech applications.
- **Foxboro electrochemical measurement technology:** Foxboro electrochemical technologies assist in analysis or control of pH, ORP, conductivity, resistivity, or dissolved oxygen. The line includes a broad range of robust, accurate, high quality liquid analytical instrumentation for industries including pharmaceutical, chemical, food and beverage, pulp and paper, metals, semiconductor, power generation, water and wastewater, and more.
- **Foxboro positioners:** The Foxboro line of positioners covers all control applications from traditional pneumatic control and 3-15 psig control through the latest 100% solid state sensing and control circuitry to 21st century communications for HART, PROFIBUS PA, FOUNDATION Fieldbus, and FoxCom digital protocols.

In addition to its products, the following Foxboro offerings support efficient ethanol production:

- **Next day shipment:** In currently running plants, downtime can be expensive. In expansion or new constructions, staying on plan, on budget requires having parts there when they are needed. Sometimes long range planning is just not possible and a project could be placed on hold waiting for instrument shipment for a critical part of the facility. To eliminate the process some instrument manufacturers are guaranteeing next day ship on certain transmitters.
- **Training:** Foxboro Measurement & Instruments offers customer designed training classes to supply knowledge in the areas of installation, configuration, operation, and troubleshooting for all products. These classes can be done on-site or at the factory, whichever meets the customers' convenience.
- **24/7 Customer support :** Given the recent expansion of the ethanol industry, a vendor that understands the needs of producers as well as the technology can be a significant source of cost savings in and of itself. Two innovations which would be particularly relevant to ethanol producers are next day shipment of user defined instruments and 24/7 technical support.

Summary

Ethanol production is expected to grow significantly and much of this growth will be in dry mill ethanol production. In addition to price/performance in instruments, ethanol producers need ease of implementation, flexibility, scalability, low maintenance, and support. Many new technology advances are available to help them in these areas, including changes in device characterization and compensation; and ability for one device to monitor multiple variables. Furthermore, with on-going improvements in design and materials, and methods of delivering technology and support, careful evaluation of instrumentation can reduce both equipment and operating costs significantly, while improving overall ethanol production efficiency.

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