SENSORS FOR PROCESS CONTROL REQUIREMENTS FOR DESIGN AND TEST

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Abstract

Sensors for industrial process control have to meet many and varied requirements. The eventual specific applications may even be unknown to the designer and manufacturer as some industries are very close on details of their proprietary processes. Sensor research provides a new technique for quantifying a physical parameter. The task is then to identify it with a need in the marketplace and match the sensor with the requirements of that application. A process control sensor is rarely targeted for a single application. An awareness of the details of and breadth of requirements may assist in the development process of a sensor that has eventual application in the process control marketplace.

Markets

Industrial process markets include:

- Chemicals
- Petroleum
- Pulp and paper
- Foods
- Electric utilities
- Steam and heating
- Maritime
- Waste water treatment
- Ceramics
- Metals refining and processing
- Cement

Each market may have specific requirements and environments for the measuring equipment it uses to extract the process variable information it needs for use in its control systems.

Requirements and Specifications

Economic considerations are very important. The required measuring function is important but cost may appear more important when trying to sell the device to a customer.

Those involved in selling sensors (included in transmitters) have (or should have) an understanding or feel for the needs and requirements for the market they serve. Market research reports from consultants, etc., are available or can be generated identify requirements. More important they can predict if there is a market, and if so how many, to whom, and for how much? This is needed to get funding to continue development.

Similar devices already on the market can be used to develop target specifications. Some "market surveys" consist of tabulating competitors specifications and saying "do slightly better at less cost".

There is usually a disparity between an adequate sensor and ideal sensor (the golden one). An excellent device doesn't always sell. Sometimes a dependable, adequate one sells over the "better" one. The trick is to know when you have an adequate one that will sell.

Can the sensor fill a niche or is it targeted as a universal design? Process control sensors typically attempt to fit a wide range of applications. If it fills a niche, try to find additional applications. Also the niche market should be related to the company's mainstream control system business.

Design Considerations

The sensors must be connected to a control system. A sensor generates a signal, usually electrical, proportional to the process variable being measured. This signal must then be amplified (conditioned) and transmitted to a control system. Often a signal must be transmitted up to 500 feet or more. The sensor signal is typically amplified and converted to a 4-20 mA format or in the near future, a digital format before transmission. A 4-20 mA two-wire loop places restrictions on the processing that can be done at the sensor but is especially important in retrofit applications. Also there is much inertia in changing formats of measurement systems.

Input-output isolation is often necessary in transmitters. Many sensors make electrical contact to the process system being monitored. The control system typically has many sensors and also has a ground point different from any of the several sensors. Thus for noise and safety considerations, any sensor not isolated electrically from the process installation being measured should have electrical isolation from the control system's input.

The transmitter, including the sensor, must be able to function in the environment where the process variable is being sensed. Some of the environments are quite hostile.

Sensors must be designed for long life and ease of replacement. Spare parts considerations are very important. In an installation with perhaps 200 of a given sensor, covering many different measurement ranges, the user doesn't want to stock more than one spare or type of spare if at all possible, or at least minimize the number of spares that must be stocked. This brings up considerations such as rangeability, turndown, elevation, and suppression. A particular sensor-transmitter may be adjusted significantly away from optimal performance to minimize the number of ranges that have to be handled. The associated circuitry must be capable of accommodating these adjustments at the stated accuracies.

Consider the measurement of excess oxygen or combustibles in the exit gases of a lime kiln. If your automotive sensor suddenly began experiencing a heavy dose of lime dust the sensor would be the least of your worries. However this measurement must contend with the abrasive lime dust all the time since measurements taken after the precipitators introduce errors due to stream dilution prior to the measurement point.

Flue gas measurements for oxygen, combustibles, etc. are hampered by the presence of abrasive particles, sulfur dioxide, etc. Poisoning elements often are present in the process fluid being measured. Catalytic sensors are easily poisoned by the presence

of the wrong materials--lead for example. Sulfur dioxide causes a degradation; however, this can often be reversed.

Materials compatibility is also important. The fluids in contact with your sensor and its housing must not attack and degrade or destroy the sensor system. Would you like to have acid rain in your sensor? Many applications involve acid fumes or hot gases that generate acids when combined with water. These do not cause problems unless the temperature drops below the dew point. When this happens a coating of acid forms on the materials in the area. This in conjunction with dissimilar metals gives an electrolytic cell. It also leads to corrosion. This can occur in the measurement fluid or in the general ambient of the measuring equipment. Also oxygen service for a transmitter with silicone oil fill fluid is a problem since silicone oil is flammable in the presence of high concentrations of oxygen.

Many of the markets have potentially flammable atmospheres at their measuring locations. An example is that of coal slurry preparation, which has free hydrogen present. The sensor, its associated circuitry and connecting wires must not be able to cause an explosion or fire.

Smart Electronics

Microprocessors are being used in the electronics packages for sensors. This permits error correction to be incorporated in the transmitter packages even while using a 4-20 ma current loop format. Remote gain changes, zeroing, etc. is possible. Analog or digital communications is possible. Digital communications is possible both directions. Investigations are underway regarding local area networks of sensors.

Testing

Engineering testing and separate Qualification testing is performed on sensor based products. Testing is done to cover the possible applications and to give independent review of the several specs. Testing is also done for information only on others, for example operating outside of the specified ranges.

An analytical determination is made when possible determine what the test results should be and identify when some new or outside factors have entered the picture.

Test procedures and equipment accuracies must be well documented in order to be sure of the test results.

Tests

Elevation and suppression
Turndown
Output loading
Ambient temperature range
Process fluid temperature range
Pressure range

Flow conditions
Radiation
Shock
Vibration
Position sensitivity
Response time
RFI
EMI
Dielectric withstand voltage
Reproducibility
Power supply effect
Relative humidity effect
Input-output isolation
Linearity
Hysteresis
Repeatability
Dead band
Accuracy
Long term drift
Lightning suppression
IEEE Surge Withstand
Overrange influence

Other Considerations

Certification -- OSHA requires third party review for any equipment operating in hazardous (flammable or explosive) locations. Almost all Canadian process control equipment sales require certification by CSA (Canadian Standards Association). Also in the event of Product Litigation it is helpful to be able to show that the product was reviewed by a third party to demonstrate that it was designed with proper care.

Flow effect -- Non-intrusive sensors are preferred. If not then specify the pressure drop in process fluid flow.

Maintenance -- What will it cost to service? What is the replacement parts policy (maybe the life of the installation is for 40 years)? Can it be calibrated online or must it be returned to the Calibration Lab or Instrument Shop for calibration and ranging?

Reliability -- What MTBF, MTTR or Availability numbers will the customer use in his system reliability calculations and predictions?

Adjustments -- Design for no adjustments or make the adjustments external so that they can be made without taking the cover off.

Specifications -- Are your specifications Typical, Worst Case or Statistical?

Installation -- Your little gem will likely be installed with a wrench and large screwdriver (and hammer?)

Housing -- Is the housing suitable for corrosive environments? Will it withstand (meet the piping codes for) the operating pressure and for containing an explosion. Will it keep out any adverse ambient (survive cleansing with a fire hose,etc.)?