Instruments

Instruments are the eyes and ears of the process system. Without good measurements, operations is blind. Temperature, pressure, level and flow are common process instrumentation that have many measurement points in the field. pH is the most common on line analytical measurement. Sample stations are usually implemented to take composition samples to an off line lab for analysis. In recent years, many different approaches have been applied to bring lab measurements to the process system in the units.

Many of the instrument installations must consider in classified electrical locations due to the presence of flammable and combustible fluids in the systems. Many details regarding intrinsic safety and hazardous environment instrument installation methods must be evaluated as part of each systems installation. The instruments installed must have wetted parts that are compatible with the various process fluids in the systems. System process fluids could have conflicting materials of compatibility (MOC) information. Compounding the many factors involved in the MOC selection includes the fact that many process unit operations see changing concentrations and characterization of various active materials that cause compatibility problems. An example of a complex and changing MOC as material is moved downstream is the example is the level of free fatty acid (FFA) in a biodiesel feed stock. The higher the FFA, then the more it tends to require more chemical resistant materials than its base composition components. FAME or FAEE and methanol have been found to have mutually exclusive materials of compatibility concerns. In general, stainless steel for hard wetted surfaces and PTFE (common trade name: Teflon) for elastomeric surfaces have been successful. Different grades and brands of FKM (common trade name: Viton) in differing service have exhibited different results. Viton is not compatible with caustic, which in this example is used as a catalyst at a 10% concentration in the reacting stream. An example of conflicting compatibility data and experience regards the use of FKM for biodiesel applications. In some applications it is quite successful, and in others with just slightly different temperature and minor constituent in process components has caused failure of the material.

Temperature

A wide variety of temperature measuring devices can be installed in a variety of systems. Local indicators are as simple as a bimetallic dial gauge installed in a common thermowell. Unique to the application is the need for considering the thermal insulating properties of the feedstocks due to the varying melt points, viscosity versus temperature profiles and the low thermal conductivity of the solidified feedstocks.   Each feedstock is made up of various components that can have a varying effect on the bulk properties of the feedstock itself. The different components of a stream can drop out of solution and form coatings on the surfaces of instrument measurement devices.

Another interesting aspect of many applications is that as the separation of an oil/water mixture as temperature increases. The water coalesces and drops to the bottom of the various feedstock tanks. Since the tanks are filled with various fluids with varying moisture levels, the interface region and the measurement point composition will vary as they are used and refilled. Depending upon the placement of the temperature probe or gauge, the actual temperature of the material in the tank will show variations versus catch samples due to thermal conductivity of the material that would be now closest to the thermowell that would contain the temperature element or gauge probe. If a film is formed on the thermowell due to the material changing its flow properties as the concentration of both moisture and triglyceride mass fraction vary, this also leads to erroneous reading in the bulk temperature of the material in the tank.

In the high pressure process systems, the temperature measuring devices have to be installed with the requirements of the high pressure piping in mind. Thermowells have to be rated consistent with the high pressures in the piping system. The pressures used in the system require high pressure flanges, so the connection details are critical to safety and success.   Keep in mind the need to consider the classification of the electrical installation.   The most important temperature measurement applications of the system are the dual temperature measurements for the control of the discharge of the process heater to insure that no over temperature failure can occur in the fired process heater coil. The common configuration of a local PID controller backed up by a separate high temperature relay contact is installed. The system follows the usual NFPA best practices for burner control, with careful considerations of the changes in the state of the process fluid.

A series of separation columns are usually installed downstream of the reactors for the separation of the various reaction products. The temperature measuring devices in the columns are installed in the common arrangement of: overhead, feed and bottoms . The installation uses a thermowell extending deep into the most turbulent flow path for the feed and overhead vapors. The bottoms measurement is placed in the headspace below the bottom column packing but above the liquid collection still. An interesting example of a surface coating problem is the effect of the glycerin. Glycerin is a reaction byproduct that remains in the bottoms in the production of FAME and it is immiscible in the FAME unless in the presence of the methanol.   The glycerin may begin to coalesce on the surface of the bottoms thermowell and give an insulating effect on the thermowell due to its different thermal and flow properties than the methanol and fatty acid methyl ester also in the system. Since the glycerin is the most viscous material at the lowest temperature, it tends to insulate the thermowell and give a reading in the bottoms that has a bias from sample temperatures taken from the sample port nearby. This problem is solved by careful control of the bottoms make up during the start up and instrument maintenance data runs to keep a good understanding of the bias presented by the bottoms thermowell coating by the glycerin.

Pressure

A series of pressure transmitters and gauges are usually installed throughout the process. Some key elements for each device is the MOC details of the tubes, sockets and in some cases the isolation diaphragms. The range applied to the desired measurement area seems simple, but in a new system start up the establishment of the process operator measurement unit "lingo" is important to consider. Vacuum and pressure can become confusing and the pressure ranges in the various unit operations of the system have a wide range. An interesting confusion that can occur in the training of operators with common terminology and measurement units for the various pressures and the establishment of the right plant terms for the operators understanding. Since these were grassroots plant start ups with no historical local nomenclature, the following was established as practice: For pump discharges and any pressure above 0 gauge, all terms are in psig. For the local gauge readouts on the vacuum systems, the use of dual range gauges lead to the local plant term of "inches" which is actually inches of Hg vacuum. For the pressure transmitters in vacuum service, the use of torr absolute was established as the terms for the units of measure of the pressure in the system. It seems a simple detail, but in training and troubleshooting, and in discussions with many people new to the system, many errors and misunderstandings can be avoided if the basis of unit "lingo" is established beforehand.

Flow

The use of a high pressure coriolis meter as the flow control element on the fired heater control system allowed the rangeability required for the needed stability in the control loop for the different start up, steady state, shutdown, and emergency shutdown process conditions. One of the more interesting applications in the systems is the concentration control of the stream by correlating its density to concentration. The Coriolis meter has a god history of providing very accurate density measurements in addition to mass flow. The coriolis mass flow meters have been some of the most reliable and repeatable devices in a wide variety of systems.

Level

Systems commonly have both radar and guided wave radar level devices in the system. The radar level sensor is placed on the top of the various tanks. Once calibrated for the tank geometry, the devices have given excellent service through the varying headspace conditions of temperature and moisture to which the tank has been exposed. The more interesting application has been the guided wave radar devices installed through the system in the smaller tanks and the side chambers in the system. A culprit that had originally caused problems was the glycerin and its tendency to form films or enter the small tanks and side chambers in small globs versus a steady stream. These most occur due to the environmental conditions changing between night and day and cold spots forming in the piping where the heat tracing or insulation has been exposed due to repairs or other operations. As the glycerin hits the probe, it has been observed that false signals are reflected back to the transmitter which result in erroneous level readings. The problem can be contained by using the software functions of the transmitter to block out and ignore areas that are repeated problems like the entrance ports to some of the various side chambers. A changing value comparison trap in the PLC logic was helpful to keep these random errors from affecting the stability of the various level control loops in the system.