There are a number of key technologies that are applicable to pipeline interface detection and it is important to know the differences between them as well as the pros and cons of using one over the other. Over the last couple of decades the composition of refined oil and gas products has changed considerably. From being sent through a pipeline in relatively easy-to-detect batches caused by the major differences in the liquid’s density and viscosity, most of today’s refined products are highly specialized fuels. Because they share distinct similarities, they require highly sophisticated measurement equipment to be detected. To find a solution that provides the best fit for pipeline operators, however, is not always an easy task. There are a number of key technologies that are applicable to pipeline interface detection and it is important to know the differences between them as well as the pros and cons of using one over the other.

For a pipeline to become truly effective it has to be able to carry several types of refined products such as different grades of gasoline, kerosene, jet fuel etc. at the same time. This is made possible by installing interface detection devices along the pipeline that are able to identify where a specific batch of refined product is located. A few decades ago, the task of detecting interfaces was relatively simple because most liquids had distinctive differences in the way they were composed. Today, the picture has changed with the introduction of highly specialized fuels and gases that are very similar in texture, density and viscosity that makes identification, isolation and storage of multiple fuel products even more critical to optimal pipeline and distribution network operation.

Careful planning and investigation has become a crucial part of deciding which interface detection system best suits a specific application. The consequences of having a system that does not function properly can be dire with liquid contamination or unnecessary accumulation of transmix in the slop oil tanks. Since transmix requires additional refining as does liquid contamination both occurrences add to the cost of the final product.

**Interface detection at a glance**

When assessing which type of interface detection system to use, it is important to realize that there are several technologies available. All of them offer different pros and cons that should be considered carefully before making a decision on which one to select. In the following, only the four most common types of interface detection systems and their methods will be explained: the refractive index method, the ultrasonic wafer method, the insert densitometer principle and finally, the clamp-on ultrasonic method.

**The refractive index method**

When applying the refractive index method to pipeline interface detection, manufacturers of light refraction systems exploit the fact that refraction measurement is extremely sensitive to small differences in liquid composition. And since different liquids have different refraction angles, the system has the ability to sense a change in liquid.

The method requires the use of a fiber optic and a sapphire lens. Light beams are sent from the fiber optic lens, through the liquid and into the sapphire lens. How much light is caught by the sapphire lens depends on the refractive index of the fluid. In an interface detection system, the refractive index is constantly being measured so when a preset change in the index occurs, the system detects this change as a change in interface, triggering an alarm to trigger. Most light refraction systems are so sensitive that they respond instantaneously to a change in fluids.

Although a very high degree of precision can be obtained, several things need to be taken into consideration before choosing the light refraction method. For one it only detects interfaces; it cannot be used for density measurement. This makes it a very cost-ineffective solution since efficient pipeline operation requires knowing the density of the liquids flowing through it. The only way of obtaining density is to install an additional device for density measurement that will require additional maintenance and know-how to operate. Another consideration is the location of the system. If no existing taps can be used there is only one way to install it; by shutting down operation and drilling a hole in the pipe to make room for the two lenses. This takes up valuable production time and would require consider-
The most commonly applied interface detection method is based on the ultrasonic wafer technology. Being that it is based on the ultrasonic technology it is very reliable with consistent repeatability and high accuracy. The wafer houses a varied number of ultrasonic transducers, allowing for a direct interface detection method. The transducers produce ultrasonic pulses that are sent through the liquid to detect the liquid interfaces.

Similar to the light refraction method, the wafer technology only detects a change in liquid. No density, temperature or viscosity measurements are possible. Installing the meter poses a major challenge: since the main component of the interface detector is a wafer that needs to be installed between the flanges of a pipe, the pipeline has to be shut down before mounting on an existing pipe or via a bypass loop.

The insert densitometer principle
The most commonly applied interface detection method is the use of an insert densitometer. The main advantage of this approach is that it is considered a true density measurement that results in high accuracy, making the technology an industry standard. Two types are worth mentioning in this context: the vibrating tube and the gamma ray principle.

The vibrating tube densitometer works on the principle that when a sensing element is immersed into or filled with fluid, the frequency of the vibration is proportional to the density of the fluid. To adjust the reading to relative density, the frequency is compared to its calibration and the line density can be determined under process conditions. The vibrating densitometer is considered the most accurate density reading because of the small size of the tube. Things to consider when choosing this method is the non-intrusiveness of the installation and the fact that changes in viscosity can affect the accuracy.

The other densitometer principle is based on a radioactive source and is also known as the gamma radiation method. It works similar to the light refraction systems in that it uses the absorption of rays to determine the density of a liquid. The denser a fluid, the fewer rays make it through the liquid to the detector. The only difference is that the gamma radiation method requires the use of a radioactive source rather than light. The radioactive source is placed in a lead casing mounted on the outside of the pipe. A detector is located opposite from the radioactive source so it can read the amount of gamma rays penetrating the liquid.

The most important aspect to consider before using a gamma radiation densitometer is the requirement for special licenses and permits needed to handle and dispose of the radioactive materials. In addition they can be slow and expensive to install; especially when high resolution densitometers are necessary.

The clamp-on ultrasonic method
Since the clamp-on method is based on the ultrasonic technology as is the case with the wafer method, it shares the same main advantages: reliability, high accuracy and consistent repeatability. The clamp-on method, however, also allows for density, viscosity as well as temperature measurement, which alleviates the need for any additional equipment. To correct the calculated density to standard conditions and to convert it into relative density/API, simultaneous measurement of temperature as well as pressure is required.

One additional factor that only the clamp-on ultrasonic device takes into account is the patented method of measuring the liquid identification (or sonic signature). When combining a liquid’s sonic velocity and temperature, it is possible to determine the temperature-compensated sonic signature which is a more sensitive and precise method of calculating density (API) compared to using the insert densitometer. A liquid’s sonic signature can be compared to a human being’s unique fingerprint in that it provides an extremely accurate way of distinguishing between products that have even very close densities.

In determining the sonic signature, the interface detector analyzes the liquid’s temperature and sonic velocity. When this value has been calculated, it is utilized to identify the density, which is available to the user, and also for a user-settable rate of change in the measured liquid over a specific time. If this rate of change is reached, the meter identifies it as an interface change and therefore triggers an alarm, alerting an operator or an automated system to perform a certain action or set of actions, such as opening or closing a valve.

Things to consider before choosing a clamp-on ultrasonic interface detection system is that the density is inferred as opposed to the insert densitometer that represents a true density measurement. In addition, the transducers can be mounted virtually anywhere on the outside of a pipe, and can be fitted onto very small as well as very large pipe diameters. Operation does not have to be stopped and the pipe does not need to be cut. Since the transducers can be physically located exactly on the part of pipe where measurement is needed, the ability to measure interfaces or multiple grades of liquids within the same pipe is greatly improved.

Choosing the right method or technology for interface detection depends on various application-specific characteristics and requirements that should all be taken into account before a final decision is made. Some methods might work better under certain conditions and not so well under others. In some instances, pipeline operators choose to install an extra set of eyes in the form of an additional interface detection system to supplement the existing system. Although this might not always be necessary it can provide a higher sense of security and also prevent errors of an outdated or misaligned system from occurring. In any event, an interface detection system should accommodate the very basic requirements of making sure that product batches are directed to the right storage tanks at the right time to prevent surplus transmix and product contamination. Written by James Doorhy, Siemens, Sitrans F US Product Manager for Oil and Gas.

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