Question 74: Please discuss the pros and cons of the various coke drum level technologies.

Jeff Lewellen (HollyFrontier)

The ideal coke drum level indication would provide accurate and reliable information to the unit operator for all of the following:

• The foam front level for anti-foam/silicone addition control

• Coke/hydrocarbon level to optimize drum use

• Quench water level to verify (along with pressure/temperature/flow totalizer) adequately quenched drums This is also a demanding environment for instrumentation.

The process conditions are highly fouling, high temperature, changing pressure and composition, and high velocity hydraulic decoking every cycle. Most common technologies use “non-contact” methods with a radiation source and detector system. These include:

• Neutron backscatter

• Gamma point source (density and/or level switch)

• Gamma continuous level

Neutron backscatter

These devices use a common neutron source and sensor housing that directs fast (high energy) neutrons from typically Americium-Beryllium (AmBe) or similar neutron emitter source through the vessel wall into the vessel interior. If hydrogen bearing material is present, the fast (high energy) neutrons are converted into slow (low energy) neutrons which are scattered back to the neutron sensor in direct proportion to the hydrogen density.

Due to significant differences in hydrogen density, the technology is very effective in detecting changes from clear vapor to foam (including light to heavy foam densities) to coke level and detecting water level. The limitations of this technology are:

• Point detection only.

• Measures only the area immediately adjacent to the vessel wall.

• Historically has experienced difficulty with thick wall vessels. Trials at our facility in the 1980s were unsuccessful. However, these detectors are used very successfully throughout the industry.

Gamma point source

This technology utilizes a gamma emitter source (usually Cesium-137) shielded to emitting gamma radiation only across the diameter of the drum with a detector located opposite of the source. The gamma radiation reaching the detector is inversely proportional to the mass of material between the source and sensor. The detector output can be reported as either:

• An analog signal representing density changes in vapor to foam to coke/liquid.

• Or a digital signal between clear vapor and the foam/coke level.

Our previous drums were equipped with this technology utilizing 5 detectors per drum at various levels. The indications were fairly reliable; however, lightening/electrostatic discharge from thunderstorms did cause some problems.

This technology has (and continues to be) used throughout the industry in multiple applications.

However, there are some significant disadvantages:

• Does not detect foam height. Addition of anti-foam may cause the level to drop below the detector, but how far and for how long?

• Predicting drum outages and switch times are difficult with changing rates or feed composition. Extrapolating drum fill rate between level detectors may not provide adequate time to make unit adjustments.

• We have experienced low density foam fronts that did not activate the level indicators resulting in a drum “foam-carryover” event. The foam was confirmed by a contractor scanner, and detector sensitive were adjusted to account for the change.

Gamma Continuous Level

Similar to the point source, this method utilizes a gamma emitter source that is shielded to project a fan shape beam diagonally across the drum. The detector is a lengthened scintillation tube or (more recently) a fiber-optic scintillation bundle. Multiple sources and detectors can be used to expand the range of the level indication to provide a continuous indication for the drum.

Items to note on this technology:

• The level is interpreted from the amount of gamma radiation blocked. It does not directly detect the vapor/foam/coke interface. However, a handheld detector can be used to find this interface if verification is needed.

• Level indication is normally the combined coke and foam level. The foam portion is determined by

collapsing the foam front using the silicone anti-foam and monitoring the change in level.

We have installed this technology in our El Dorado facility. In addition to the fiber optic continuous levels, the system utilizes bottom of range point detector to reset zero and a density point detector at top of range for both vapor density correction and the LAHH redundancy to the continuous level.

We have noted a deviation between the level indication at the end of the drum cycle and the level determined by drill stem gauging the coke outage at the beginning of the drum decoking. This deviation at times has been several feet. At these times, we have confirmed coke to be higher on the walls with a depression toward the center of the drums. We have attributed this, in part, to the bed collapsing during the quench/draining steps of the drum cycle.

The advantages of the continuous level technology are best seen when utilized in combination with the vapor density and low-level detectors as a packaged system.

• Foam level is inferred by the change in level with the introduction of antifoam/silicone

• Coke/hydrocarbon level is continuous for the full cylinder length of the drum.

• Redundant high-level indication Probably the most significant disadvantage of this system is the complexity. Although this equipment has been very reliable, it has been in service for less than 3 years.

Gary Gianzon (Marathon Petroleum Company

MPC currently uses both neutron backscatter and gamma continuous level detection and here are the pros and cons based on our operating experience: Gamma continuous level detection.

Pros:

1. Measure the level continuously throughout relevant levels of the drum. We use the continuous level measurement to optimize antifoam usage. The level can also be used to determine the height of the foam front, and this information can be used to adjust furnace outlet temperature.

2. Continuous level detection measures across the drum so it can detect the peak level in the drum.

3. Measures the vapor density across the top of the coke drum, which we use to optimize steam-out time to the fractionators and can indicate foam carryover to the main fractionators. 4. Smaller source than the neutron backscatter which is easier to permit.

Cons:

1. Difficult to calibrate and easily gets out of calibration. This is quite problematic if this is your only source of drum level measurement.

2. Only measures the total level, cannot distinguish between foam, coke, and water. Neutron

Backscatter

Pros

1. The neutron backscatter can distinguish between foam, coke, and water.

2. The level is exact and does not drift.

Cons

1. Level can be difficult to detect on very thick drums.

2. Point source only detects about a foot inside the drum, level measurement is not continuous across the drum.

3. Long half-life responsibility

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