Up or Down? Understanding nuclear gauges on Delayed Cokers

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Purpose

- Company Information
- Typical Level measurement system on coke drums
- Detector Technology – Basic Principles
  - Gamma Continuous Levels
  - Neutron Backscatter (NBS)
- Trends of Normal operation
- Trends of Abnormal Operation – Foam Overs
Company Information

VEGA
Benefits of working with VEGA

- Experience on Coke Drums
  - 40 different Oil Refiners
  - 82 different customer sites
  - Over a Total of 300 coke drums

- Strong working relationships with delayed coking Licensors
Benefits of working with VEGA

- 82 Different Customer Refinery Sites
  - ExxonMobil - 6 sites
  - Phillips 66 - 6 sites
  - BP - 6 sites
  - Valero - 6 sites
  - Petrobras – 5 sites
  - Chevron - 3 sites
  - Tesoro - 3 sites
  - Pemex - 3 sites
  - Flint Hills Resources - 2 sites
  - Total – 2 sites
  - Shell - 2 sites
Over 40 Refiners
Over 290 drums
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VEGA Coking Level System Deliverables

- Increased throughput
  - Increase cycle times
  - Reduce total of drum cycles per year
- Operations can use less anti-foam
  - Use it for automatic anti-foam control
  - Manage anti-foam inventory
  - Extend downstream catalyst life
- Increase Operator confidence
- Manage foam overs
  - Measures top level of foam accurately
  - Greatly reduced risk of shutdown
Typical

Level Measurement Arrangement
Typical Drum

- Typical Gamma Continuous covers up to 30 meters starting at ~ 300mm below top tangent.
Typical Drum

- Typical Gamma Continuous covers 14 meters starting at ~ 300mm below top tangent.

- Typical Neutron Backscatter located at 3m, 4.5m and 7.6m down from top tangent.
Typical Drum

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Typical Drum

- Typical Gamma Continuous covers 14 meters starting at ~ 300mm below top tangent.

- Typical Neutron Backscatter located at 3m, 4.5m and 7.6m down from top tangent.
Typical Drum

This example

- 3m NBS ≈ 78% of level span
- 4.5m NBS ≈ 67% of level span
- 7.6m NBS ≈ 45% of level span
Detector Technology – Gamma Continuous Levels

How do they work?
Basic Principle

How does a radiometric level transmitter work?

Needs 4 things to work

Source

Detector

Vessel

Process
Basic Principle

How does a radiometric level transmitter work?

Vessel Empty, the detectors receive the most amount of radiation.
Basic Principle

How does a radiometric level transmitter work?

Vessel full, the detectors received the least amount of radiation.
Basic Principle

How does a radiometric level transmitter work?

Gamma levels are inversely proportional to the radiation

More Radiation = Lowest Level
Less Radiation = Highest Level
Basic Principle

- **Disadvantages**
  - NDT Radiographic sources
    - Can be minimized
  - Changes in Vapor Density
    - Can be measured and compensated

- **Advantages**
  - Continuous level indication
  - Measure effectiveness of anti-foam (Automatic foam control)
  - Can be used to measure outage
  - Can measure water during quench
  - Can be used to measure vapor carryover (Vapor Density Gauge)
  - Switches can be moved if needed
Detector Technology – Neutron Backscatter (NBS)

How do they work?
Basic Principle

- NBS not actually level but Hydrogen Density
  - More Hydrogen, higher the signal
  - Foam has more hydrogen than Hydrocarbon Vapor
  - Coker has more hydrogen than foam
  - Water has more hydrogen than coke.
Basic Principle

- NBS needs two things to operate
  - Scatter back towards the detector
  - Neutron to be thermalized (slow down)
Basic Principle

- Disadvantages
  - Effected by Water
    - Either in/on insulation
    - Rain or water
  - Heat
    - Welded to the drum wall
    - No Insulation
  - Only Points (fixed due to mounting to the vessel).

- Advantages
  - Can distinguish the difference between foam and coke (under proper conditions)
  - Can distinguish the difference between coke and water (under proper conditions)
Trends

Normal Drum operation
Foam Levels

- From experience, foam level is higher toward the middle of the drum, and lower along the walls.
Foam Levels

- NBS and Gamma continuous will not always match. The NBS reading is depending upon the Hydrogen concentration (low density foam or high density foam. The Gamma Continuous level tracks the top of foam be it either low or high density.
Typical Drum

This example

- 3m NBS ≈ 78% of level span
- 4.5m NBS ≈ 67% of level span
- 7.6m NBS ≈ 45% of level span
Gamma Continuous Level

7.6m NBS ≈ 45%
4.5m NBS
3m NBS
Gamma Continuous Level
7.6m NBS
4.5m NBS ≈ 67%
3m NBS ≈ 78%
Gamma Continuous Level

7.6m NBS
4.5m NBS ≈ 67%
3m NBS ≈ 78%
Trends

Abnormal Drum Operation (Foam Overs)
Foam Level

Is Level Going up???

Or Going Down???
Light Blue = Pressure
Green = Continuous Level
Dark Blue = Vapor Density
Brown = Lowest NBS
Red = Middle NBS
Purple = Top NBS
Light Blue = Pressure
Green = Continuous Level
Dark Blue = Vapor Density
Brown = Lowest NBS
Red = Middle NBS
Purple = Top NBS
Most foam overs happen after switching drums. This is the time mostly likely for disagreement between NBS and Gamma continuous. BE AWARE!!!!!
Thank you!!!!!
Foam up after switch
Different amount of foam at switch
Use of Anti-foam
Level Tangent to Tangent (not linear) 20 meters total

- 3 hrs
- 4 hrs
- 12 hrs

All level gauges are 6.7m long (all equal lengths)
Vapor Carryover

Vapor Density

Graph showing vapor density over time.
Buildup in vapor space
Buildup in vapor space
VEGA outage
Outage measured by Drill