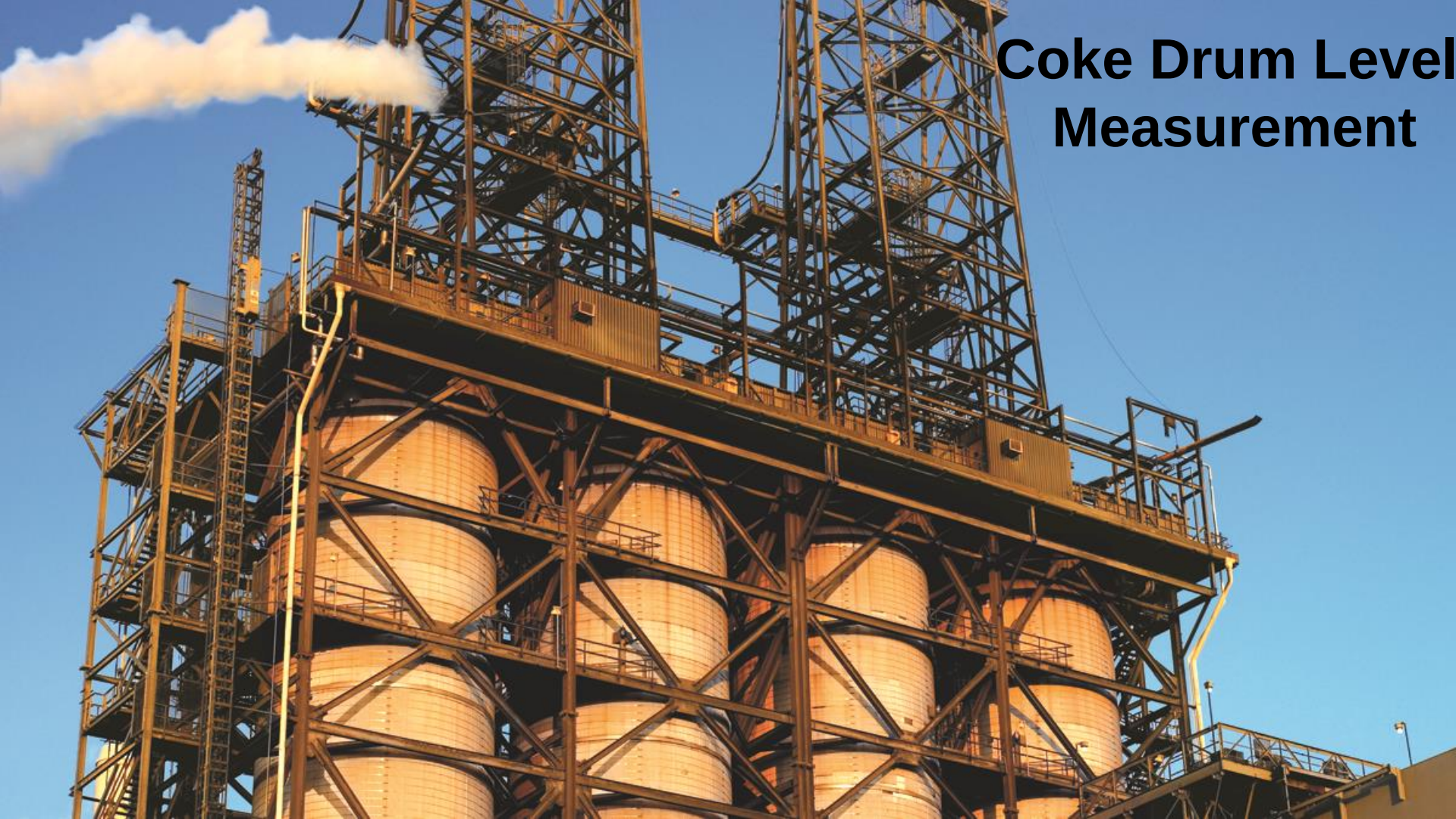
Up or Down? Understanding nuclear gauges on Delayed Cokers

David Williams
Business Development Engineer/
Process Licensor Advisor
VEGA Americas
d.williams@vega.com

REFCOMM GALVESTON MAY 2-6 2016

VEGA



Coke Drum Level Measurement

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


Chevron
Husky Energy
PHILLIPS 66
TESORO
VALERO
Shell
BR PETROBRAS
SUNCOR ENERGY
MOTIVA ENTERPRISES LLC
PEMEX
AXION energy
HollyFrontier
YPF
PDVSA
ExxonMobil
Orpic
sasol
TOTAL
MARATHON
bp
COSMO
CPCL
PETRONAS
INA
LOTOS
Over 40 Refiners
Over 290 drums
Greenland
Iceland
Finland
Sweden
Norway
United Kingdom
Russia
Kazakhstan
Mongolia
China
South Korea
Japan
Ukraine
Spain
Italy
Turkey
Afghanistan
Pakistan
Saudi Arabia
Algeria
Libya
Egypt
Mali
Niger
Sudan
Chad
Nigeria
Ethiopia
Kenya
DR Congo
Tanzania
Angola
Namibia
Botswana
Madagascar
South Africa
Thailand
Indonesia
Papua New Guinea
Australia
Canada
Mexico
Venezuela
Colombia
Peru
Brazil
Bolivia
Chile
Argentina
North Atlantic Ocean
South Atlantic Ocean
Indian Ocean

Company	City	Country	# of Drums	Company	City	Country	# of Drums	Company	City	Country	# of Drums
Valero	Port Arthur	USA	6	P66	Carson	USA	4	Guru Gobind	Punjab	India	4
Flint Hills Resources	Corpus Christi	USA	2	Sinclair	Sinclair	USA	2	HollyFrontier	Tulsa	USA	2
Lyondell	Houston	USA	8	BP	Toledo	USA	2	Husky	Lima	USA	2
ExxonMobil	Baton Rouge	USA	2	CNRL	Fort McMurray	Canada	2	Lotus Enerji	Turkmenbashi	Turkmenistar	2
Pemex	Madero	Mexico	4	P66	Sweeney	USA	4	NCRA	McPherson	USA	2
Valero	Texas City	USA	4	Chevron	Salt Lake City	USA	2	PDVSA Petroanzoategui	Jose	Venezuela	2
BP	Toldeo	USA	2	Hunt Refining	Tuscaloosa	USA	2	PDVSA Petrozuata	Bariven	Venezuela	2
Petrobas	Sao Paulo	Brazil	4	Repsol/YPF	LaPlata	Argentina	4	PDVSA Petrozuata	Bariven	Venezuela	2
Seadrift Coke	Seadrift	USA	3	BP	Blaine	USA	4	Pemex	Caderyeta	Mexico	4
Valero	Corpus Christi	USA	2	BP	Texas City	USA	4	Petrobas REPAR	Araucaria	Brazil	4
BP	Carson	USA	1	Cosmo Oil	Osaka	Japan	2	Petrobas RNEST	Pernambuco	Brazil	12
ExxonMobil	Beaumont	USA	2	Delek Refining	Tyler	USA	2	Petrobras Comperj	Rio de Janerio	Brazil	4
Cenex Havest States	Laurel	USA	2	Nafto Gaz	Bina	India	6	Petrobras REPAR		Brazil	4
CNRL	Fort McMurray	Canada	4	P66	Billings	USA	2	Repsol/YPF	LaPlata	Argentina	2
ExxonMobil	Baytown	USA	4	Shell	Deer Park	USA	6	Tesoro	Wilmington	USA	2
HollyFrontier	El Dorado	USA	2	Valero	Port Arthur	USA	6	Valero	Wilmington	USA	4
Husky	Lloydminster	Canada	4	Motiva	Port Arthur	USA	6	CPCL	Chennia	India	2
Marathon	Garyville	USA	4	Petronas	Penapisan	Malaysia	2	INA		Crotia	2
P66	Borger	USA	2	Total	Port Arthur	USA	4	KNPC	Kuwait City	Kuwait	4
PBF	Chalmette	USA	2	Valero	Norco	USA	4	LOTOS	Gdansk	Poland	2
Repsol/YPF	LaPlata	Argentina	4	Ebramex/Pemex	Minatitlan	Mexico	4	P66	Lake Charles	USA	4
Repsol/YPF	Mendoza	Argentina	4	Marathon	Detroit	USA	2	Pemex	Tula	Mexico	6
Suncor	Edmonton	Canada	2	BP	Whiting	USA	6	Sasol	Sasolburg	South Africa	4
Tesoro	Martinez	USA	4	Coffeyville Resources	Coffeyville	USA	4	Sohar (ORPIC)		Oman	4
Valero	Aruba	Aruba	8	ExxonMobil	Ceera Negro	Venezuela	4	Tesoro	Carson	USA	6
BP	Castellon	Spain	2	P66	Roxana	USA	4	Total SATORP	Yanbu	Saudi Arabia	4
Chevron	Pascagoula	USA	6	Suncor	Fort McMurray	Canada	6	Axion		Argentina	4
Flint Hills Resources	Pine Bend	USA	2	Chevron	El Segundo	USA	6	Shell	Martinez	USA	2

VEGA Coking Level System Deliverables

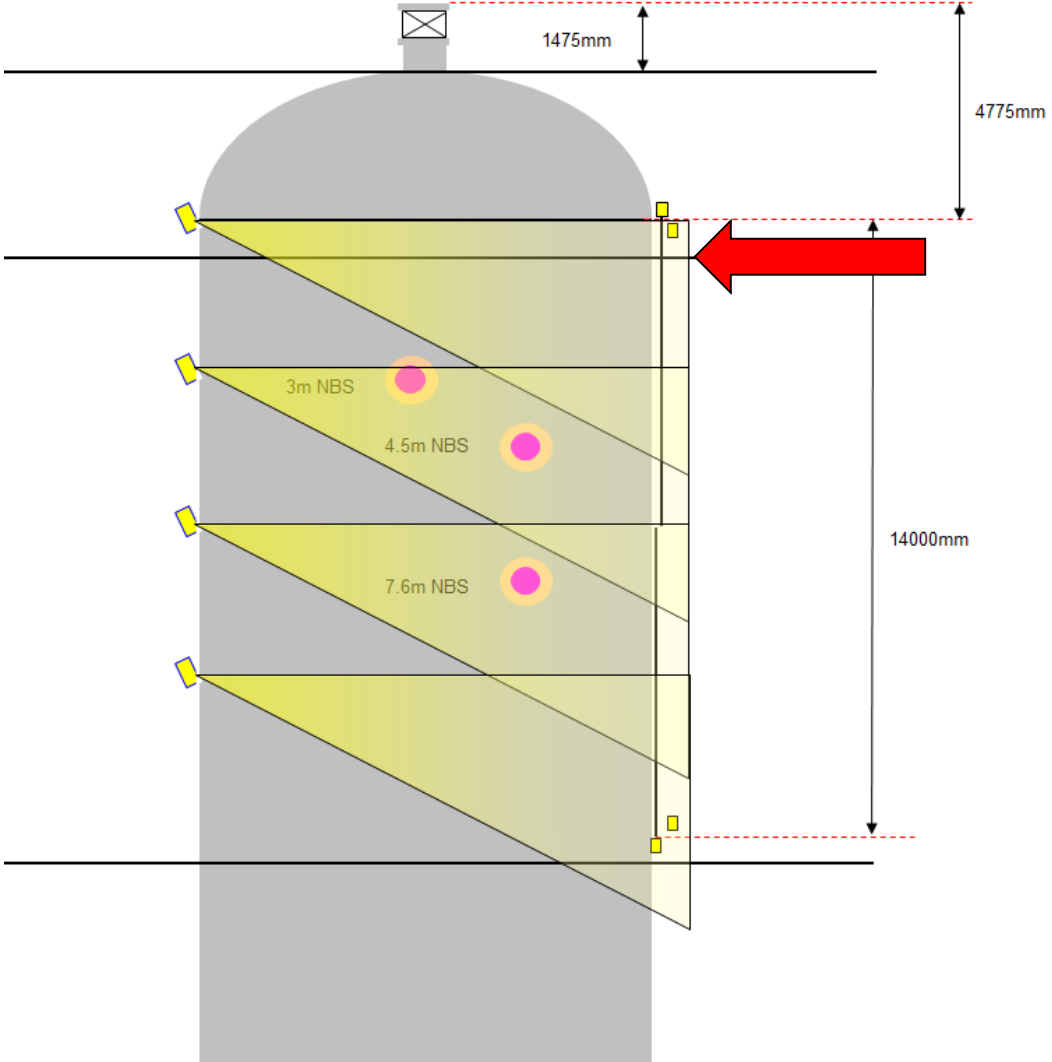
- Increased throughput
  - Increase cycle times
  - Reduce total of drum cycles per year
- Operations can use less anti-foam
  - Use it for automatic anti-foam control
  - Manage anti-foam inventory
  - Extend downstream catalyst life
- Increase Operator confidence
- Manage foam overs
  - Measures top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

- Typical

Level Measurement Arrangement

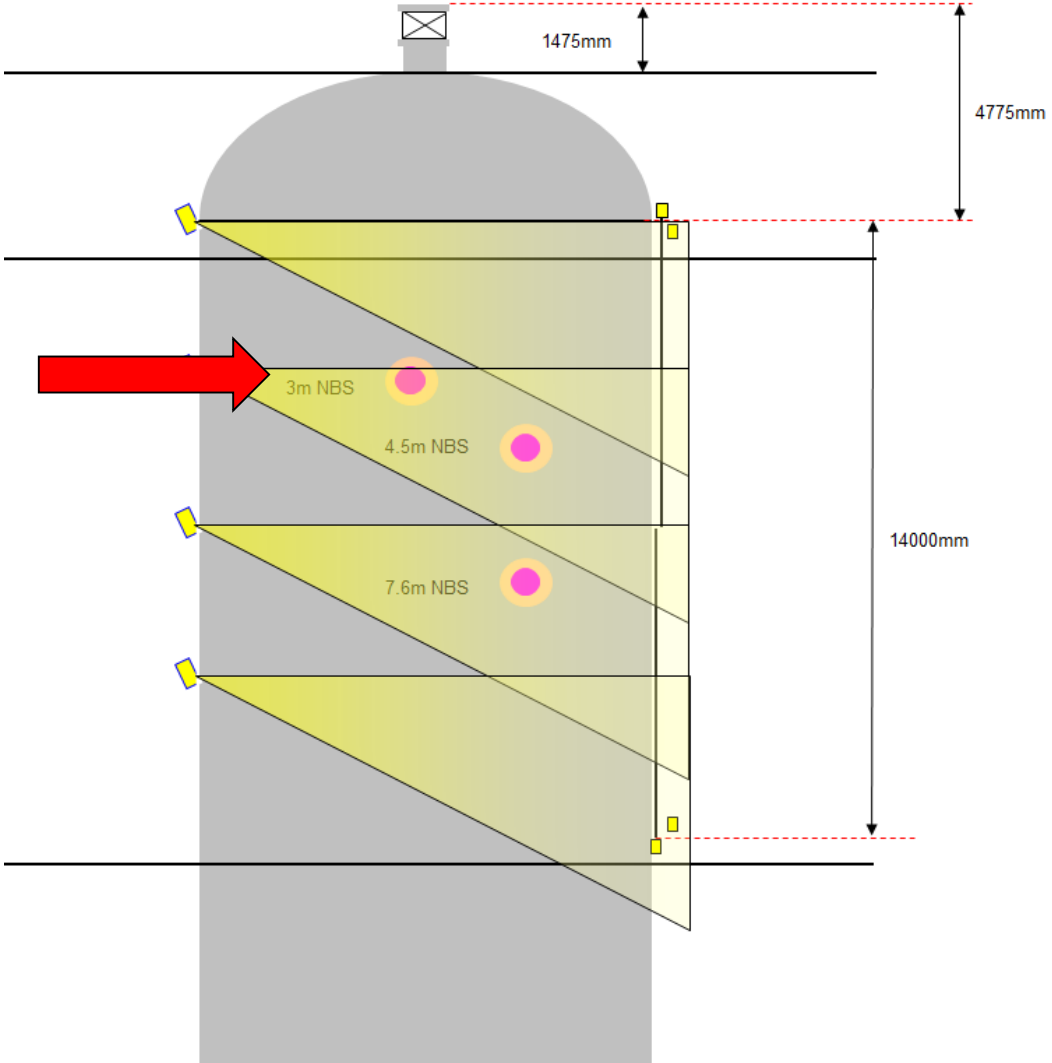
Typical Drum

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



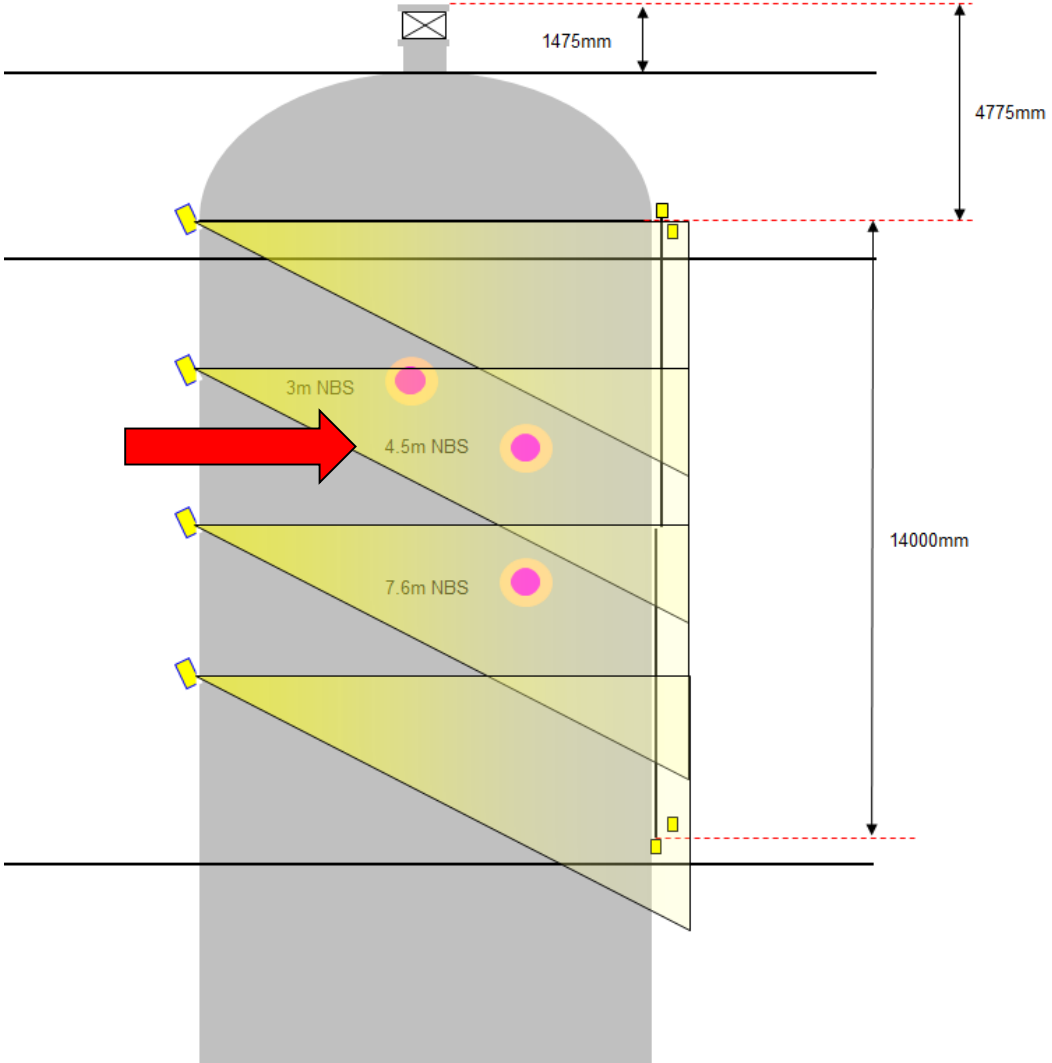
Typical Drum

- 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.



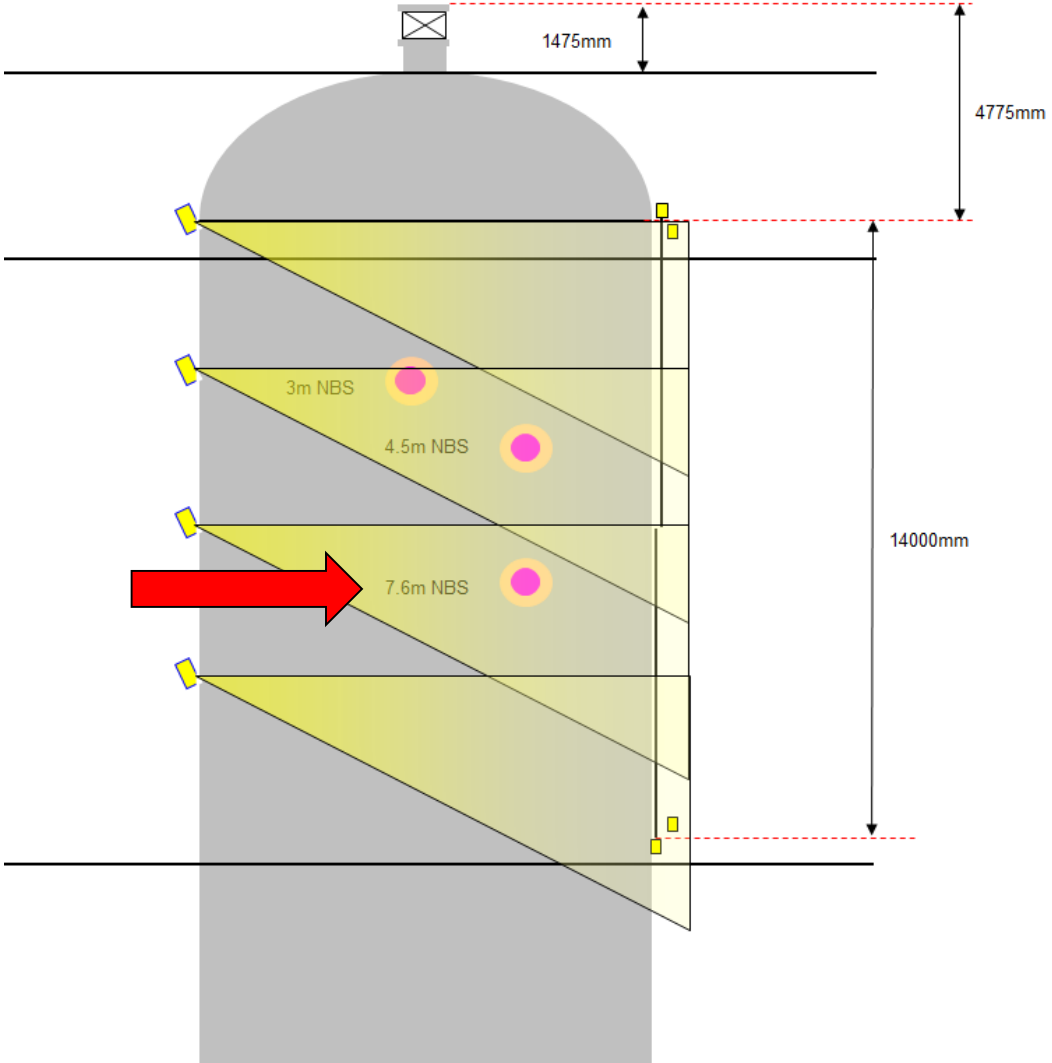
Typical Drum

- 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

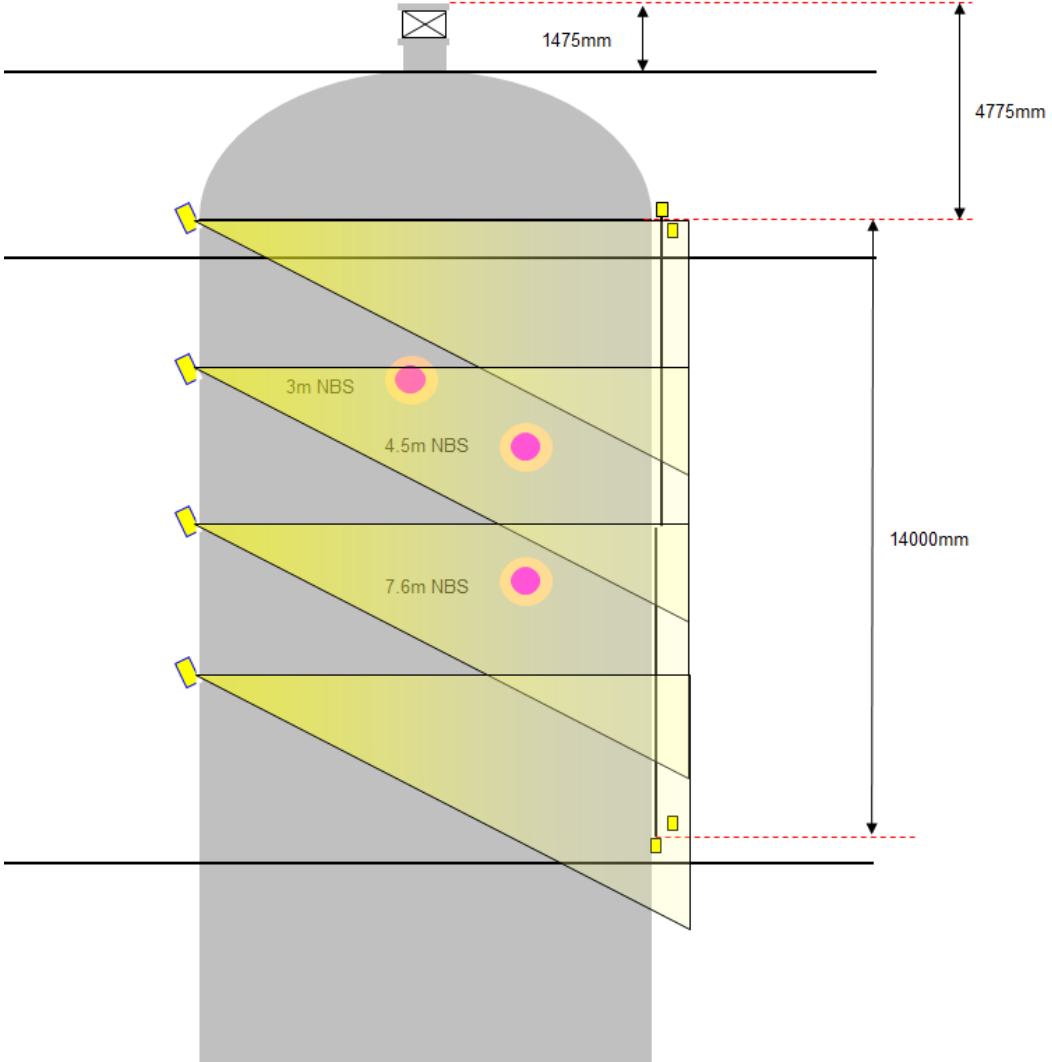
- Typical Gamma Continuous covers 14 meters starting at ~ 300mm below top tangent.
- Typical Neutron Backscatter located at 3m, 4.5m and 7.6m down from top tangent.



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?

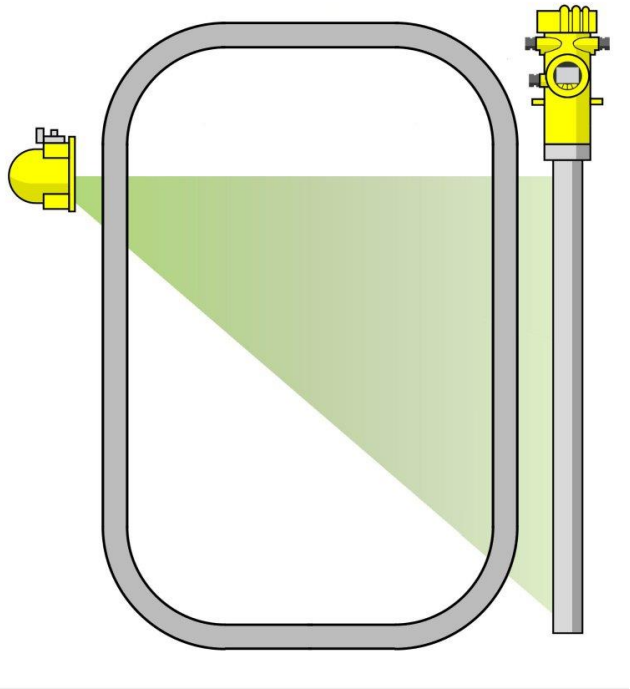
Needs 4 things to work

Source

Detector

Vessel

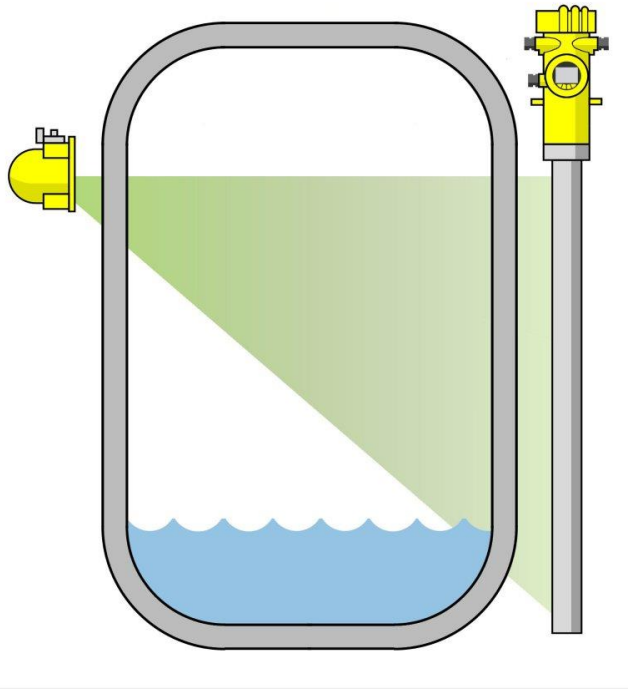
Process



Basic Principle

How does a radiometric level transmitter work?

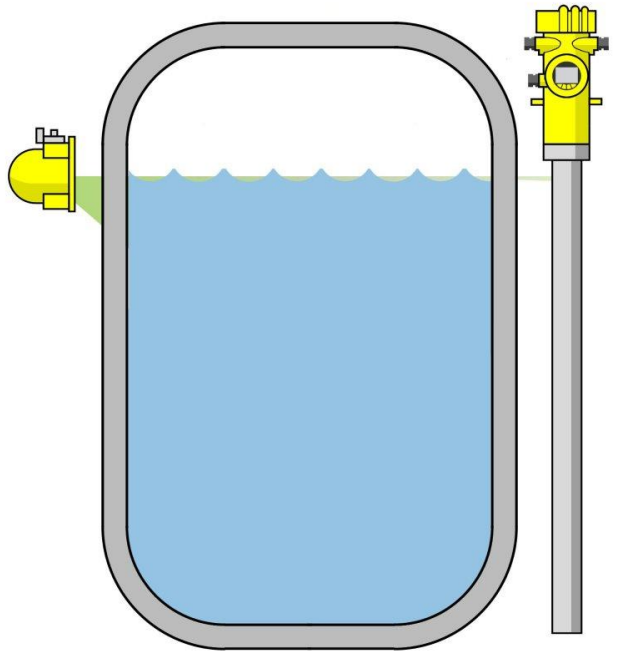
Vessel Empty, the detectors receive the most amount of radiation.



Basic Principle

How does a radiometric level transmitter work?

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



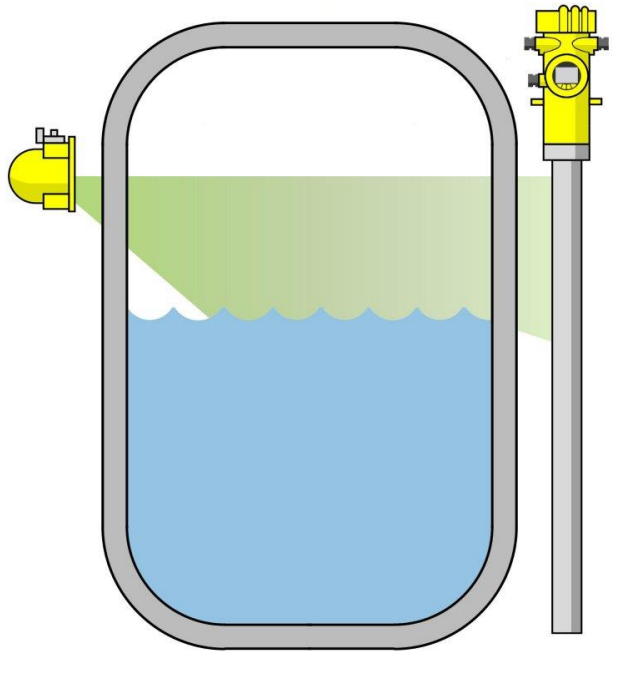
Basic Principle

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

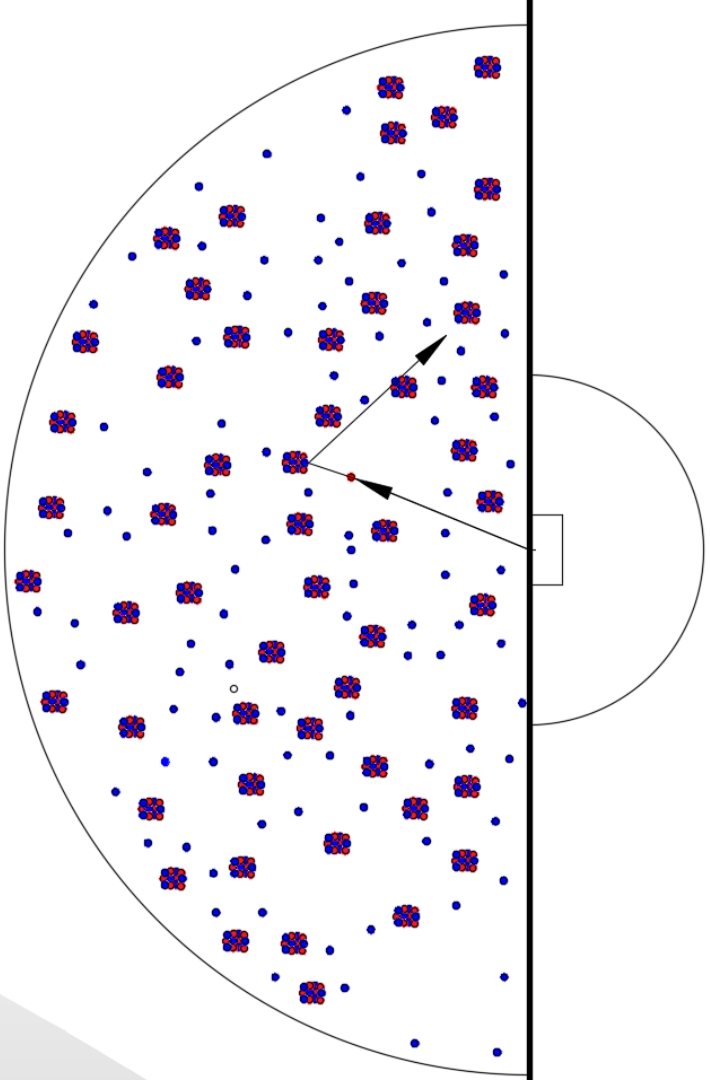
- Advantages
  - Continuous level indictation
  - Measure effectiveness of anti-foam (Automatic foam control)
  - Can be used to measure outage
  - Can measure water during quench
  - Can be used to measure vapor carryover (Vapor Denisty Gauge)
  - Switches can be moved if needed

Detector Technology – Neutron Backscatter (NBS)

How do they work?

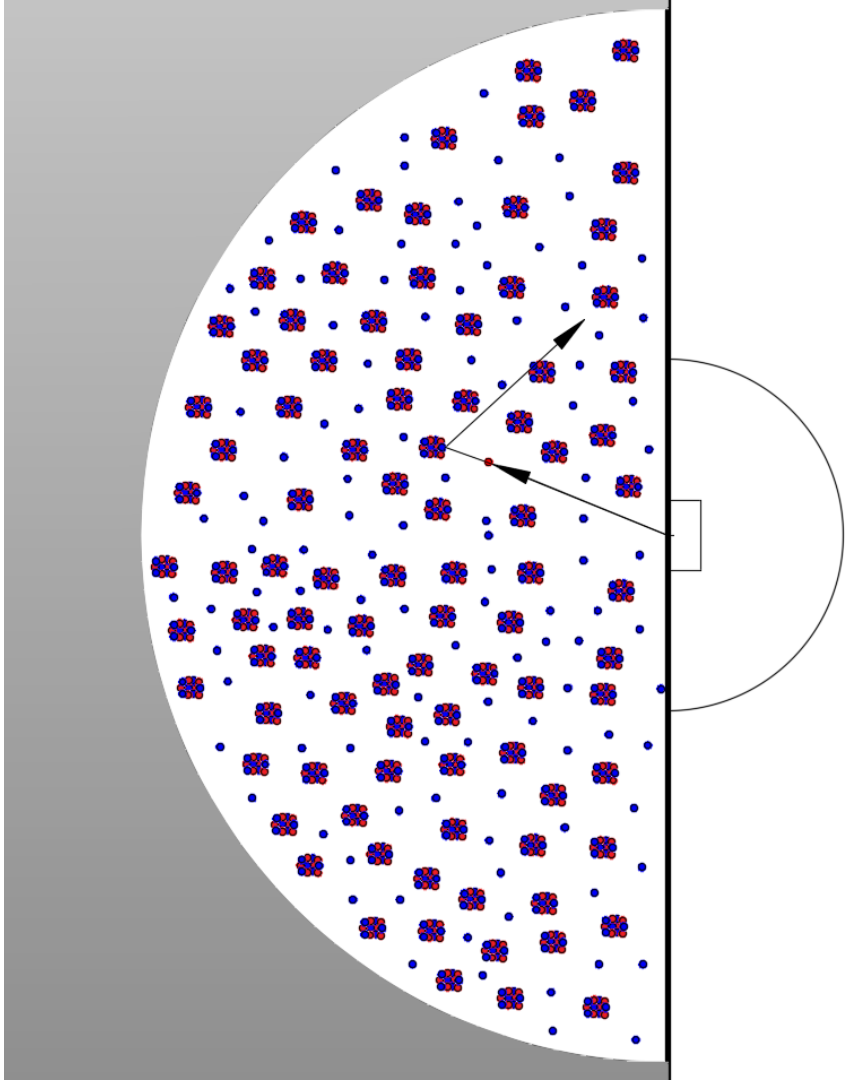
Basic Principle

- 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).

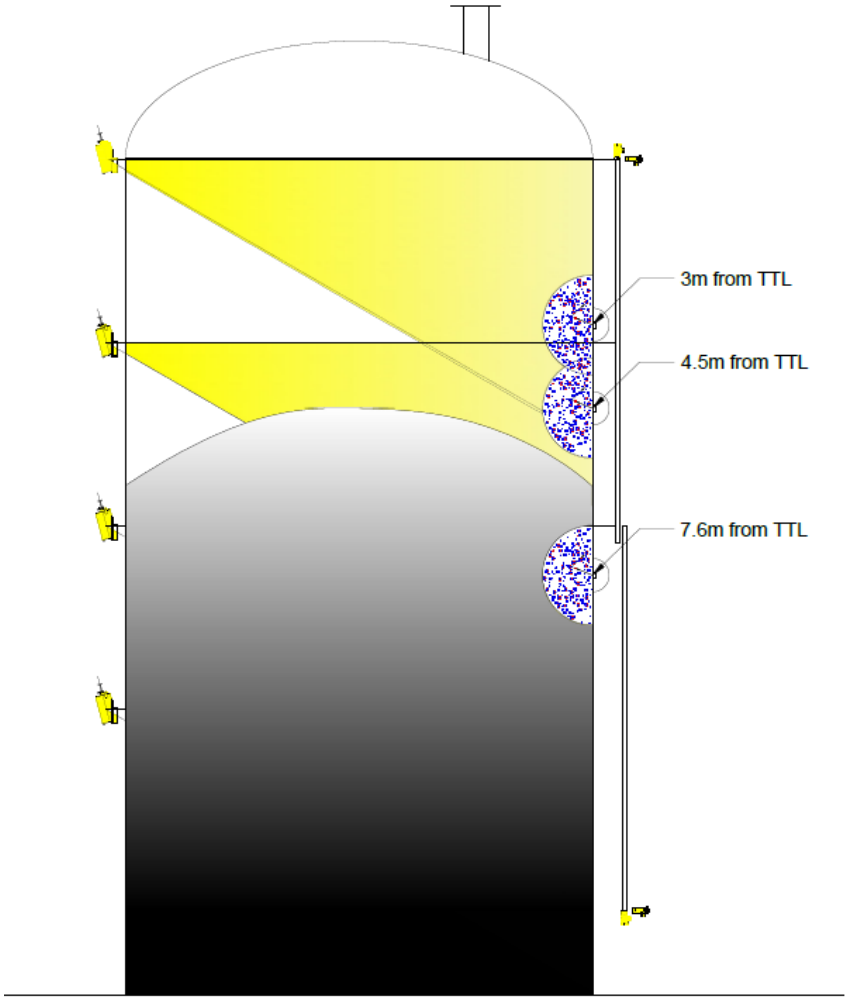
- Advantages
  - Can distinguish the difference between foam and coke (under proper conditions)
  - Can distinguish the difference between coke and water (under proper conditions)

Trends

Normal Drum operation

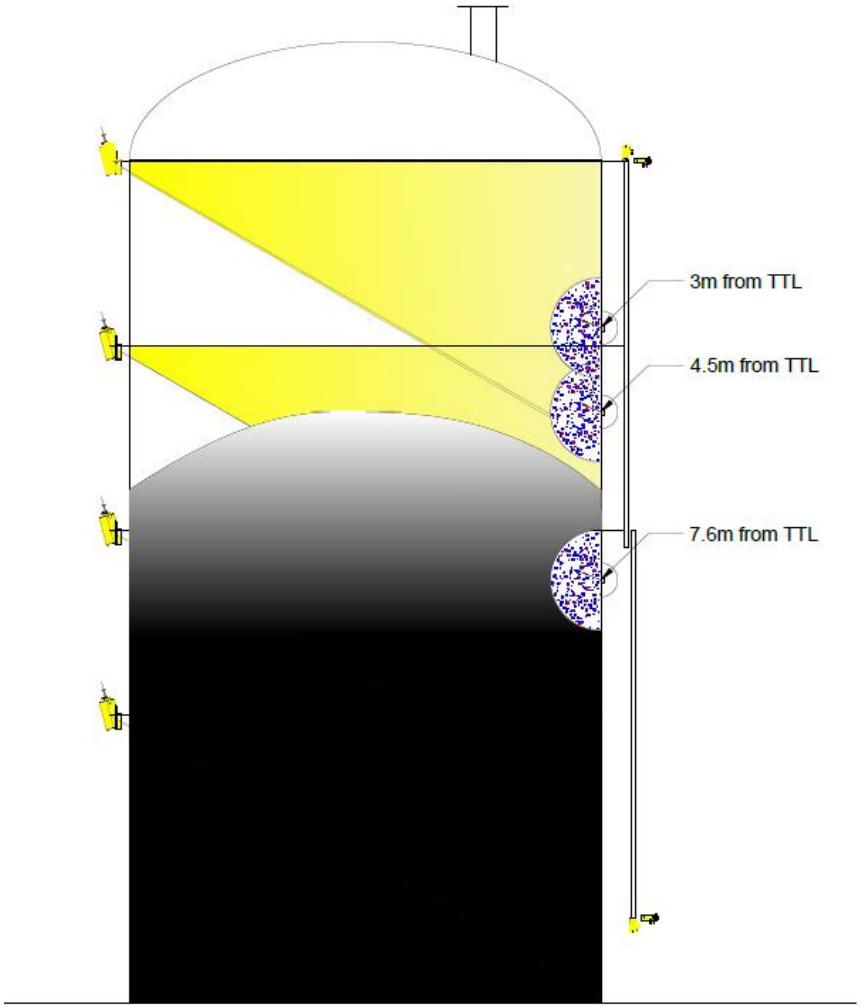
Foam Levels

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



Foam Levels

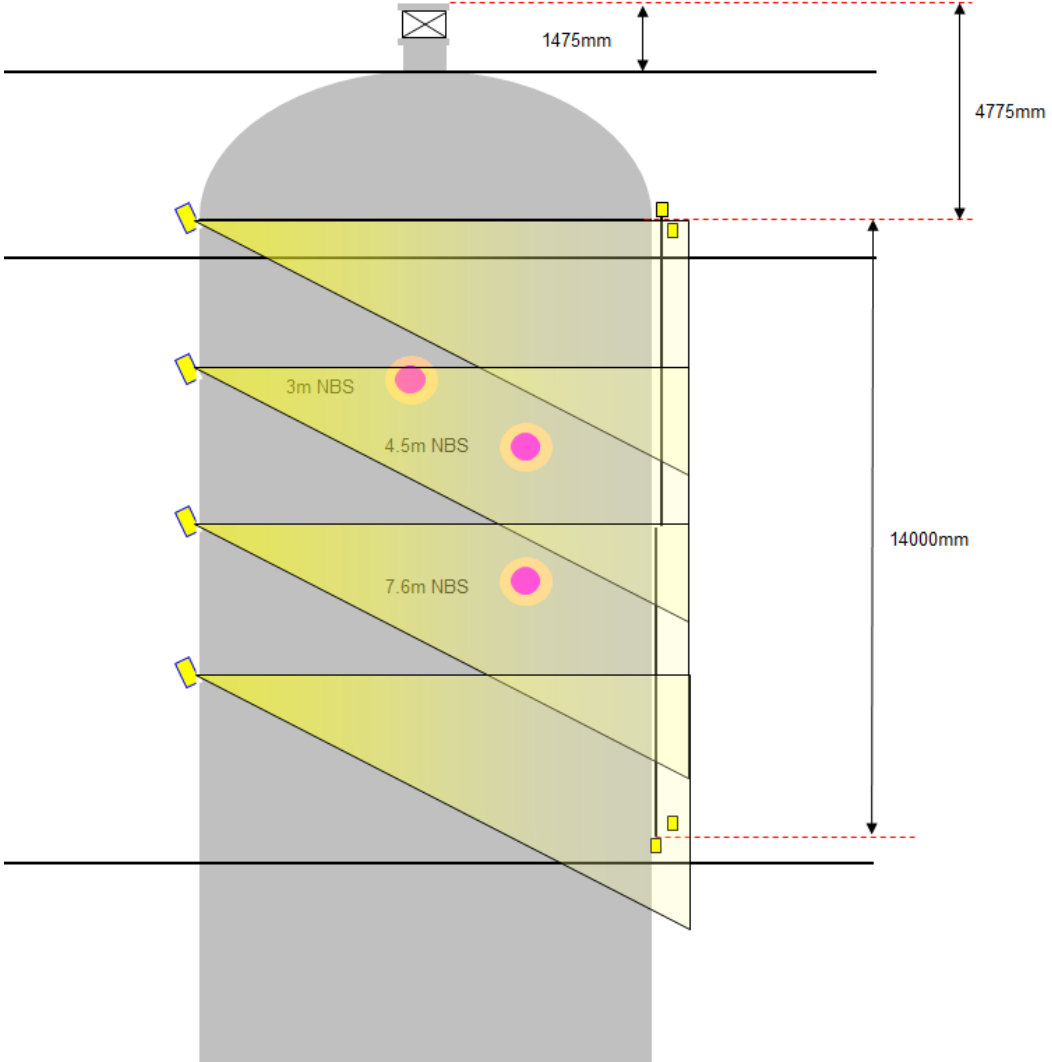
- NBS and Gamma continuous will not always match. The NBS reading is depending upon the Hydrogen concentration (low density foam or high density foam. The Gamma Continuous level tracks the top of foam be it either low or high density.



Typical Drum

This example

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

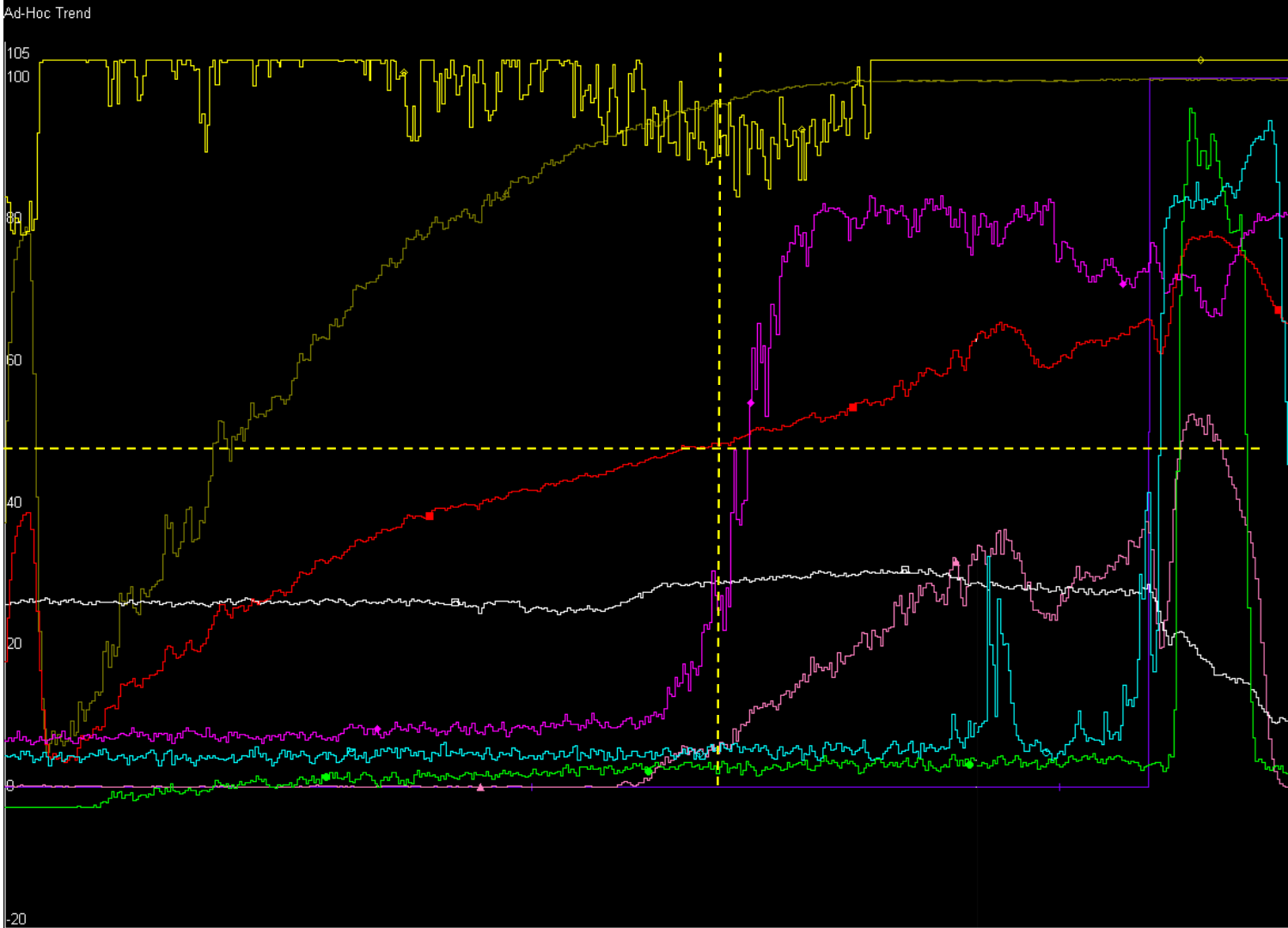


Gamma
Continuous Level

7.6m NBS ≈ 45%

4.5m NBS

3m NBS

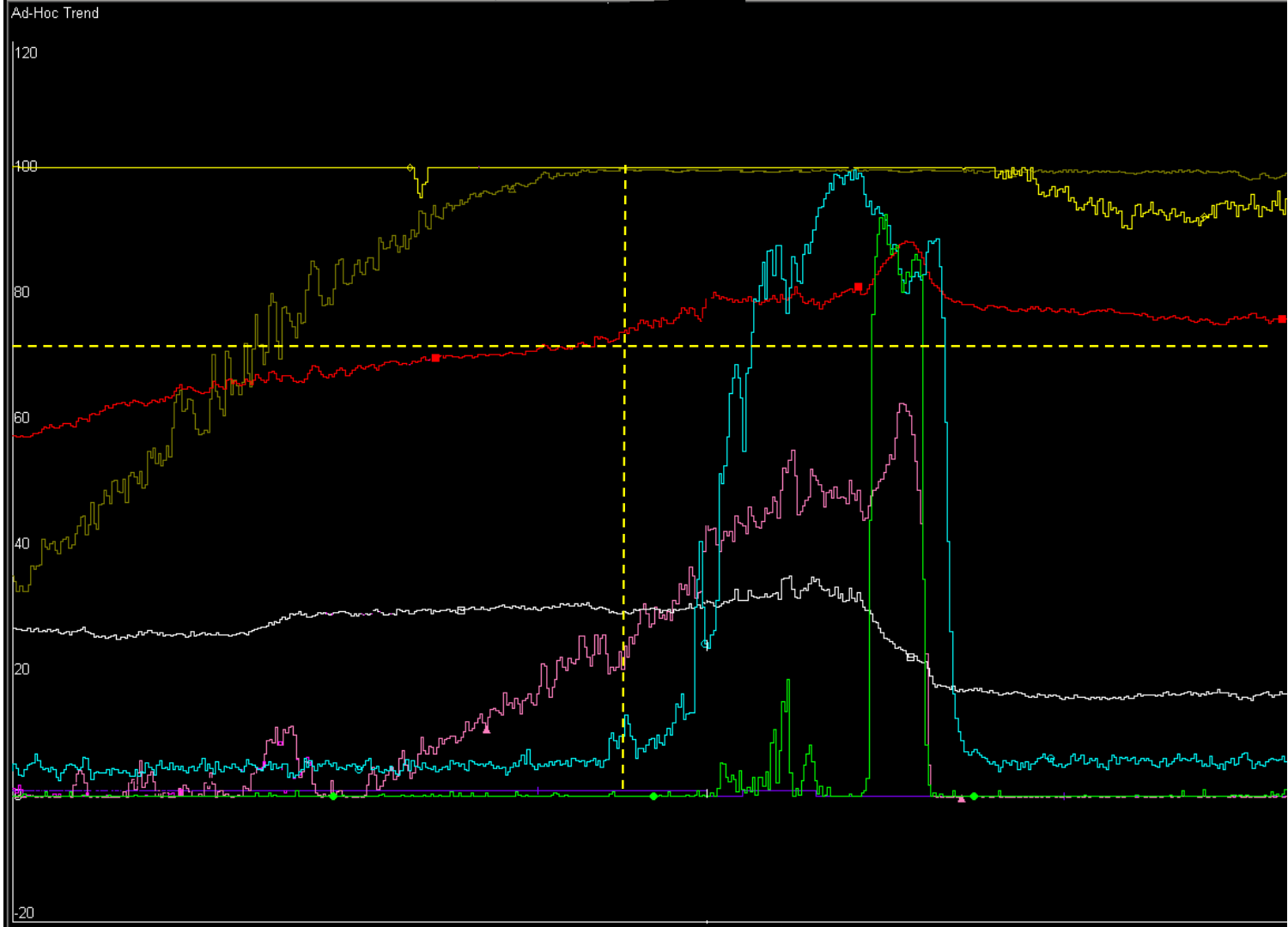


Gamma Continuous Level

7.6m NBS

4.5m NBS ≈ 67%

3m NBS ≈ 78%

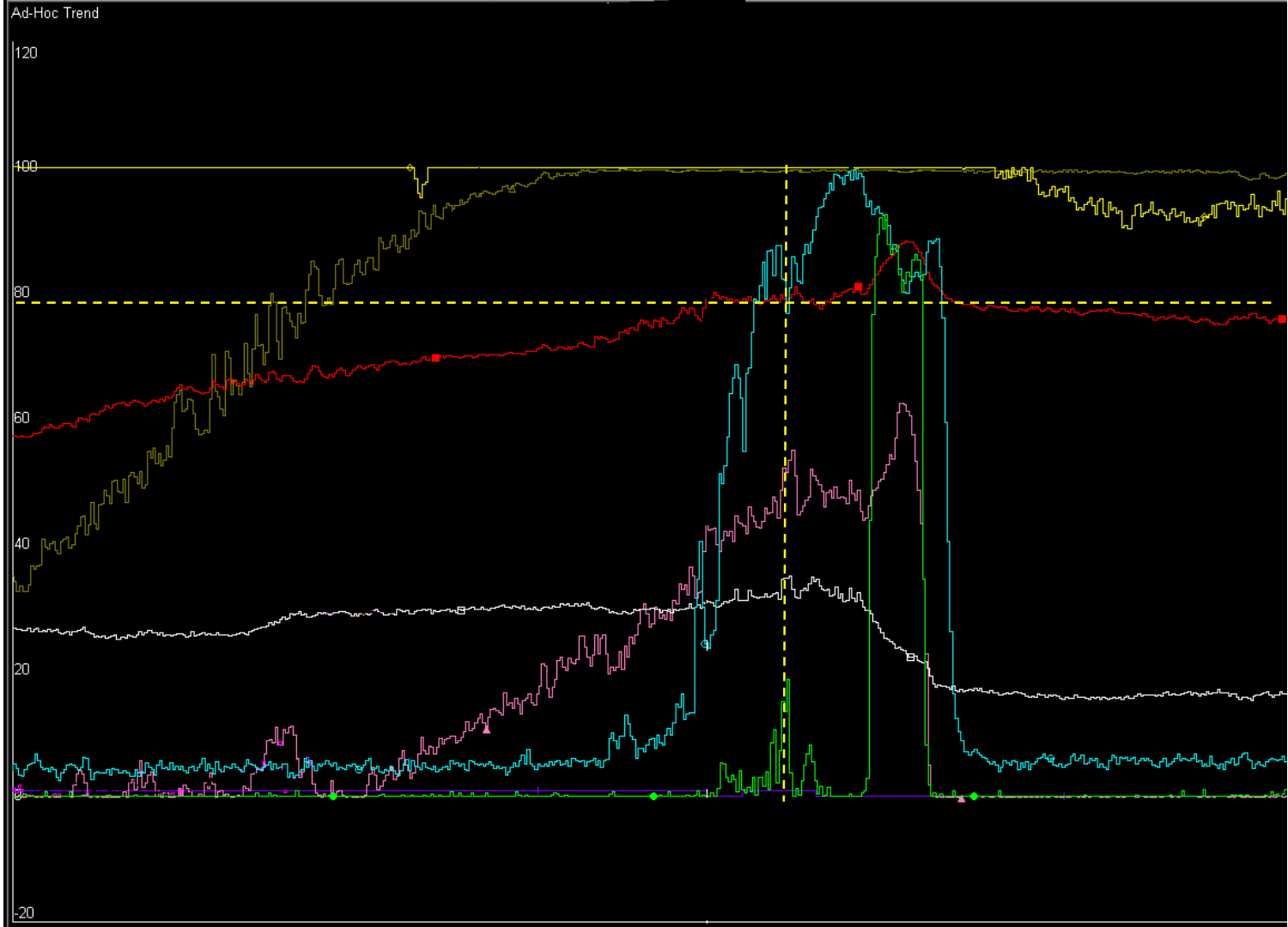


Gamma Continuous Level

7.6m NBS

4.5m NBS ≈ 67%

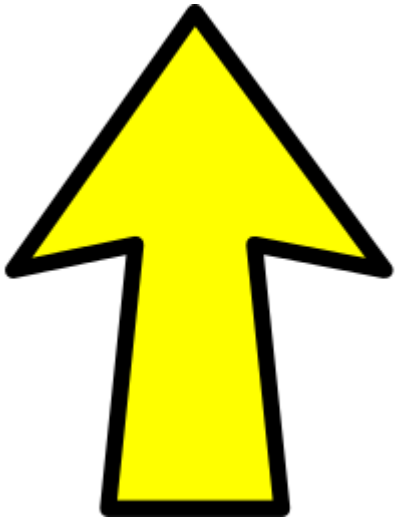
3m NBS ≈ 78%



Trends

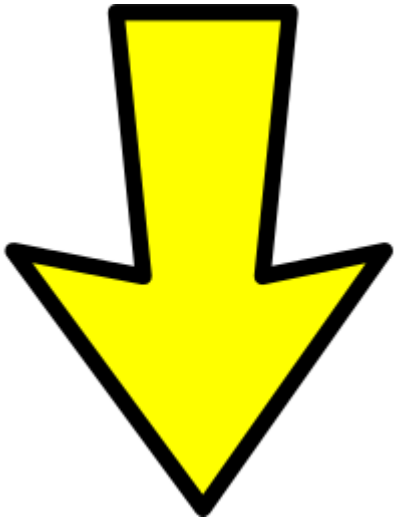
Abnormal Drum Operation (Foam Overs)

Foam Level



Is Level
Going up???

Or Going
Down???



Light Blue = Pressure

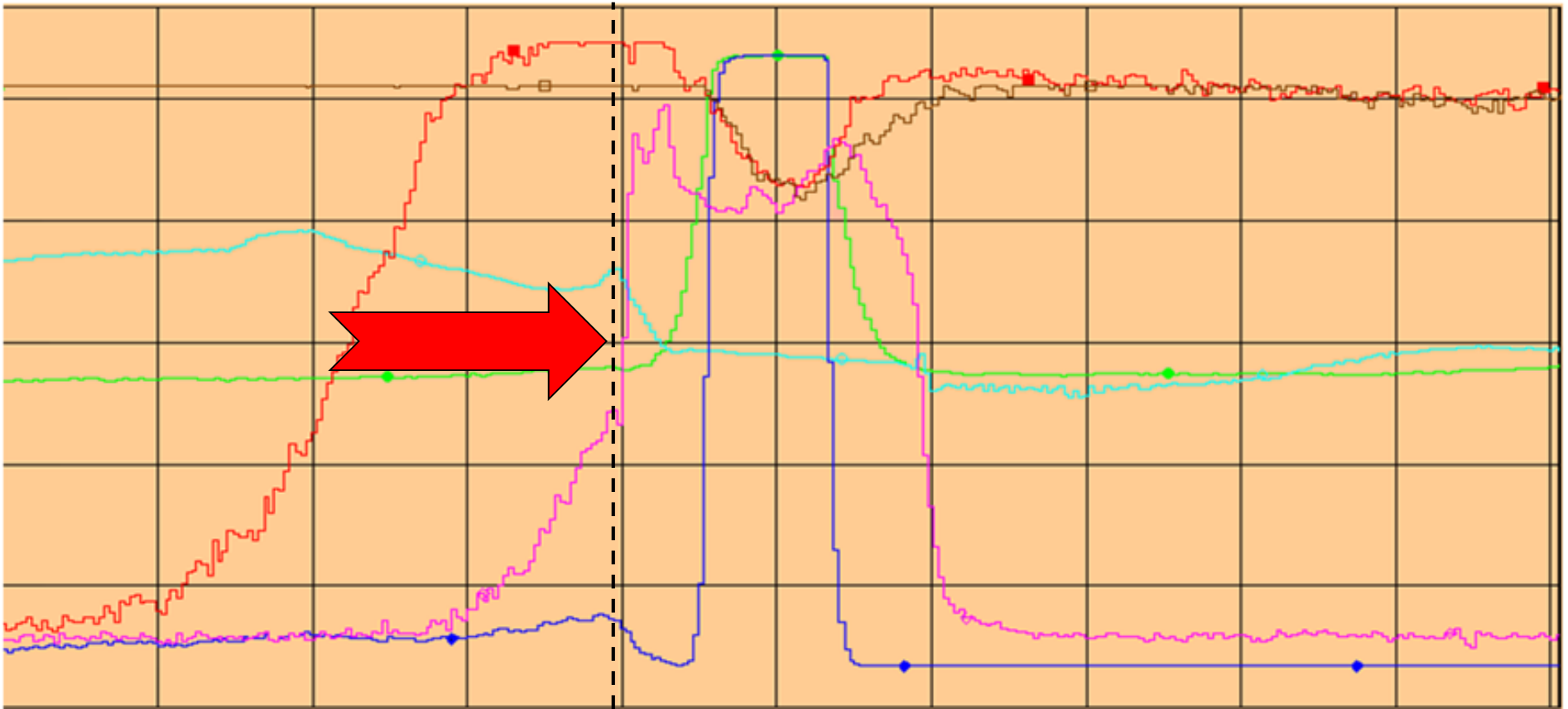
Green = Continuous Level

Dark Blue = Vapor Density

Brown = Lowest NBS

Red = Middle NBS

Purple = Top NBS



Light Blue = Pressure

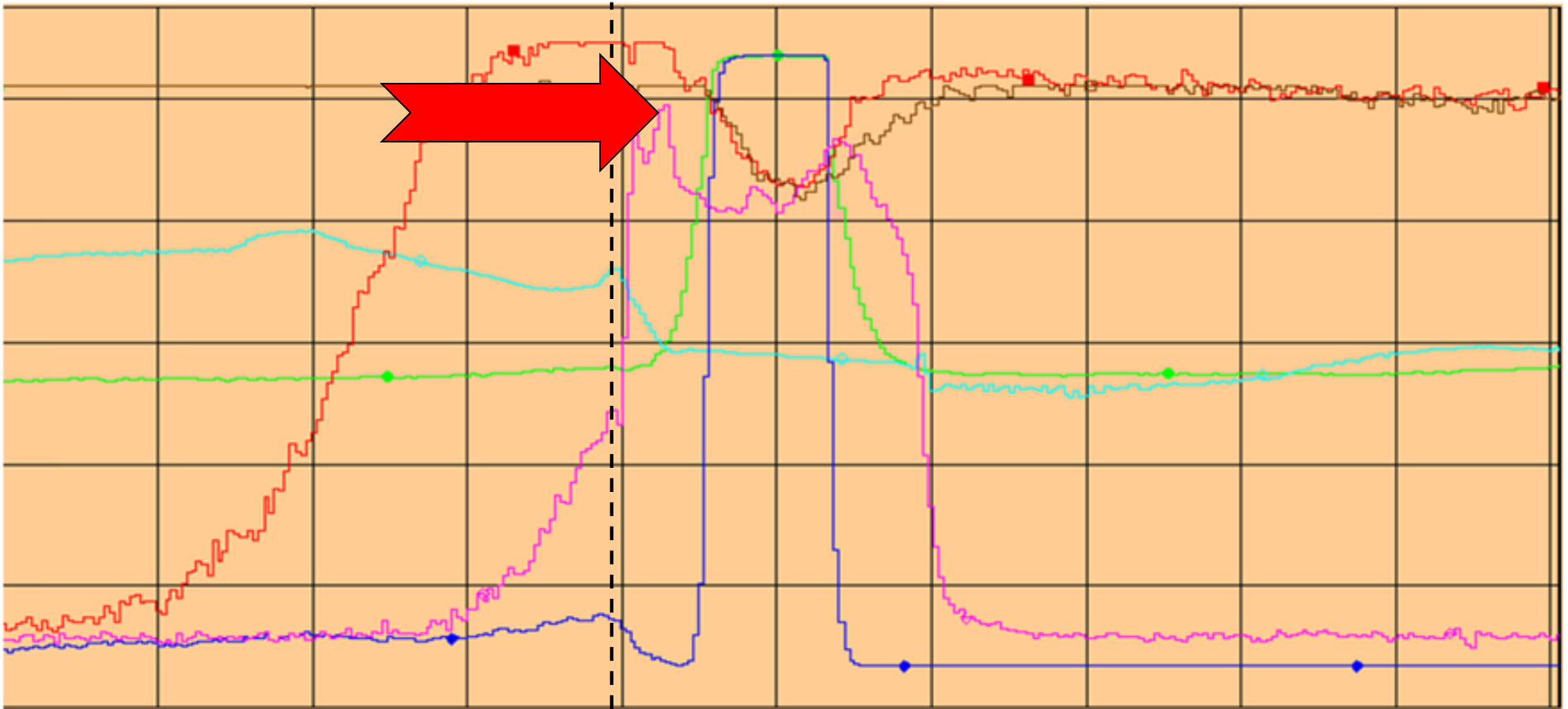
Green = Continuous Level

Dark Blue = Vapor Density

Brown = Lowest NBS

Red = Middle NBS

Purple = Top NBS



Light Blue = Pressure

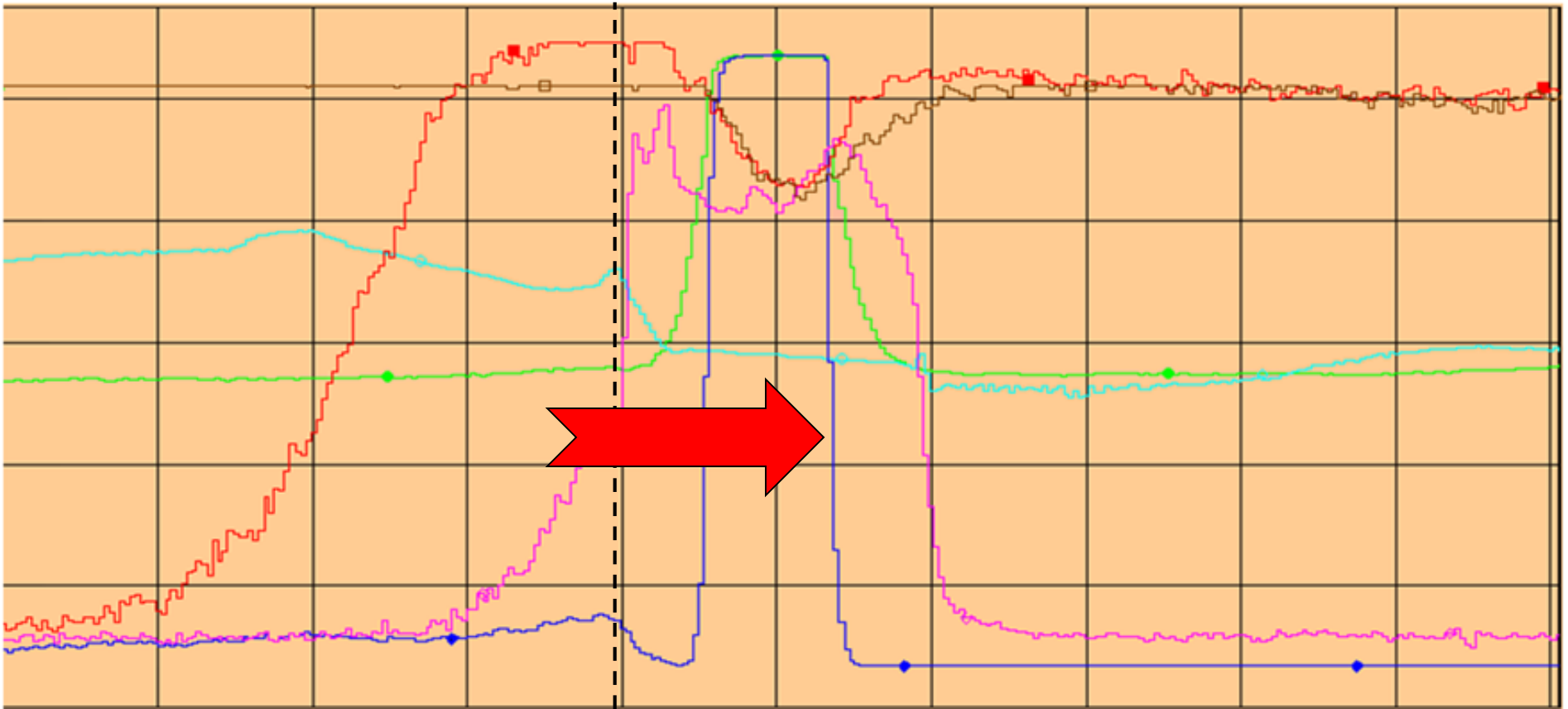
Green = Continuous Level

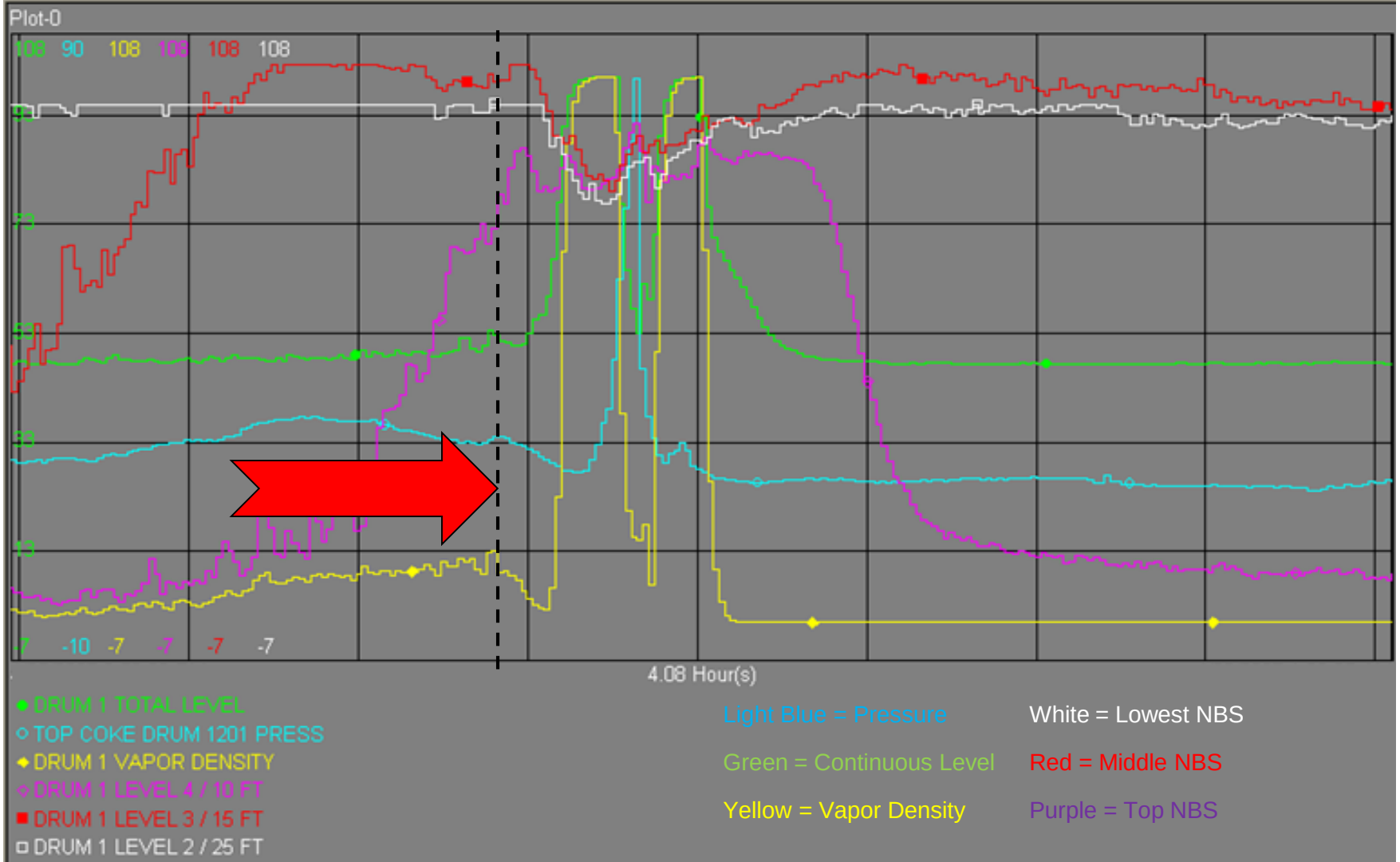
Dark Blue = Vapor Density

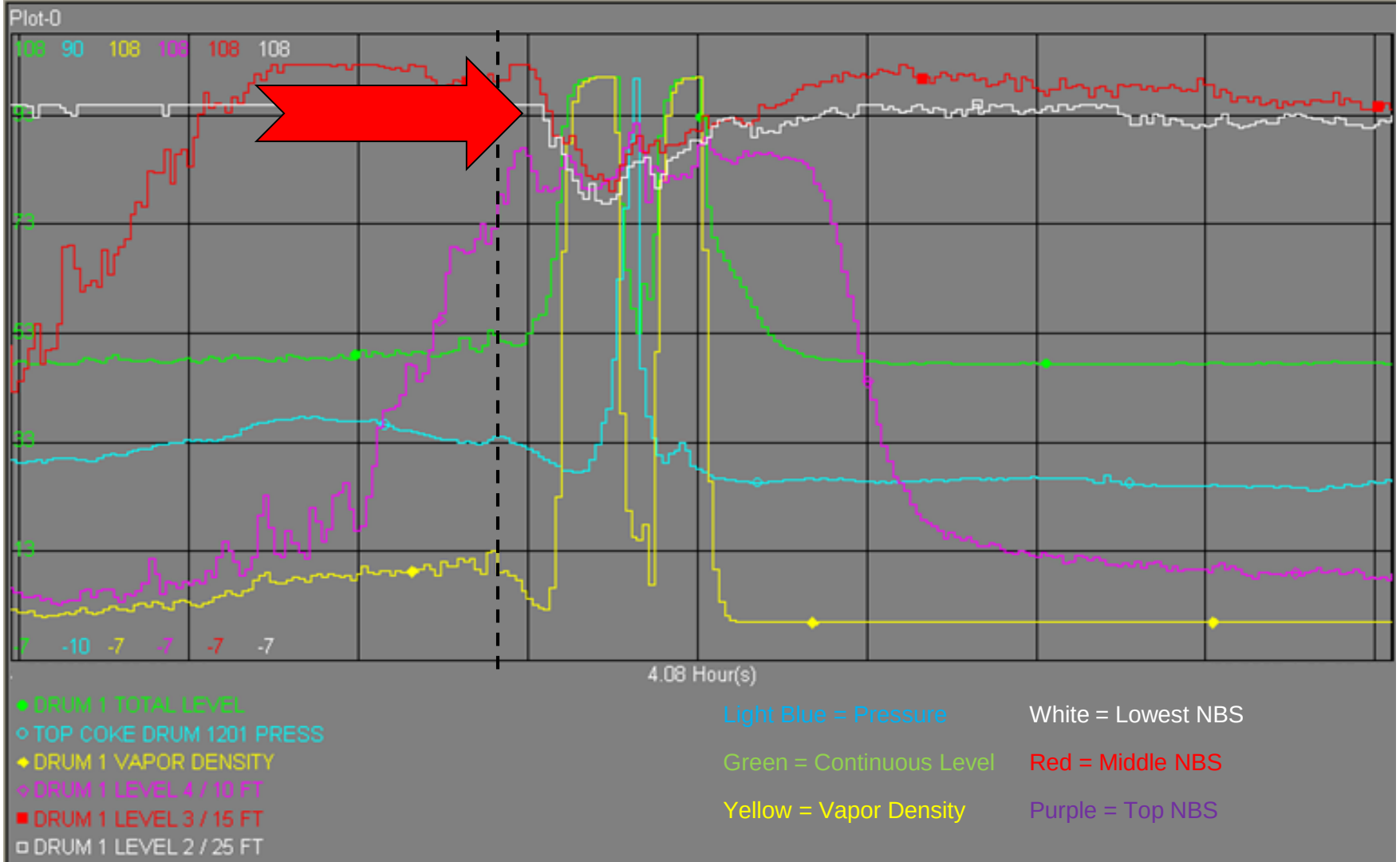
Brown = Lowest NBS

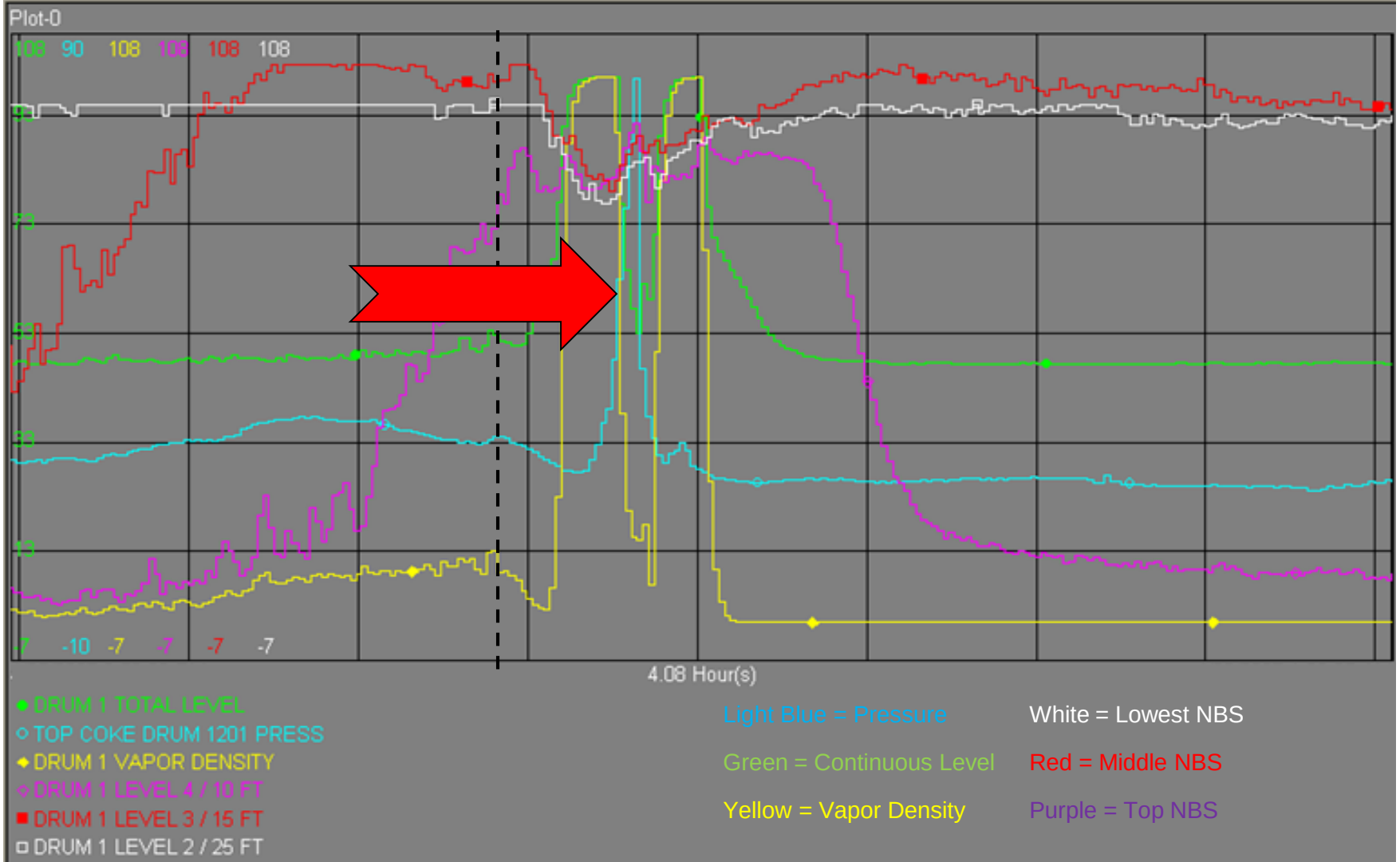
Red = Middle NBS

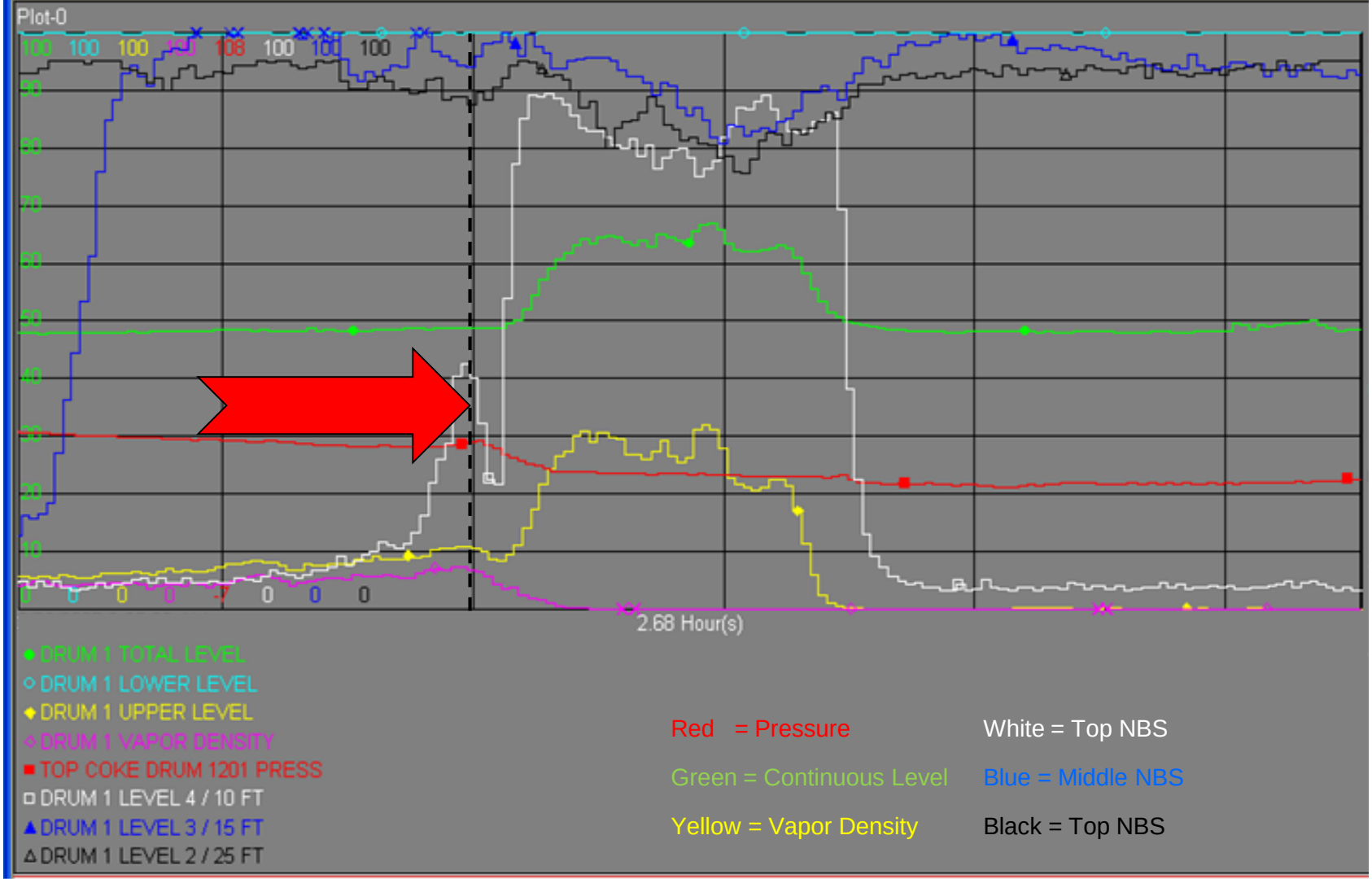
Purple = Top NBS

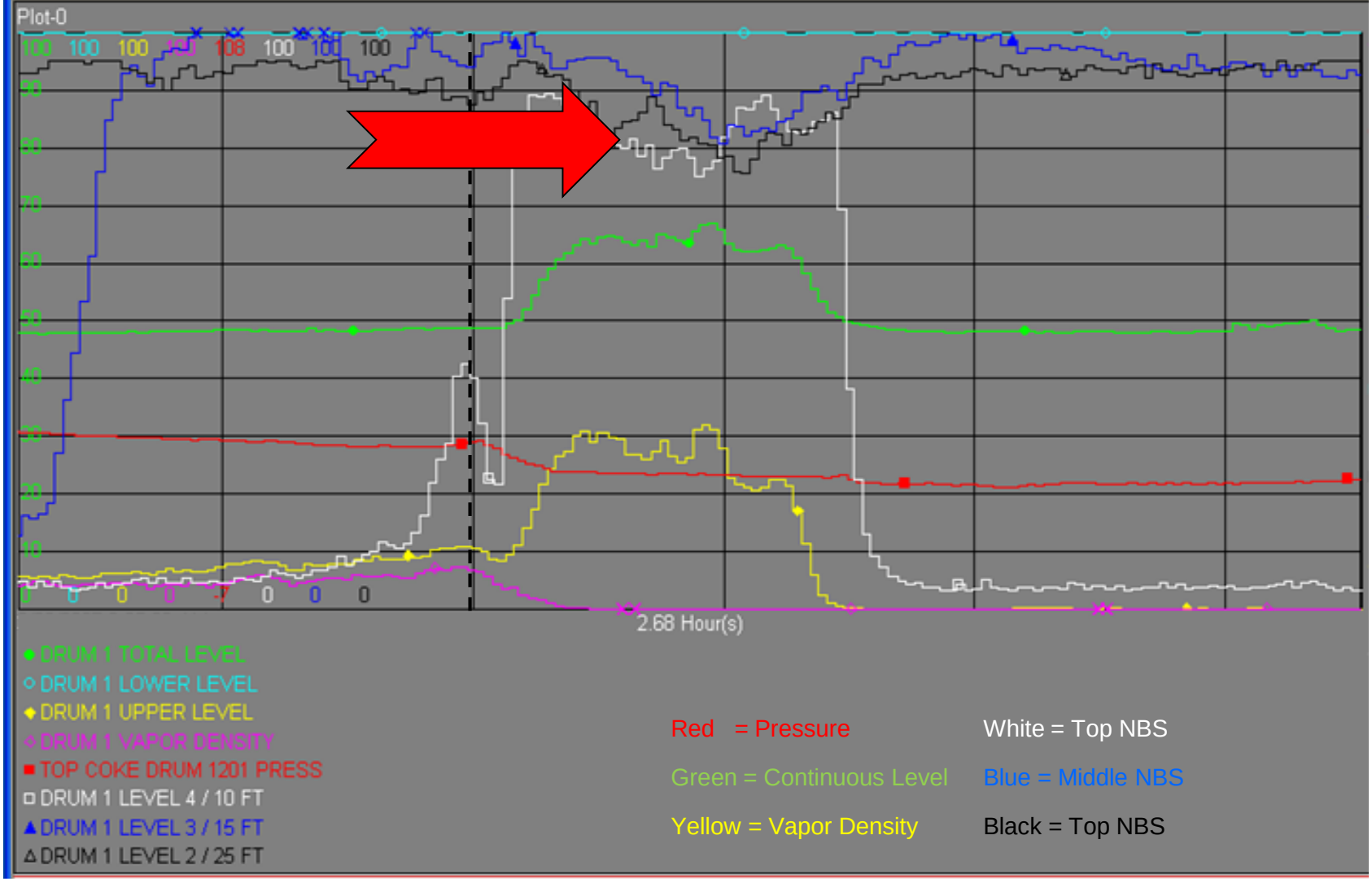


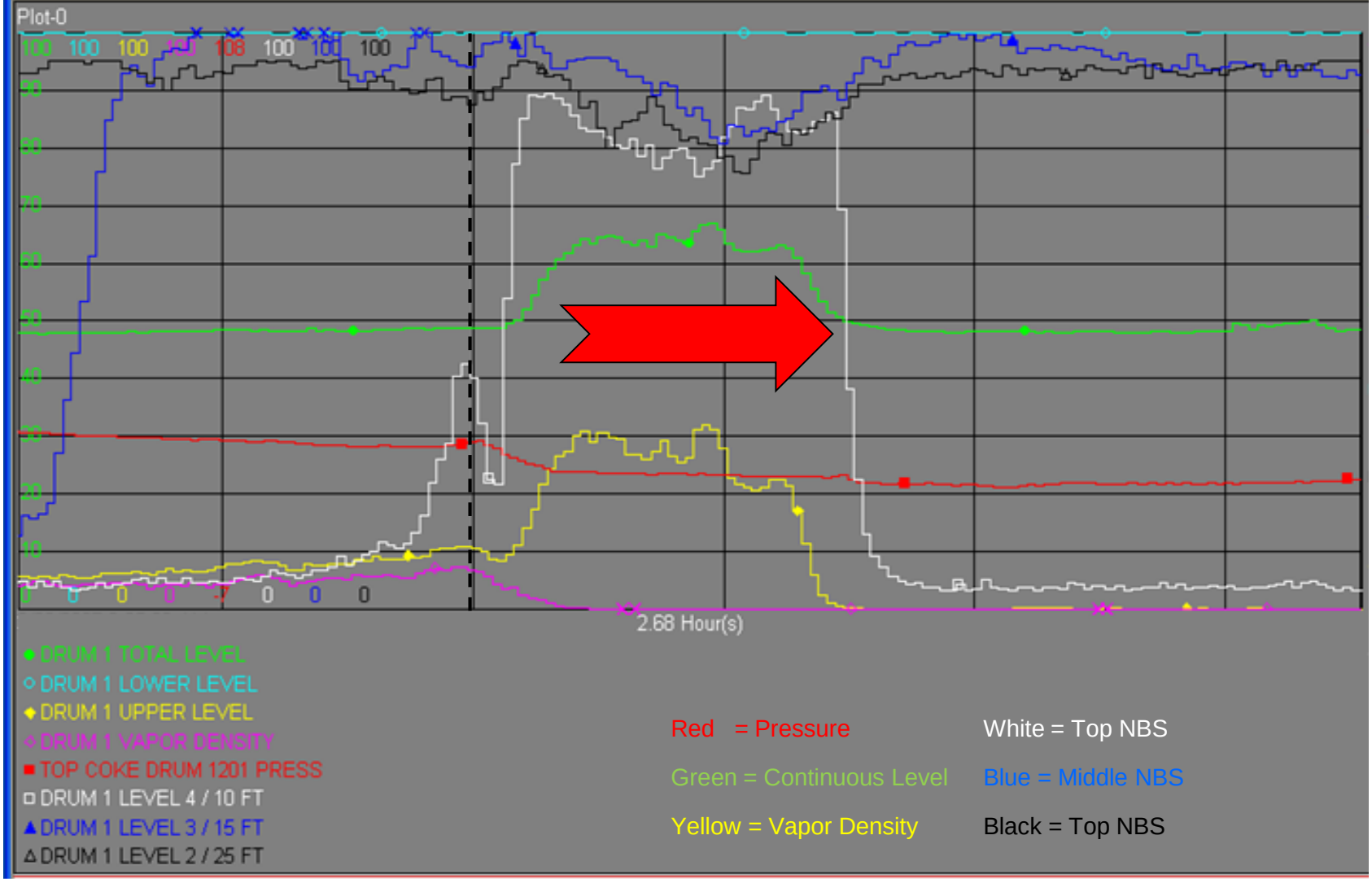

Plot-0
108 90 108 108 108 108
-7 -10 -7 -7 -7 -7
4.08 Hour(s)
DRUM 1 TOTAL LEVEL
TOP COKE DRUM 1201 PRESS
DRUM 1 VAPOR DENSITY
DRUM 1 LEVEL 4 / 10 FT
DRUM 1 LEVEL 3 / 15 FT
DRUM 1 LEVEL 2 / 25 FT
Light Blue = Pressure
Green = Continuous Level
Yellow = Vapor Density
White = Lowest NBS
Red = Middle NBS
Purple = Top NBS


Plot-0
108 90 108 108 108 108
-7 -10 -7 -7 -7 -7
4.08 Hour(s)
DRUM 1 TOTAL LEVEL
TOP COKE DRUM 1201 PRESS
DRUM 1 VAPOR DENSITY
DRUM 1 LEVEL 4 / 10 FT
DRUM 1 LEVEL 3 / 15 FT
DRUM 1 LEVEL 2 / 25 FT
Light Blue = Pressure
Green = Continuous Level
Yellow = Vapor Density
White = Lowest NBS
Red = Middle NBS
Purple = Top NBS


Plot-0
108 90 108 108 108 108
-7 -10 -7 -7 -7 -7
4.08 Hour(s)
DRUM 1 TOTAL LEVEL
TOP COKE DRUM 1201 PRESS
DRUM 1 VAPOR DENSITY
DRUM 1 LEVEL 4 / 10 FT
DRUM 1 LEVEL 3 / 15 FT
DRUM 1 LEVEL 2 / 25 FT
Light Blue = Pressure
White = Lowest NBS
Green = Continuous Level
Red = Middle NBS
Yellow = Vapor Density
Purple = Top NBS


Plot-0
100 100 100 106 100 100 100
90
80
70
60
50
40
30
20
10
0 0 0 0 0 0 0
2.68 Hour(s)
DRUM 1 TOTAL LEVEL
DRUM 1 LOWER LEVEL
DRUM 1 UPPER LEVEL
DRUM 1 VAPOR DENSITY
TOP COKE DRUM 1201 PRESS
DRUM 1 LEVEL 4 / 10 FT
DRUM 1 LEVEL 3 / 15 FT
DRUM 1 LEVEL 2 / 25 FT
Red = Pressure
Green = Continuous Level
Yellow = Vapor Density
White = Top NBS
Blue = Middle NBS
Black = Top NBS


Plot-0
100 100 100 106 100 100 100
90
80
70
60
50
40
30
20
10
0 0 0 0 0 0 0
2.68 Hour(s)
DRUM 1 TOTAL LEVEL
DRUM 1 LOWER LEVEL
DRUM 1 UPPER LEVEL
DRUM 1 VAPOR DENSITY
TOP COKE DRUM 1201 PRESS
DRUM 1 LEVEL 4 / 10 FT
DRUM 1 LEVEL 3 / 15 FT
DRUM 1 LEVEL 2 / 25 FT
Red = Pressure
Green = Continuous Level
Yellow = Vapor Density
White = Top NBS
Blue = Middle NBS
Black = Top NBS

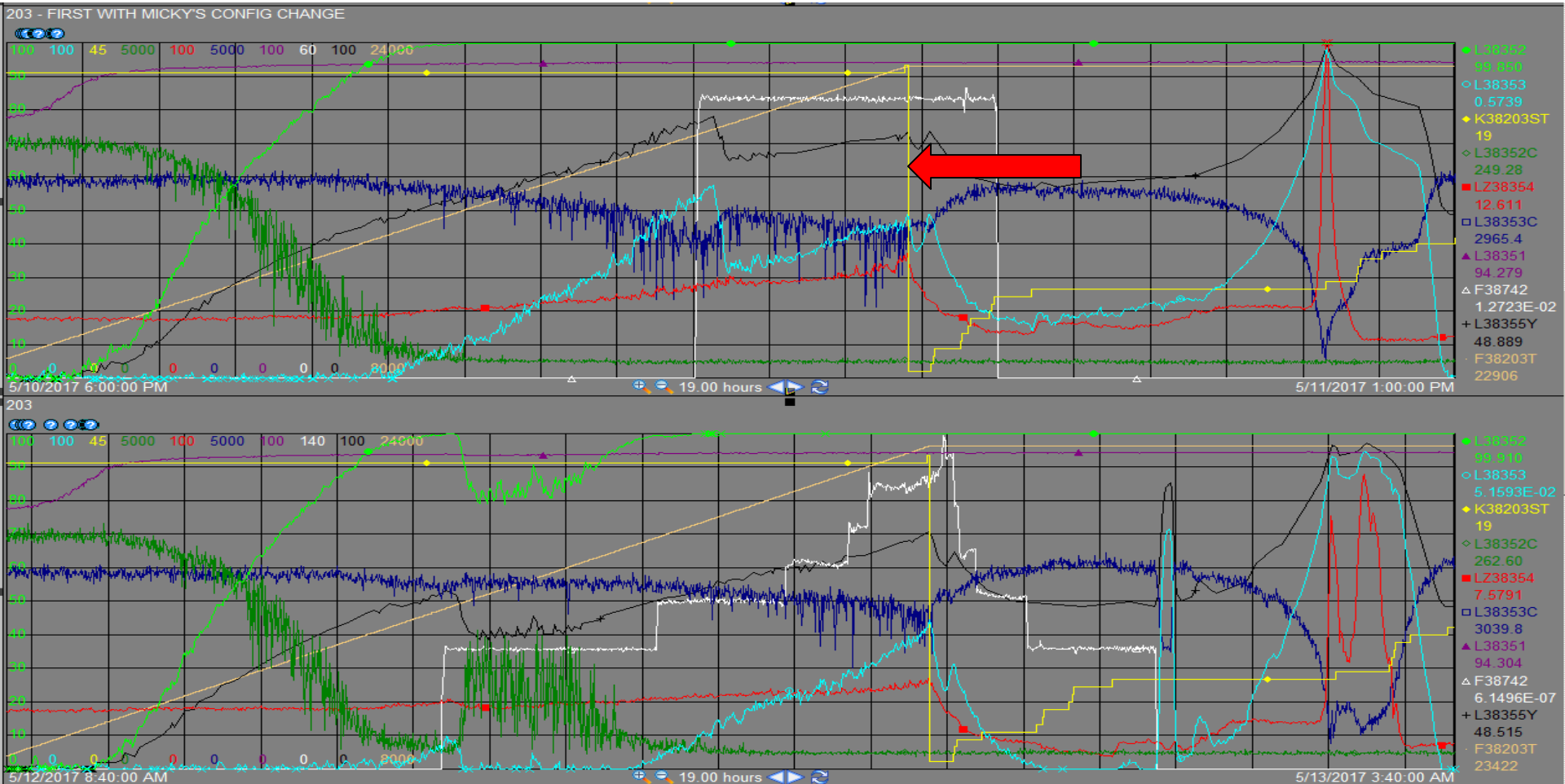

Plot-0
100 100 100 106 100 100 100
90
80
70
60
50
40
30
20
10
0 0 0 0 0 0 0
2.68 Hour(s)
DRUM 1 TOTAL LEVEL
DRUM 1 LOWER LEVEL
DRUM 1 UPPER LEVEL
DRUM 1 VAPOR DENSITY
TOP COKE DRUM 1201 PRESS
DRUM 1 LEVEL 4 / 10 FT
DRUM 1 LEVEL 3 / 15 FT
DRUM 1 LEVEL 2 / 25 FT
Red = Pressure
Green = Continuous Level
Yellow = Vapor Density
White = Top NBS
Blue = Middle NBS
Black = Top NBS

Conclusions

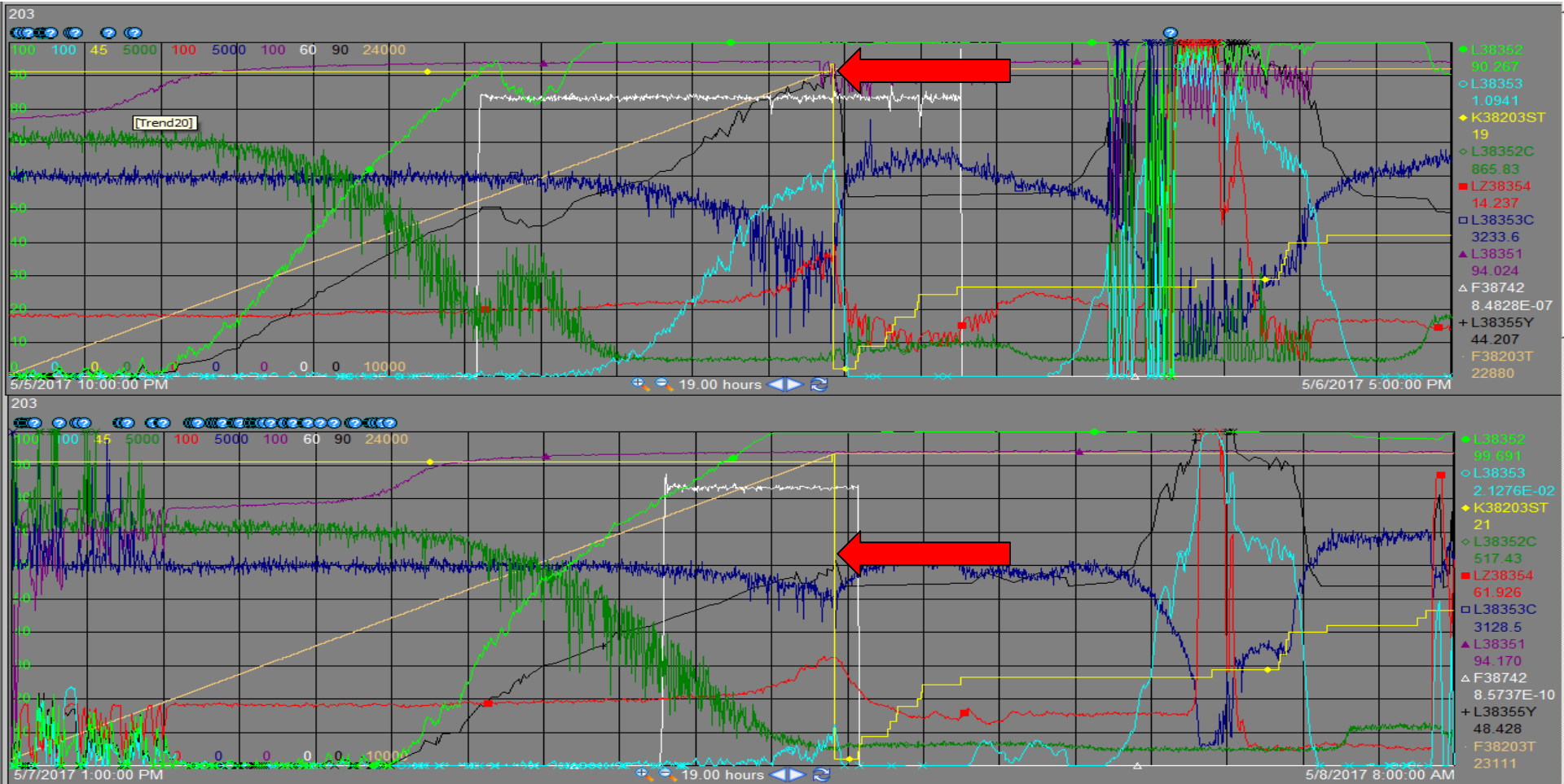
Most foam overs happen after switching drums
This is the time mostly likely for disagreement between NBS and Gamma continuous
BE AWARE!!!!!

Thank you!!!!!

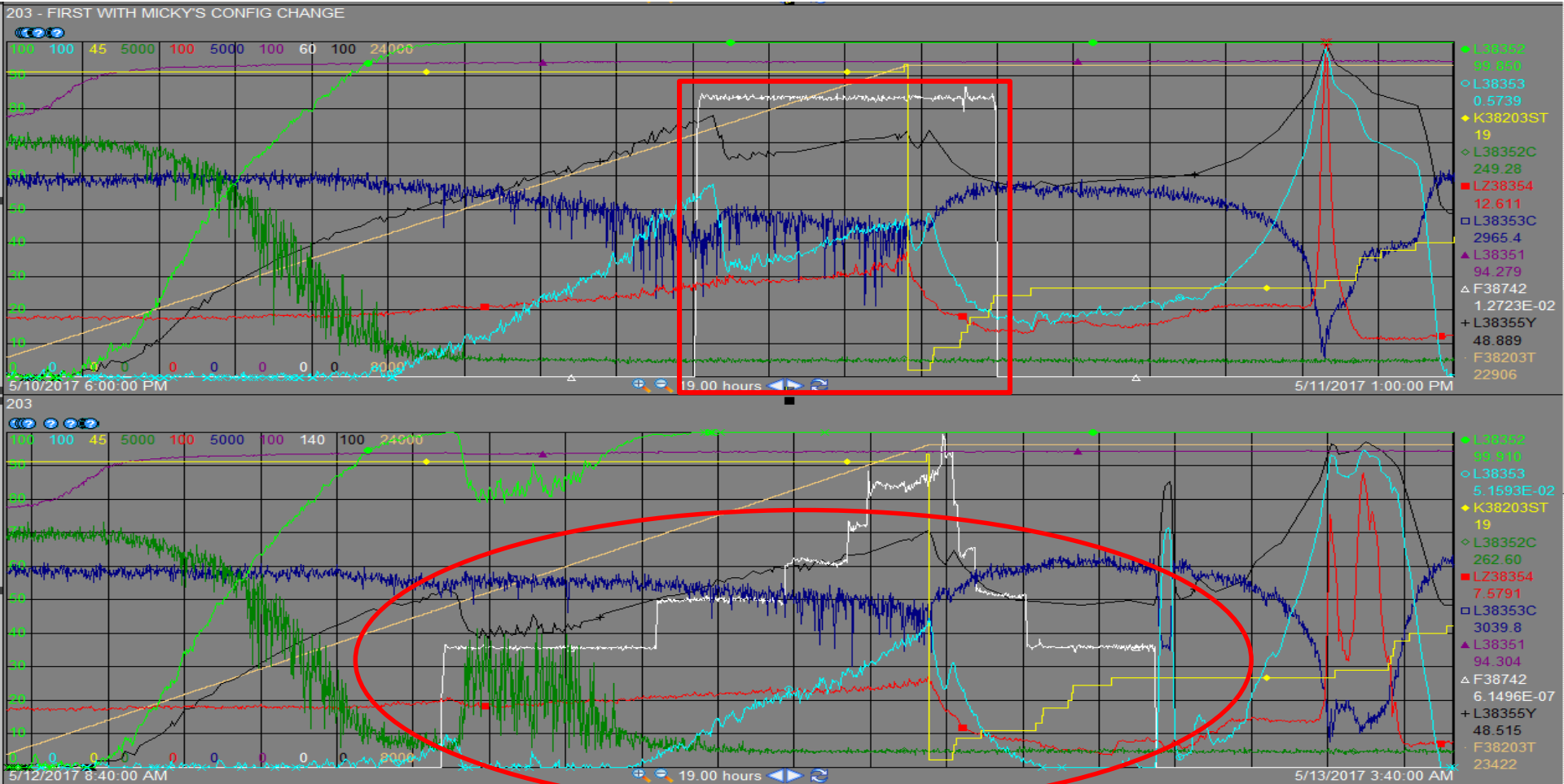
Foam up after switch



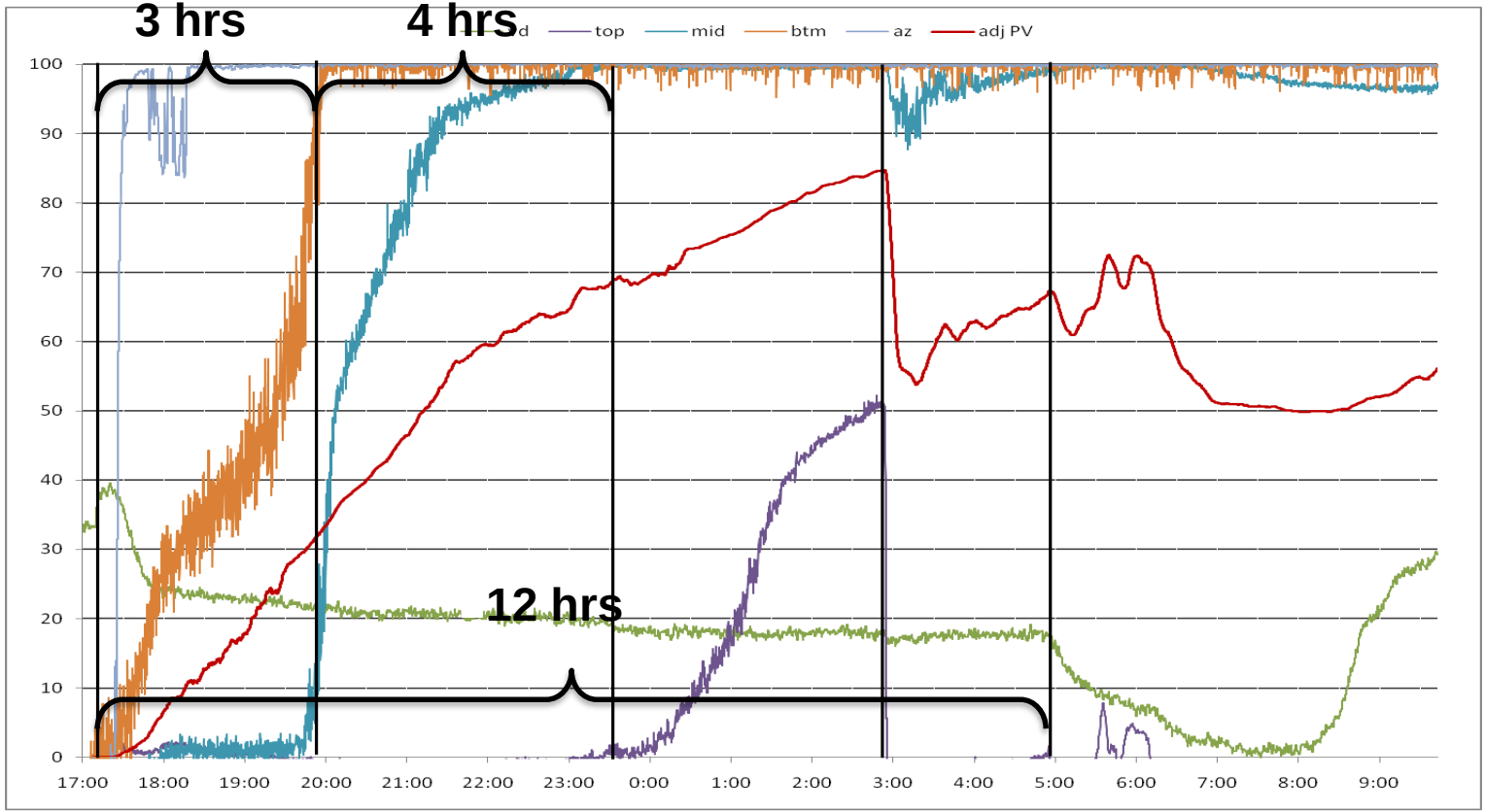
Different amount of foam at switch



Use of Anti-foam

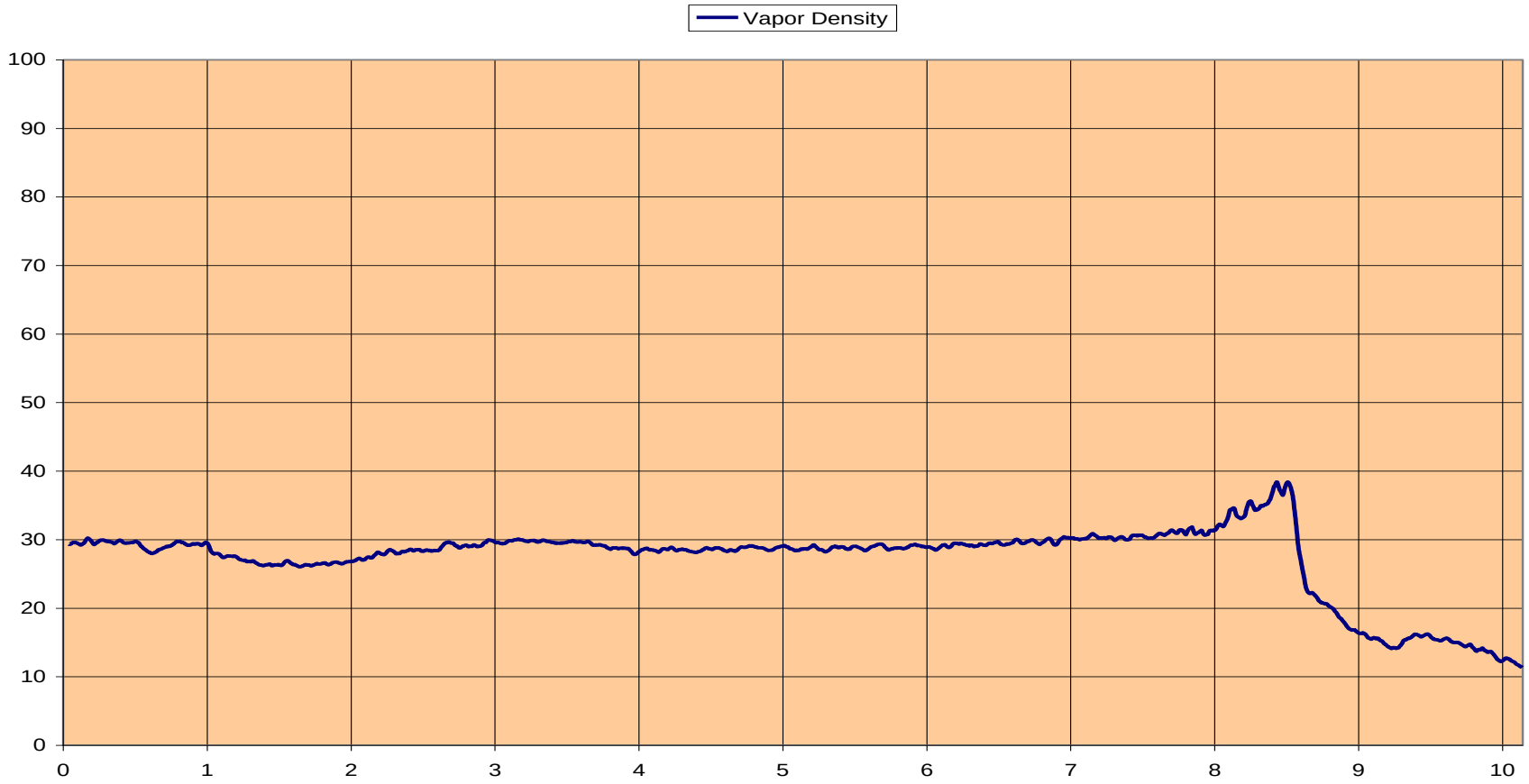


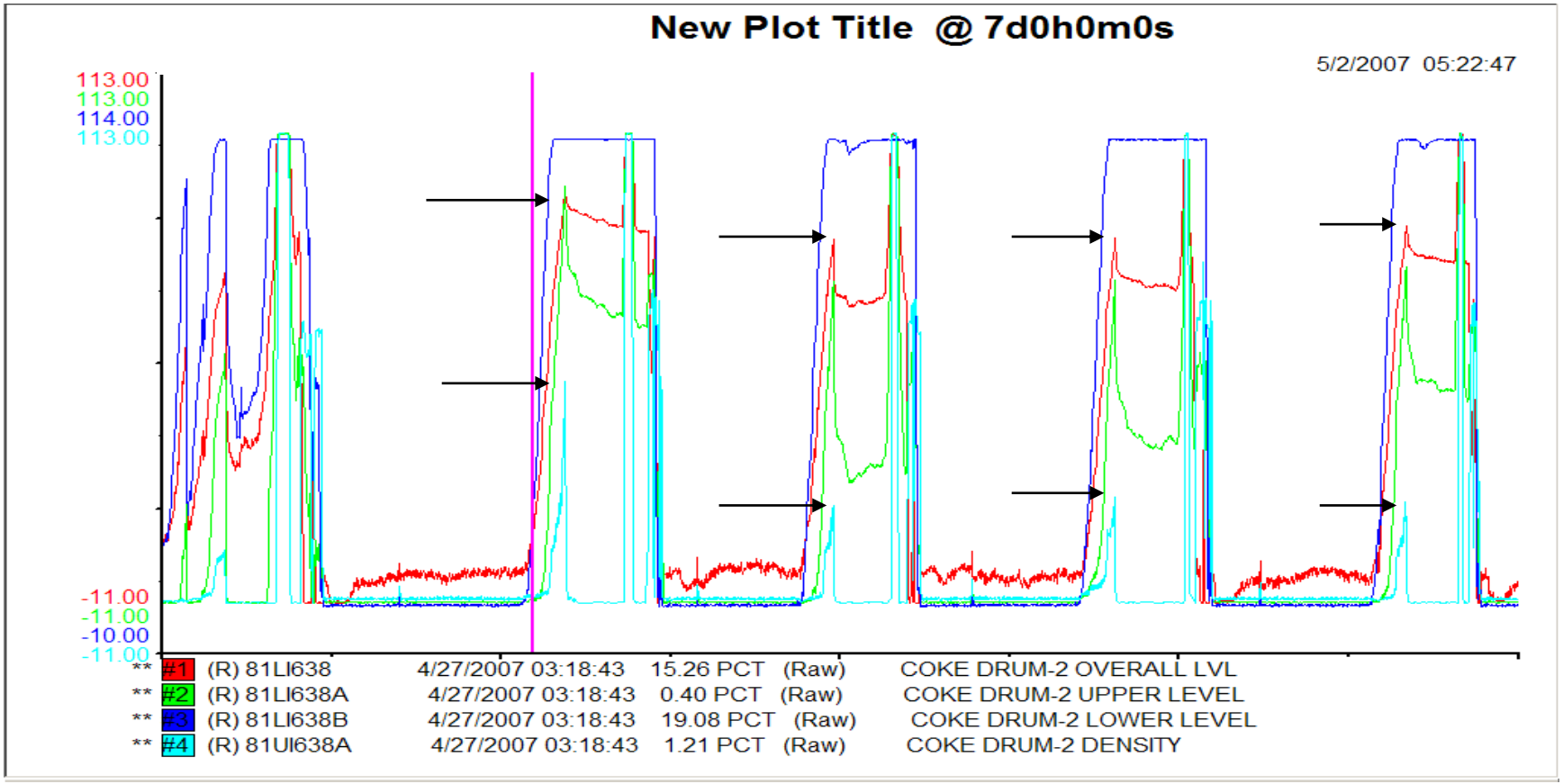
Level Tangent to Tangent (not linear) 20 meters total

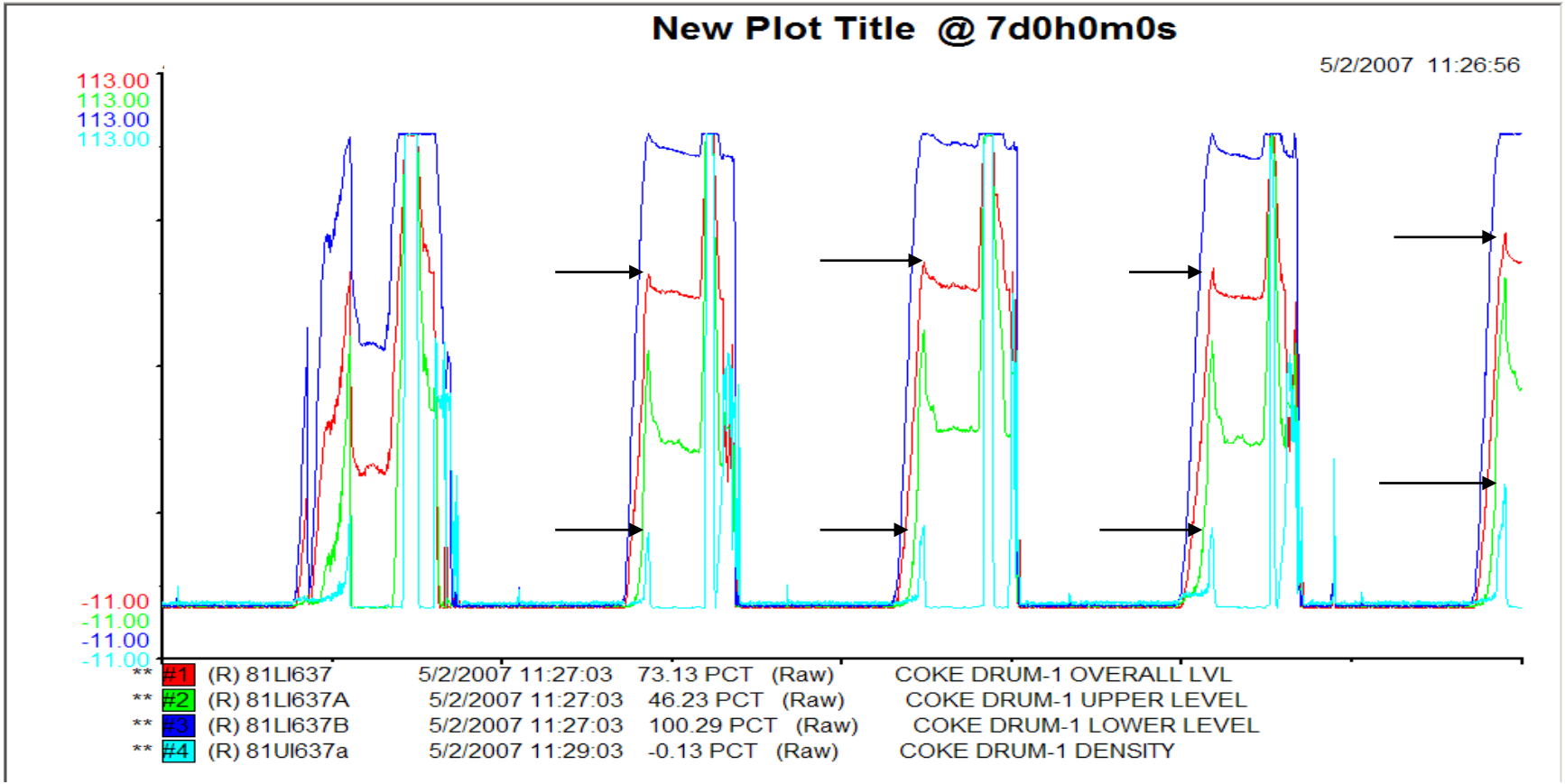


All level gauges are 6.7m long (all equal lengths)

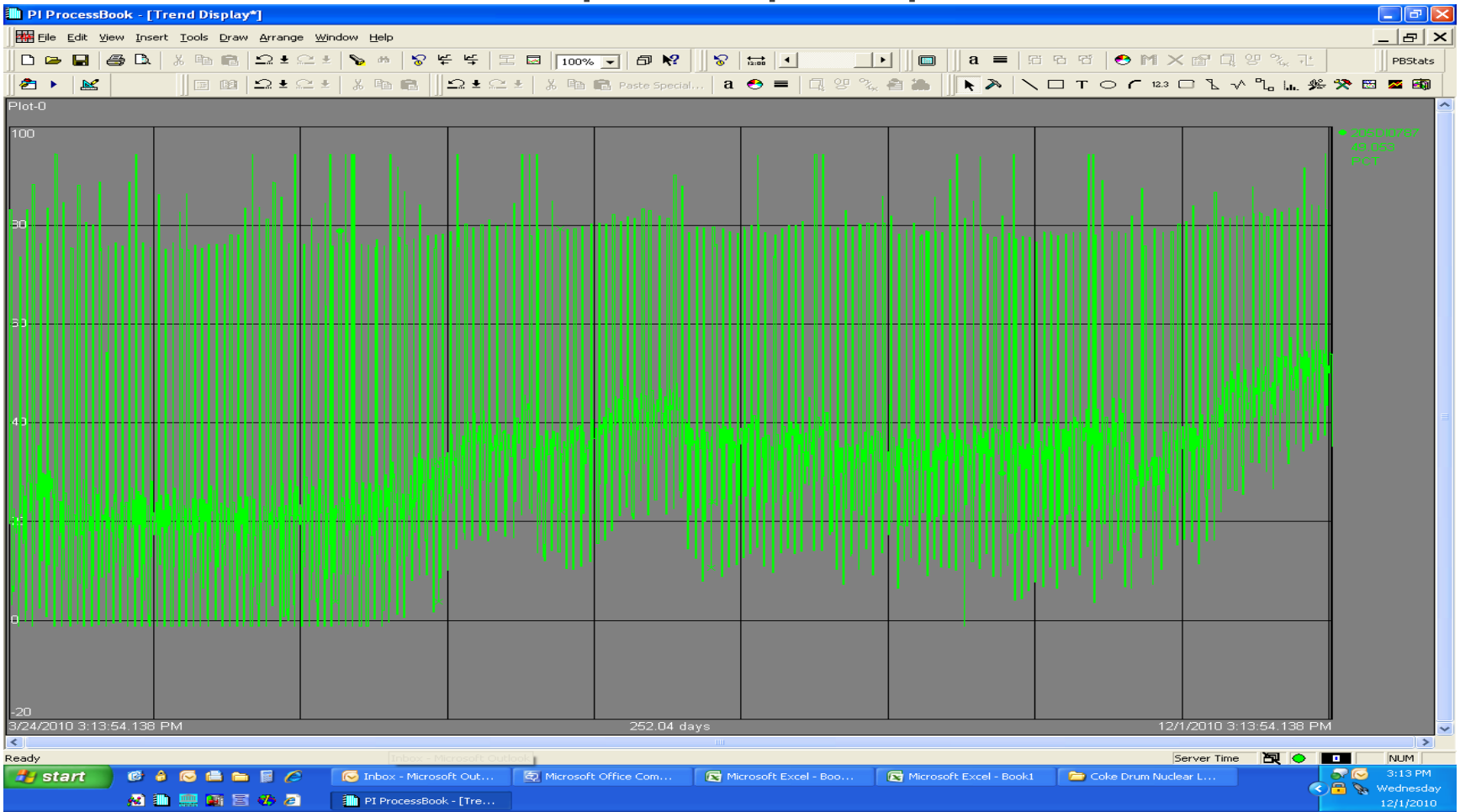
Vapor Carryover



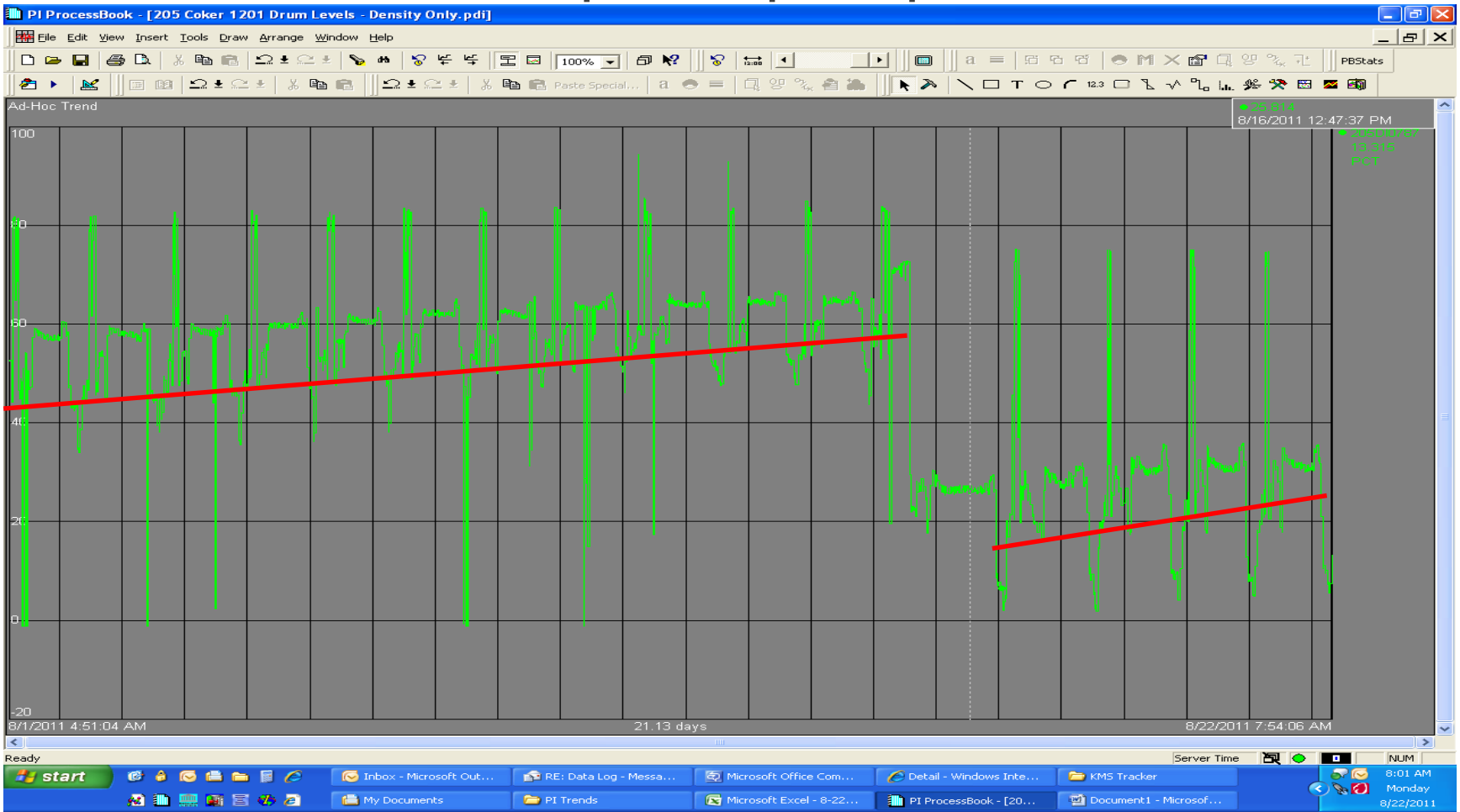

New Plot Title @ 7d0h0m0s
5/2/2007 05:22:47
113.00
113.00
114.00
113.00
-11.00
-11.00
-10.00
-11.00
** #1 (R) 81LI638 4/27/2007 03:18:43 15.26 PCT (Raw) COKE DRUM-2 OVERALL LVL
** #2 (R) 81LI638A 4/27/2007 03:18:43 0.40 PCT (Raw) COKE DRUM-2 UPPER LEVEL
** #3 (R) 81LI638B 4/27/2007 03:18:43 19.08 PCT (Raw) COKE DRUM-2 LOWER LEVEL
** #4 (R) 81UI638A 4/27/2007 03:18:43 1.21 PCT (Raw) COKE DRUM-2 DENSITY

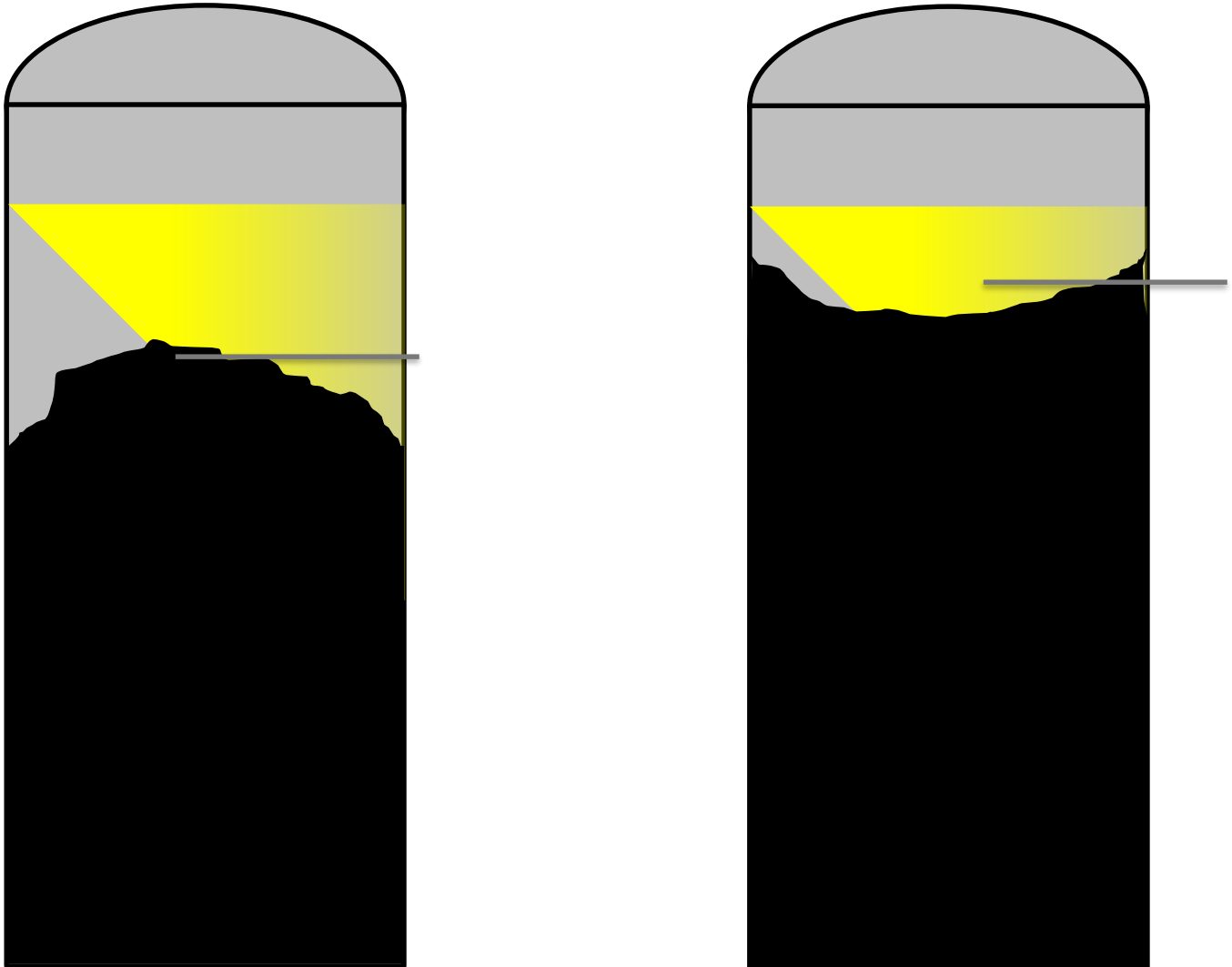

New Plot Title @ 7d0h0m0s
5/2/2007 11:26:56
113.00
113.00
113.00
113.00
-11.00
-11.00
-11.00
-11.00
** #1 (R) 81LI637 5/2/2007 11:27:03 73.13 PCT (Raw) COKE DRUM-1 OVERALL LVL
** #2 (R) 81LI637A 5/2/2007 11:27:03 46.23 PCT (Raw) COKE DRUM-1 UPPER LEVEL
** #3 (R) 81LI637B 5/2/2007 11:27:03 100.29 PCT (Raw) COKE DRUM-1 LOWER LEVEL
** #4 (R) 81UI637a 5/2/2007 11:29:03 -0.13 PCT (Raw) COKE DRUM-1 DENSITY

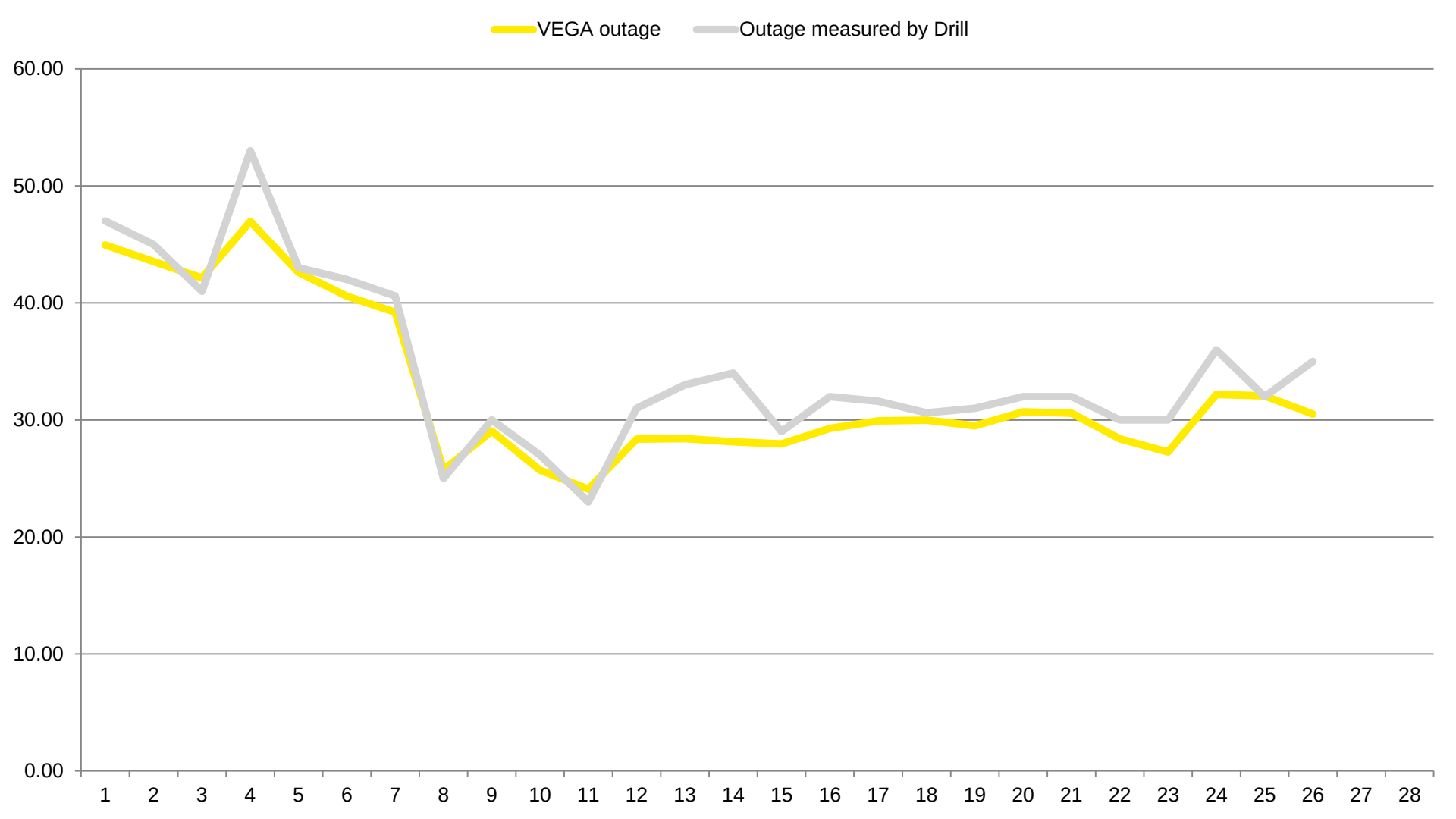
Buildup in vapor space



Buildup in vapor space






VEGA outage
Outage measured by Drill
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28