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Asphaltene Precipitation in Domestic Sweet

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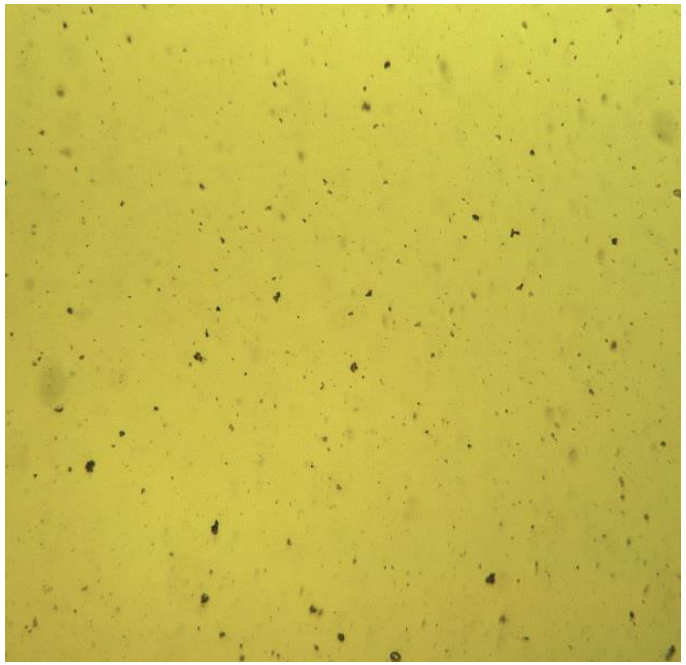
June 11, 2015

Overview

- Precipitated asphaltenes can cause storage tank and heat exchanger fouling, desalter upsets, high-temp furnace fouling, and residual fuel specification failures
- Samples of domestic sweet taken during 4Q2014 and 1Q2015 at Cushing, on the gulf coast, and at BP Whiting refinery were found to contain significant quantities of precipitated asphaltenes
- Some samples also showed an increase in total asphaltenes versus historic assays

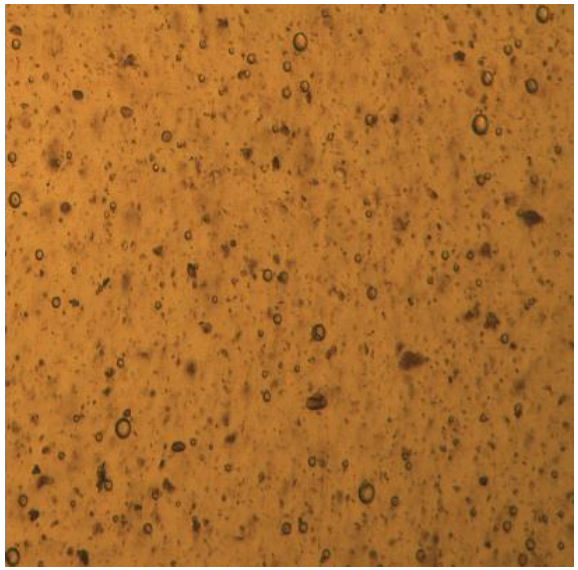
Micrographs of Domestic Sweet Crude



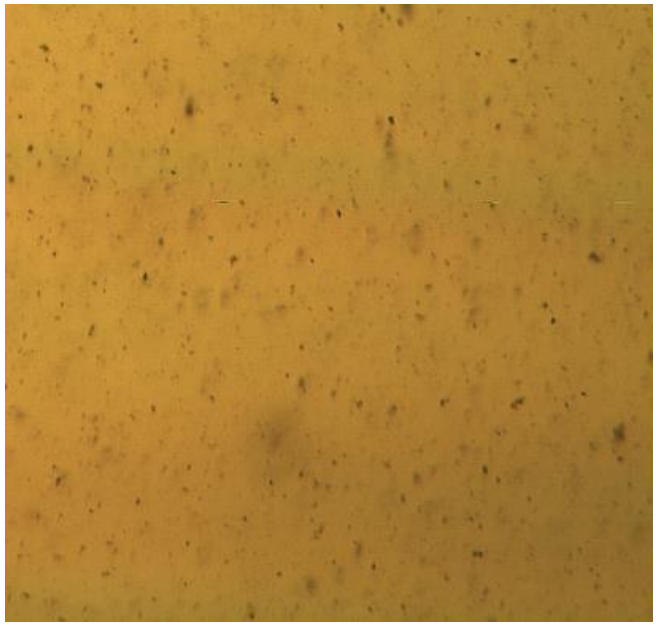
Low levels of asphaltenes in a sample at Cushing

High levels of asphaltenes in a sample at Cushing

Micrographs of Domestic Sweet Crude



Heavy precipitation in Domestic Sweet sampled on US Gulf Coast



Light precipitation in Domestic Sweet sampled on US Gulf Coast

Quantity of Precipitated Asphaltene

- Historical asphaltenes

Total Asphaltenes	
2000-2011	0.2-0.5%
2013-present	0.7 - 1.0%

- The precipitated asphaltenes seen in the preceding micrographs were collected and separated from inorganic sediment using a BP proprietary method.

- Precipitated asphaltenes:

Precipitated Asphaltenes	
low levels	~0.1%
high levels	0.2-0.4%

Discussion and Recommendations

- Analysis using a BP proprietary model has shown that the solvency requirements of the asphaltenes themselves have not changed significantly, but the Solvent Power of the crude oil has dropped to the point that the asphaltenes precipitate
- Such drop in Solvent Power are usually caused by addition of lighter or more paraffinic oils to a crude blend
- Tight oil production in the Permian basin and rail/pipeline delivery of other tight oils to Cushing with subsequent blending to domestic sweet are possible contributing factors
- Additionally, some of the asphaltene precipitation could be caused by blending small amounts of sour crudes (i.e. WTS or Canadian) in to domestic sweet.
- Domestic sweet gathering systems, storage terminals, and blenders should examine their processes to determine which oil sources are destabilizing the common stream, and improved segregation should be established to prevent degradation across the entire domestic sweet distribution system.

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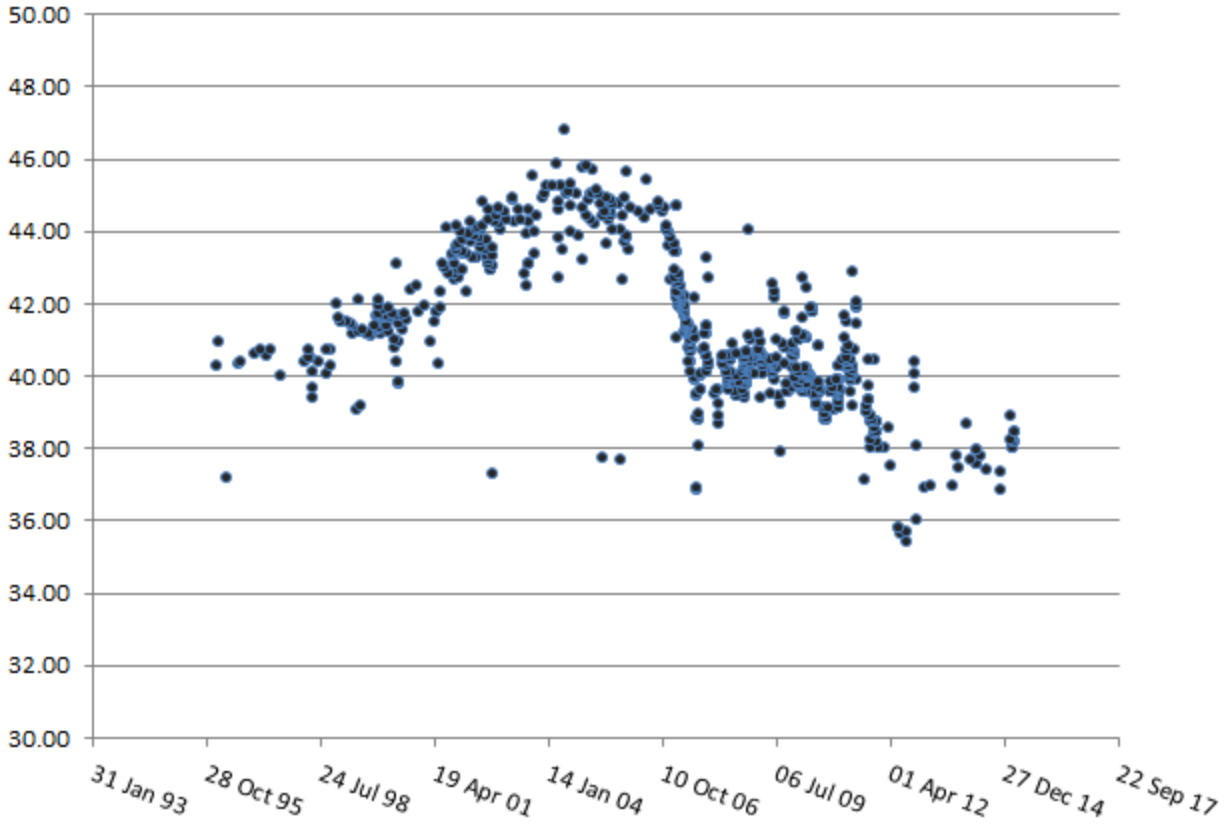
Crude Quality Trends

North Sea Quality Issues

- Forties
  - Equalization for producers of diverse quality oils
  - Quality monitoring for refiners and marketers
- Grade consolidations and blending
  - Optimize existing infrastructure
  - Blend away quality problems
- High acid crudes
- Chemical additives
  - Phosphorus
  - Amines

Forties API Gravity



Year:	1995	2003	2008	2012
WHOLE CRUDE INSPECTIONS				
GRAVITY, API	40.7	44.8	40	38.7
SULFUR, WT%	0.3	0.2	0.6	0.8
CRUDE DIST. YIELDS, VOLUME %				
C4 & LIGHTER	4.3	4.5	3.9	4.1
LT. VIRGIN NAPHTHA (180F EP)	10.9	12.7	11.1	10.7
REFORMER FEED (320F EP)	19.6	23.1	19.0	18.4
JET "A" FUEL DIST. (485F EP)	17.3	17.8	16.3	15.3
FURNACE OIL DIST. (650F EP)	16.2	15.8	15.6	15.9
FCU FEED	25.0	21.0	25.4	25.6
REDUCED CRUDE (1030+ TBP)	6.6	5.2	8.6	10.0
REFORMER FEED				
GRAVITY, API	55.5	55.3	56.2	56.4
AROM.+NAPH, VOL.%	49.9	48.5	46.4	45.5
JET "A" FUEL DIST.				
GRAVITY, API	42.5	45	44.1	43.5
NAPHTHALENE, VOL. %	2.5	1.99	1.95	1.9
FURNACE OIL DIST.				
GRAVITY, API	33.8	36	34.9	34.5
SULFUR, WT%	0.25	0.113	0.416	0.509
FCU FEED				
GRAVITY, API	24.7	27.5	25	23.5
SULFUR, WT%	0.607	0.37	1.07	1.25
NITROGEN, PPM	1090	757	1010	1130
REDUCED CRUDE				
GRAVITY, API	10.4	12.4	9.7	9.1
SULFUR, WT%	1.22	0.976	2.47	2.76
VANADIUM, PPM	15.7	24.9	72.7	81.3

Refining in America

- Supply Changes
  - Canadian imports to the Gulf
  - Shale Oil Expansion (Bakken, Niobrara, Permian, Eagle Ford, Marcellus/Utica)
  - Crude by Rail
  - Gulf of Mexico production recovery after the drilling moratorium
  - Reduction in imported oils from Latin America, Africa, and the Middle East
  - Storage and Blending terminal expansion

- Impacts
  - Many refineries considering or switching to new crudes they are not used to processing
  - Many new grades with shifting qualities from the shale plays
  - Opportunities for blending and dumbbelling on and off site
  - More oil types moving through terminals and pipelines – cross contamination, etc.

- Refiners have a lot of moving pieces to work with
  - it provides commercial opportunity
  - but creates risks that need to be managed