Email chain between Thomas Mullen and Matthew Stobart including a discussion of the “levers” available to manipulate the targeted methane number of LNG produced by the facility (10/4/2019)

Message

From: Mullen, Thomas [Thomas.Mullen@mcdermott.com]
Sent: 10/4/2019 12:38:56 PM
To: Stobart, Matthew E [Matt.Stobart@mcdermott.com]
Subject: RE: Updated Heat & Material Balance

Matt,

I have to revise my liquefaction number. In my haste I referenced the flow rate in GPM in my spreadsheet. So its 156 GPM accumulation or about 224k GPD. Much more palatable, hope this didn't affect your BBQ enjoyment and sleep!

From: Stobart, Matthew E
Sent: Thursday, October 3, 2019 4:00 PM
To: Mullen, Thomas <Thomas.Mullen@mcdermott.com>
Subject: Re: Updated Heat & Material Balance

Of course you know I realize it's 152kgal/day.

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From: Stobart, Matthew E
Sent: Thursday, October 3, 2019 3:54:07 PM
To: Mullen, Thomas <Thomas.Mullen@mcdermott.com>
Subject: Re: Updated Heat & Material Balance

We can talk about this tomorrow. The alarming thing in all this is the reduction in LNG production rate to 152GPD. Is that right? That's nearly 40% short of our current guarantee. They paid us about 8mil to make an adjustment to our design to account for heavier gas. Has it really gotten that much worse since that time? 152GPD!!!! We might be brewing a serious problem here. Yikes!!!!

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From: Mullen, Thomas <Thomas.Mullen@mcdermott.com>
Sent: Thursday, October 3, 2019 3:43:02 PM
To: Stobart, Matthew E <Matt.Stobart@mcdermott.com>
Subject: RE: Updated Heat & Material Balance

Matt,

For the composition provided by Jake here's a stab:

For the composition provided, we'd be interested to understand the calculation method for the Methane Number. For this composition we calculate either a 75.7 based on SAE Paper 9222359 and ISO 15403-1 or alternatively 82.2 based on the CARB (i.e. original Cummins) method. Note that we've been utilizing the former methodology to target a heavies cut temperature to produce a MN >80 for the LNG produced.

Based on the provided composition a heavies cut temperature of approximately -68F is utilized to produce an LNG with the following characteristics and a MN exceeding 80 (without contingency):

Methane	91.702
Ethane	6.939
Propane	1.018
i-Butane	0.071
n-Butane	0.054
C5+	0.006
Nitrogen	0.209

Here's a shot at a generalized technical explanation of what's happening: The Methane Number is in essence lowered by any component that is not Methane. In order to target a minimum methane number we need to extract non-methane constituents. We accomplish this via utilization of the originally designed heavies cut exchanger which partially condenses the feed stream which relies on the vapor/liquid equilibrium of the mixture to target heavier constituents. In this partial condensation there is a fair amount of methane dragged out with the liquid, see below for an example of the stream that is partially condensed based on the feed composition provided. Subsequently, when this partially condensed stream is warmed and reduced in pressure it does not remain as a liquid. The high concentration of C1 through C3 has raised the vapor pressure to around 200 psi. As the proportion of Ethane/Propane has gone up in the feed gas with coincidental reductions in C4+ (to keep the HHV level), the opportunity to extract hydrocarbons as liquid in V-802 diminishes.

	Liquefaction Cut				Fuel Drum V-801 @ 200 psi		
	Mix	Vapor	Liquid	➔	Mix	Vapor	Liquid
C1	90.159	91.702	40.297		40.297	40.765	3.568
C2	7.579	6.939	28.287		28.287	28.487	12.588
C3	1.587	1.018	19.999		19.999	19.926	25.729
iC4	0.195	0.071	4.184		4.184	4.085	11.958
nC4	0.203	0.054	5.037		5.037	4.855	19.331
iC5	0.033	0.004	0.983		0.983	0.894	7.951
nC5	0.022	0.002	0.680		0.680	0.608	6.347
C6	0.015	0.000	0.507		0.507	0.354	12.527

Under these conditions there are no liquids predicted to accumulate in V-802 for subsequent removal and the LNG production rate is on the order of 156k GPD. As you correctly surmise, the facility bottleneck with the increase in Ethane/Propane in the feed is the ability to dispose of the nearly 0.7 MMSCFD

produced by the heavies cut required to hit the target LNG methane number. The disposition of said heavies is, as you identified, first the fuel system and secondly the enclosed ground flare. In the fuel system we'd expect to be utilizing approximately 6 MMBTU/hr when not actively heating a dryer bed and about 7 when we are. We can push this by 1-1.5 MMBTU/hr if we artificially load the amine unit by increasing the circulation rate and reboiler load. The rest, about 37 MMBTU/hr goes to the flare.

We don't have a lot of levers left to manipulate, we can raise the operating pressure of V-801 to about 200 psi(g) in order to collect and discharge some liquid to V-802. In this instance we'd be able to collect maybe 100 gallons a day of liquid which only gains about 2k GPD of LNG production. About the only other thing to manipulate is the operating pressure and subsequently the vapor pressure of the NGLs in V-802, but that might be a hard sell to find someone to take pressurized liquid heavies; we're at diminishing returns here.

-Thomas

From: Mullen, Thomas
Sent: Thursday, October 3, 2019 1:08 PM
To: Stobart, Matthew E <Matt.Stobart@mcdermott.com>
Subject: RE: Updated Heat & Material Balance

I ran a test case earlier with some September data. We were accumulating zero NGLs in V-802.

From: Stobart, Matthew E
Sent: Thursday, October 3, 2019 1:03 PM
To: Mullen, Thomas <Thomas.Mullen@mcdermott.com>
Subject: Fwd: Updated Heat & Material Balance

Give this a think and we'll respond when I'm back in the office tomorrow or Monday.
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From: Stobart, Matthew E
Sent: Thursday, October 3, 2019 1:01:20 PM
To: Green, Jake <Jake.Green@pse.com>
Subject: Re: Updated Heat & Material Balance

Jake,
I'm on the road today, but will try to respond by tomorrow or Monday.
Matt

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From: Green, Jake <Jake.Green@pse.com>
Sent: Thursday, October 3, 2019 12:57:41 PM
To: Stobart, Matthew E <Matt.Stobart@mcdermott.com>
Subject: Updated Heat & Material Balance

Matt,

I'm working internally on this end about Heavies management.

Considering the variation in feed-gas stock it would aid me immeasurably to know where we stand with estimated Heavies volumetric liquid flow rates during liquefaction with the current below feedstock.

	HHV	N2	CO2	Methane	Ethane	Propane	Ibutane	Nbutane	Ipentane	Npentane	Hexanes	Methane Number
Sumas September												
Average 2019	1102.6	0.203167	0.307167	89.88453	7.556033	1.582267	0.193867	0.202633	0.0329	0.0222	0.015333	76.8

I have reviewed Thomas' email from February with updates and do have several questions. He states there would be Zero heavies creation. While Butanes+ with the September 2019 are proportionally less than original or alternative feed stock design points, does this preclude ***any*** heavies creation at all? Help me understand the physics here if I'm misguided in thinking there should be less, but not Zero.

Am I also to understand that with such a high Ethane/Propane composition that the fuel gas system utilizing the first cut gas is essentially being 100% supplied by this composition; that in-fact there's so much Ethane/Propane that thermally oxidizing becomes the required next destination for the remaining balance and that because there is such quantities that we become BTU limited on our flair and subsequently need to either turn-down liquefaction rates or tweak Amine system settings to consume extra fuel.

Any updates would aid me greatly. Call if it's easier. Thanks.

Jake Green, P.E. | Sr. Project Manager
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