Magee, Melanie

From: Carlson, Larry <LCarlson@TENASKA.com>
Sent: Thursday, April 10, 2014 12:18 PM
To: Randy Hamilton
Cc: Latha Kambham
Subject: RE: Brownsville CO2 emissions

Randy-

It appears the discrepancy in the lb/MMBtu CO_2 values at 20 deg F vs the other ambient cases is in error. The CO_2 lbs/hr data included in the table (see below) were supplied by MHI and calculated based upon exhaust mass flow multiplied by CO_2 concentration. The values (at all ambients other than 20 deg) included a nominal 6% margin applied by MHI to account for uncertainty and variation in exhaust flow rate, CO concentration (i.e., degree of combustion completeness), fuel carbon content, and other factors that could affect a combustion-based calculation. The hourly data contained in the table for the 20 deg F cases do not include the 6% margin. An example calculation for the 20 deg F/100% load case is below:

CT exhaust flow: 5,339,000 lbs/hr x $6.39\%_{weight}$ CO_2 = 341,162 lbs CO_2/hr [same value shown in the table]

341,162 lbs CO_2/hr x 1.06 = 361,632 lbs CO_2/hr ÷ 2,903 MMBtu/hr = 124.57 lbs CO_2/MMBtu [similar to the values for the other ambient cases]

Ambient		Inlet Air	Output Load			Heat Input - MMBtu/hr			Heat Rate		CO_2		
Dry Bulb	RH	Air	CTG	CTG	STG	DB	Total (CT+DB)		CT	CT+ST	lb/MMBtu		
°F	%	Cooling	%	MW_{gross}	MW_{gross}	HHV	HHV	LHV	Btu/kWh - LHV		HHV	lbs/MWh	lb/hr
20	72.5	OFF	100	305	174	250	3,153	2,842	8,566	5,923	117.5	772	370,435
20	72.5	OFF	100	305	148	0	2,903	2,616	8,566	5,768	117.5	752	341,162
20	72.5	OFF	75	229	113	0	2,228	2,008	8,769	5,880	117.3	765	261,323
20	72.5	OFF	50	153	98	0	1,699	1,531	10,039	6,107	117.1	793	198,912
62	79.1	ON	100	274	168	250	2,890	2,604	8,629	5,894	124.4	814	359,612
62	79.1	OFF	100	274	142	0	2,620	2,361	8,629	5,677	125.4	790	328,503
62	79.1	OFF	75	203	106	0	2,046	1,844	9,070	5,956	124.7	824	255,148
62	79.1	OFF	50	135	93	0	1,579	1,423	10,510	6,241	124.8	864	197,009
84	69.7	ON	100	258	165	250	2,774	2,500	8,811	5,913	124.4	816	345,118
84	69.7	ON	100	258	135	0	2,524	2,274	8,811	5,782	124.4	798	314,009
84	69.7	OFF	75	189	104	0	1,952	1,760	9,307	6,013	124.4	830	242,828
84	69.7	OFF	50	126	91	0	1,518	1,368	10,866	6,310	125.2	876	189,986
106	28.9	ON	100	254	164	250	2,743	2,472	8,843	5,920	124.6	818	341,740
106	28.9	ON	100	254	133	0	2,493	2,247	8,843	5,799	124.5	801	310,279
106	28.9	OFF	75	173	99	0	1,839	1,657	9,578	6,087	124.8	843	229,578
106	28.9	OFF	50	115	89	0	1,464	1,319	11,450	6,475	125.4	901	183,552

As discussed, we did not base the hourly CO_2 emission rates on the lb/MMBtu values, as those were merely calculated by us using the MHI-supplied hourly mass rates divided by the MHI-supplied heat input rates. If we are to demonstrate compliance with the BACT limit by using equation G-4 from Part 75 (see below) to calculate hourly CO_2 emission rates and then divide by hourly gross output, equation G-4 results in a factor of 118.9 lbs/MMBtu if the default F_c factor of

1,040 is used or approximately 117.3 lb/MMBtu if a site-specific F_c factor (1,026) is calculated (which is required by other permits I have seen). The un-margined values have a calculated factor of approximately 117.5 lb/MMBtu at base load.

Two example calculations using the 20 deg F ambient un-fired base load case from the table above (2nd row from top), one using the default F_c factor and one using a calculated site-specific F_c factor (calculated using the project design fuel, not a worst-case high-Btu fuel), are below. Therefore, we propose to use the margined values (the 20 deg F values will need to be revised) to account for variations in the site-specific F_c factor (i.e., fuel carbon content/GCV) that could exceed the associated 117.5 lb/MMBtu factor.

$W_{lbs/hr}$ = **1,040** x 2,903 ÷ 385 x 44.0 = 345,042 lbs/hr [exceeds 341,162 value in table above]… 345,042 lbs/hr ÷ 2,903 MMBtu/hr = 118.9 lb/MMBtu

$W_{lbs/hr}$ = **1,026** x 2,903 ÷ 385 x 44.0 = 340,397 lbs/hr [99.8% of 341,162 value in table above]… 340,397 lbs/hr ÷ 2,903 MMBtu/hr = 117.3 lb/MMBtu

$$W_{CO_2} = \left(\frac{F_c \times H \times U_f \times MW_{CO_2}}{2000} \right) \quad (Eq.\ G\text{-}4)$$

(Eq. G-4)

Where:

WCO_2 = CO_2 emitted from combustion, tons/hr.

MW CO_2 = Molecular weight of carbon dioxide, 44.0 lb/lb-mole.

F_c = Carbon based F-factor, 1040 scf/mmBtu for natural gas; 1,420 scf/mmBtu for crude, residual, or distil other gaseous fuels.

H = Hourly heat input in mmBtu, as calculated using the procedures in section 5 of appendix F of this part.

Uf = 1/385 scf CO2/lb-mole at 14.7 psia and 68 °F.

From: Carlson, Larry
Sent: Monday, April 07, 2014 3:42 PM
To: randy.hamilton@tceq.texas.gov
Cc: Latha Kambham
Subject: Brownsville CO2 emissions

Randy-
Following up on our conversation Friday, I discussed the discrepancy with our engineers. They spoke with MHI this afternoon and MHI would like to add it to the agenda for the already-scheduled meeting here on Wednesday with our engineering staff. Therefore, we should have an answer late in the day or Thursday a.m.

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Larry G. Carlson, QEP
Director, Air Programs

TENASKA INC.
14302 FNB Parkway | Omaha | NE | 68154-5212
o: 402.938.1661 | c: 402.203.5263 | f: 402.691.9530
LCarlson@TENASKA.com

ADDRESS CHANGE NOTICE

Effective March 31, 2014, Tenaska and its affiliates are moving Omaha offices. Among the affected companies are Tenaska, Inc. (corporate), Tenaska Capital Management, LLC, Tenaska Commodities, LLC, Tenaska Gas Storage, LLC, Tenaska Marketing Ventures, and Tenaska NG Fuels, LLC.

Our new address will be:
14302 FNB Parkway
Omaha, NE 68154

Please update your records accordingly. Our phone, fax and email will remain the same.

www.tenaska.com