Effect of Synthesis Gas Quality on Yields

From the Case 6 design breakdown of the reactor effluent previously submitted, it was found that the total C_3+ yield (including WSC) per MM SCFH of syn. gas feed predicted was 36.22 Bbls. This was for a synthesis gas that was quite different from that now being produced at Brownsville.

Shown in the following Table C are randomly selected analyses of the synthesis gas in various runs compared with that predicted in design.

On Nov. 29, 1951, the end of Run 13, the practice of adding about 15% steam to the natural gas feed to the generator in order to reduce soot formation was started. It will be noted that this made a perceptible difference in the syn. gas composition, H_2/CO ratio and H_2+CO purity as shown below.

	Design	Average Runs #13 & #16 Incl. with Steam	Average Runs #6 & #12 Incl.* No Steam
Syn. Gas Rate MMSCFH	5.0	3.18	3.10
Mol % Dry: CO	33.23	31.73	33.27
H_2	61.35	59.78	60.15
CO_2	1.31	3.90	2.97
N_2+A	3.01	2.12	1.94
CH_4	1.10	2.47	1.80
H_2/CO	1.845	1.88	1.81
(H_2+CO)%	94.2	91.5	93.42

* Run #8 Excluded

TABLE C

COMPARISON OF FRESH FEED COMPOSITIONS

Run #			#16		#15		#14			#13	
Date	Design		2/22/52	2/29/52	2/3/52	2/10/52	1/11/52	1/21/52	1/22/52	12/23/51	12/30/51
Syn. Gas Rate											
MMSCF	Wet	Dry	4.06	3.30	2.856	2.663	2.646	3.354	3.771	2.999	2.990
A			.65	.63	.69	.69	.73	.68	.65	.73	.70
CO	33.1	33.23	30.92	32.34	32.20	31.43	31.74	31.62	31.69	32.08	31.56
H_2	61.1	61.35	59.70	58.98	59.65	60.14	59.58	60.23	60.08	59.82	59.87
CO_2	1.3	1.31	4.63	3.87	3.71	4.01	3.90	3.63	3.77	3.71	3.84
N_2	3.0	3.01	1.34	1.60	1.31	1.11	1.45	1.68	1.38	1.43	1.61
CH_4	1.1	1.10	2.76	2.58	2.44	2.62	2.60	2.16	2.43	2.23	2.42
H_2O	0.4	-									
	100.0	100.00									
H_2/CO	1.845		1.93	1.81	1.85	1.91	1.88	1.90	1.90	1.86	1.90
$(H_2+CO)\%$	94.2		90.62	91.32	91.85	91.57	91.32	91.85	91.77	91.90	91.43

Run #	#12		#11		#10		#9		#8		#6	
Date	11/30	12/5	11/12	11/17	7/21	7/29	6/6	6/8	4/25	5/8	3/15	3/18
Syn. Gas Rate	3.03	2.81	3.00	3.05	2.51	2.67	2.81	4.77	3.07	3.46	3.24	3.06
A	.69	.68	.65	.71	.66	.61	.67	.71	.74	.79	.74	.73
CO	33.48	32.14	32.88	34.03	32.66	34.42	33.31	33.93	34.70	34.95	33.30	32.51
H_2	59.77	59.86	60.89	59.97	60.93	60.56	60.93	60.42	58.40	58.05	58.63	59.52
CO_2	3.06	3.88	2.87	2.69	2.65	2.49	2.74	3.07	2.94	2.58	3.12	3.09
N_2	.93	1.41	1.04	1.08	1.08	.88	1.07	1.18	1.00	1.45	1.88	1.95
CH_4	2.07	2.03	1.67	1.52	2.02	1.04	1.28	0.69	2.22	2.19	2.33	2.23
H_2/CO	1.79	1.86	1.85	1.76	1.87	1.76	1.83	1.78	1.68	1.66	1.76	1.83
$H_2+CO)\%$	93.25	92.00	93.77	94.00	93.59	49.80	94.24	94.35	93.10	93.00	91.93	92.03

If it is assumed that steam will continue to be added to the generator to control soot formation the syn. gas will contain only 90.32 of H_2+CO having an H_2/CO ratio of 1.845, assuming the extra hydrogen is not beneficial, thus

$$\% \text{ CO} = 31.73 \times 1.845 = 58.6 = \% \text{ Effective } H_2$$

$$31.73 + 58.6 = 90.3\% \ H_2+CO$$

It follows therefore that the anticipated yield of C_3+/MMSCF of synthesis gas must be reduced to 90.3/94.2 = 95.9% of that originally anticipated due to inferior synthesis gas composition. This amounts to 34.73 Bbls/MMSCF of syn. gas.

Similarly if steam is not added the syn. gas will contain 92.1% of H_2+CO of 1.845 H_2/CO ratio and the anticipated yield must be reduced to $\frac{92.1}{94.2}$ = 97.82 of that predicted (35.42 Bbls/MMSCF FF). Roughly therefore some 3 or 4 percentage points of the discrepancy between anticipated and actual yields of C_3+/MMSCF of syn. gas at Brownsville can be accounted for by differences in the synthesis gas compositions.

Incidentally, it is noted that the Nitrogen plus Argon in the Brownsville gas is consistently less than that predicted. This is because it was assumed in design that the nat. gas would contain 5% N_2 whereas this has been running consistently at 0.3 to 0.5%.

On the above Fig. C we have also shown vertical lines representing the space velocity required per reactor for the present production of syn. gas (abt. 3,000,000 SCFH/Reactor) and that required ultimately for the design rate of 5,000,000 SCFH for each reactor. These values were developed as follows: