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To G. L. Foshee, Lake Charles, Louisiana

From R. W. Churns, Ponca City, Oklahoma

Date January 23, 1979

Subject Oxy Vent Gas Cleanup

/ VCM plant

As part of the Louisiana Air Control Commission's State Implementation Plan, the VCM plant is expected to reduce the quantity of hydrocarbons in the oxy vent by a minimum of 65 percent. Present regulations call for compliance by October 1981. The following table lists capital costs and annual operating costs (both with and without capital charges for a 10 percent DCF) for the alternates considered:

Process	Capital Cost, $	ANNUAL OPERATING COST, $ (1)	(2)
Solvent Absorption	2,600,000	(108,000)	398,000
Oxygen-Based Oxy	2,870,000	1,917,000	2,465,000
Carbon Adsorption	3,170,000	(28,000)	577,000
Catalytic Oxidation	3,420,000	354,000	1,007,000

(1) Total operating cost ex depreciation.
(2) Total operating cost including depreciation and capital charges for a 10 percent DCF.

Solvent absorption has the lowest capital cost and the lowest operating cost. It is, therefore, the most attractive (or least unattractive) of the proposals and is recommended.

There are two additional considerations that would cause me to recommend oxygen-based oxy over solvent absorption in spite of the higher capital and operating costs and the fact that it is not commercially proven. Solvent absorption does not remove VCM from the vent stream. If a requirement to reduce the VCM to 5 or 10 ppm were imposed at a later time, one of the other three alternates would have to be installed either in place of or along with solvent absorption. Oxygen-based oxy also has the advantage of increasing the capacity of the oxy section. I believe that at least 50 MM pounds per year of additional VCM could be produced with minor changes outside of the oxy section. If it is believed that either of the above considerations are true, I recommend proceeding with oxygen-based oxy at this time.

I am prepared to discuss these conclusions at anytime.

RW Churns

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File A-27.1

DISCUSSION

ECONOMIC EVALUATION

OXY VENT GAS CLEANUP

LAKE CHARLES VCM PLANT

As part of the Louisiana Air Control Commission's (LACC) State Implementation Plant (SIP), the VCM plant is expected to reduce the quantity of hydrocarbons in the oxy vent by a minimum of 65 percent. The present regulations call for compliance by October 1981. Four possible solutions for achieving this reduction have been investigated:

1. Solvent absorption
2. Converting oxy to oxygen-based
3. Carbon adsorption
4. Catalytic oxidation

None of these solutions can be economically justified on EDC recovery or cost savings. As shown in Table I, solvent absorption has the lowest capital cost and the lowest operating cost. It is, therefore, the most attractive (or least unattractive) proposal and is recommended.

The present regulations make it advantageous to have a system which can operate at a 65 percent hydrocarbon reduction but can achieve a higher reduction with operating changes or minor design changes. Solvent absorption and carbon adsorption (with some difficulty) can do this. Oxygen-based oxy and catalytic oxidation, for all practical purposes, can only operate at 100 percent hydrocarbon reduction.

At this time, the VCM plant oxy section must, in addition to the hydrocarbon reduction called for in the Louisiana SIP, comply with the EPA VCM standard of 0.0002 pound VCM per pound of 100 percent EDC product from oxy. We are presently in compliance with this regulation. It is not unreasonable to expect that EPA may at some future time impose the same restrictions (5 or 10 ppm VCM) on oxy reactors as on other parts of VCM plants. Oxygen-based oxy, carbon adsorption (possibly), and catalytic oxidation systems can all reach this level. Solvent absorption will not remove more than a small part of the VCM.

Oxygen-based oxy enjoys an advantage not possessed by the other alternates in that it permits an increase in oxy section throughput. Because the capacity of the VCM plant is limited by the amount of HCl that can be consumed in oxy, this increase leads to an increase in VCM production. Subject to confirmation by more detailed calculations, I believe that an increase in VCM production of at least 50 MM pounds per year can be achieved with little or no capital investment outside of the oxy section. Table II shows the amount of incremental VCM that must be produced to justify the investment in oxygen-based oxy. This table includes calculations at different oxygen prices, capital investments, VCM netbacks, and returns on investment. An incremental VCM production of 63 MM pounds per year will bring a 15 percent DCF return on an investment of $4.3 MM at an oxygen price of $60 per ton and a VCM netback of $0.05 per pound. This potential capacity increase, coupled with the ability to eliminate VCM emissions, makes oxygen-based oxy an attractive alternate. If it is believed that more stringent VCM regulations will be in effect soon, I recommend choosing the oxygen-based oxy alternate for oxy vent gas cleanup.

Solvent Absorption

Two variations of solvent absorption were considered. Each could be operated to remove either 65 percent or 90 percent of the oxy vent stream hydrocarbons. One scheme took the oxy vent gas from S-306 after it had been condensed against cooling water in H-305. This reduced the load on the propylene refrigeration system by eliminating the refrigerated after-condenser, H-306, from the system. The other scheme used oxy vent gas from S-307 after it had been condensed against propylene refrigerant in H-306. The latter approach was selected because it had a lower capital cost and a lower operating cost (primarily steam to the EDC stripper reboiler) than the first one.

EDC is removed from the oxy vent gas by being absorbed in the solvent, a narrow-cut, aromatic distillate. The vent gas passes through a separator vessel (the spare S-307) to knock out entrained HCl. It enters EDC absorber C-350 below the bottom tray and passes through the column coutercurrent to the solvent. Rich solvent from the bottom of the absorber exchanges heat with lean solvent from the bottom of the EDC stripper, C-351, in spiral solvent interchangers H-351A and B. Lean solvent is fed to the top tray of the EDC absorber. Rich solvent is fed below the center of the EDC stripper. Heat to the stripper is provided by 250 psig steam in a vertical thermosyphon reboiler. The overhead vapors are partially condensed against cooling water. The liquid is returned to the column as reflux.

The vapor is recovered by compression with liquid ring compressors using cold EDC as the seal fluid and condensation against propylene refrigerant. The liquid product is sent through the existing washing and distillation sections where EDC is recovered as furnace feed and light ends (ethyl chloride) is recovered for sales or incinerator fuel.

This system has the advantage of being a proven process, as it is a part of the B. F. Goodrich and Ethyl VCM packages. This may lead to legal difficulties, as both of them have disclosed their processes to us and Toyo Soda hold a U.S. patent on this process. This system has no effect on VCM, ethylene, or carbon monoxide. It has the lowest capital and operating costs of any of the alternates.

Oxygen-Based Oxy

This proposal eliminates hydrocarbons in the oxy vent stream by replacing air as the oxidant with pure oxygen. This reduces the size of the vent so that it can be handled in the existing incinerators. This process is different from the others in that it changes the oxy system rather than treating the vent gas and leaving oxy as is.

Oxygen-Based Oxy (Continued)

In the revised process, HCl, oxygen, fresh ethylene, and recycle ethylene are fed to the existing primary oxy reactors. Product EDC and water are condensed against cooling water and sent to the existing wash system. Noncondensables, including ethylene, which has replaced nitrogen as the diluent, are scrubbed with caustic and compressed. Most of this stream is recycled to the reactors. A purge stream is dried by condensing the water against propylene refrigerant and by dessicant. This stream is sent to the direct chlorination reactor where the ethylene reacts to form EDC. Inerts, including CO and CO_2, are vented from there to the existing incinerator system. This system is based on a proposal from Stauffer who have done pilot work on it. There is no operating prototype for this design, although Stauffer have told us that Shell have purchased equipment to convert their oxy to this type. PPG, Monsanto, Kellogg, and Mitsui Toatsu license and operate oxygen-based oxy processes.

The advantages of this proposal are that it allows an increase in VCM production, reduces oxy by-product formation, and reduces the size of the oxy vent gas stream, thus allowing it to be incinerated. At the time of Fluor's work on the VCM expansion, the plant capacity was limited by oxy, propylene refrigeration capacity, the EDC vaporizers, and the heavy ends column. Since then a new turbine has been purchased for the propylene compressor. New convection sections have been installed in the cracking furnaces, thus unloading the EDC vaporizers. The EDC tar still overhead stream has been taken out of the caustic wash, thus improving the heavy ends column feed quality. With the removal of oxy bottlenecks and subject to confirmation by more detailed calculations, I believe that an increase in VCM production of at least 50 MM pounds per year is possible. A reduction in oxy by-product formation results from eliminating the cleanup reactors. This replaces EDC produced in the low efficiency cleanup reactors with EDC produced in the direct chlorination reactor. EDC from the primary oxy reactors should also improve in quality by increasing the ethylene concentration and driving the reaction to EDC. This advantage was not considered in the economic calculations. The oxy vent gas stream goes to the direct chlorinator where the ethylene reacts to form EDC. Inerts present increase the size of the direct chlorinator vent stream but should not overload the incinerators.

At the prices used, this project is economically attractive with an incremental VCM production of 53 MM pounds per year. This is highly dependent on oxygen price. If \$30 per ton O_2 is used instead of \$60 per ton, the incremental VCM production required falls to 22 MM pounds per year.

Carbon Adsorption

The carbon adsorption scheme is similar to those considered for PVC plants. Chlorinated hydrocarbons are adsorbed onto activated carbon sites as the oxy vent gas passes through the carbon beds. The hydrocarbons are desorbed by heating the bed through an internal steam coil and evacuating the vessel

Carbon Adsorption (Continued)

with a vacuum pump. EDC and light ends are recovered by condensation against propylene refrigerant. The bed is then cooled to be put back in service.

Carbon adsorption can achieve either 65 or 95 percent reduction in the hydrocarbon content of the vent gas. It will reduce the VCM to acceptable levels but has little effect on CO or ethylene.

Catalytic Oxidation

Catalytic oxidation reduces the hydrocarbon content of the vent stream by converting the chlorinated and nonchlorinated hydrocarbons to HCl, CO_2, and H_2O. It is similar to conventional incineration except that the catalyst allows the oxidation to take place at a lower temperature, thus reducing the size and fuel requirements of the equipment. We evaluated catalytic oxidation following the oxy system and also after solvent adsorption. The solvent adsorption step reduced the organic load and thus the size and operating cost of the reactor and HCl recovery system. This alternate was selected.

In this process, air and the oxy vent gas are separately preheated in a furnace. They are mixed and fed to a reactor containing the catalyst. Reactions to HCl, CO_2, and H_2O take place in the reactor. The heat of reaction is removed by generating 250 psig steam. The reactor effluent goes to C-500 where the reaction is quenched and HCl is scrubbed out.

This approach has the highest capital cost and one of the highest operating costs. Solvent absorption and catalytic oxidation costs must be added to arrive at the total capital and operating costs. This approach eliminates all hydrocarbon air pollution from oxy.

RWC-lkm
1/23/79

TABLE I

SUMMARY

OXY VENT GAS CLEANUP

LAKE CHARLES VCM PLANT

TITLE	ORIGINAL ESTIMATE MECHANICAL COMPLETION	ORIGINAL ESTIMATE CAPITAL COST ($)	ESCALATED CAPITAL COST ($)(1)	OPERATING COST ($/YR) CAPITAL EXCLUDED	OPERATING COST ($/YR) CAPITAL INCLUDED(2)
SECONDARY RECOVERY SYSTEM	4-75	1,000,000	1,400,000	—	—
SHELL/STAUFFER OXYGEN OXY	1-79	3,500,000	3,780,000	—	—
B.F. GOODRICH OXY RECOVERY SYSTEM	12-80	740,000	740,000	—	—
SOLVENT ABSORPTION (S-306)	12-80	1,740,000	1,740,000	—	—
SOLVENT ABSORPTION (S-307)	6-79	860,000	900,000	—	—
OXYGEN PLANT	12-80	6,200,000	6,200,000	—	—
OXYGEN PLANT (3)	6-78	5,400,000	6,600,000	1,554,000	2,814,400
CATALYTIC OXIDATION	12-80	7,000,000	7,000,000	—	—
CATALYTIC OXIDATION FOLLOWING SOLVENT ABSORPTION (3)	12-80	3,420,000	3,420,000	354,000	1,007,000
OXYGEN BASED OXY (3)	6-80	2,760,000	2,870,000	1917,000	2,465,000
CARBON ADSORPTION (3)	6-80	3,050,000	3,170,000	(28,000)	577,000
SOLVENT ABSORPTION (3)	12-80	2,600,000	2,600,000	(108,000)	398,000

(1) MECHANICAL COMPLETION 12-80

(2) INCLUDES DEPRECIATION + CAPITAL CHARGES @ 10% DCF. — BASIS MID 1981

(3) THESE ARE THE CASES DISCUSSED IN THIS REPORT

TABLE II.

OXYGEN BASED OXY ECONOMICS

OXY VENT GAS CLEANUP

LAKE CHARLES VCM PLANT

CAPITAL INVESTMENT ($M)		RETURN ON INVESTMENT					
		15% DCF			30% DCF		
		OXYGEN PRICE ($/TON)					
OXYGEN BASED OXY	SOLVENT ABSORPTION	30	60	90	30	60	90
		INCREMENTAL VCM PRODUCTION (MMLB/YR)					
ABSOLUTE ECONOMICS		NETBACK = $0.05/LB					
2,870	—	22	53	84	35	66	97
4,300	—	31	63	94	51	82	113
5,740	—	41	72	104	67	98	130
INCREMENTAL ECONOMICS							
2,870	2,600	10	42	74	12	43	75
4,300	2,600	20	51	83	28	59	91
5,740	2,600	30	31	93	44	75	107
ABSOLUTE ECONOMICS		NETBACK = $0.04/LB					
2,870	—	27	66	105	43	83	122
4,300	—	39	78	117	64	103	142
5,740	—	51	90	130	84	123	162
INCREMENTAL ECONOMICS							
2,870	2,600	13	52	92	15	54	93
4,300	2,600	25	64	104	35	74	114
5,740	2,600	37	76	116	55	94	134

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TABLE III
OPERATING COSTS
SOLVENT ABSORPTION
OXY VENT GAS CLEANUP
LAKE CHARLES VCM PLANT

CAPITAL COST : $2,600,000 MECHANICAL COMPLETION - 12-80

	Units	Unit Cost $/Unit	M Units/YR	Cost/YR $
RAW MATERIALS				
CHLORINE	LB	0.060	—	
ETHYLENE	LB	0.161	—	
OXYGEN	LB	0.030	—	
EDC	LB	0.096	(3,732)	(358,000)
LIGHT ENDS	LB	0.015	(1,144)	(17,000)
				(375,000)
PROCESSING SUPPLIES				
SOLVENT	LB	0.230	84	19,000
CAUSTIC	LB	0.082	—	
CATALYST	LB	1.550	—	
CARBON	LB	0.600	—	
				19,000
UTILITIES				
STEAM	MLB	4.240	5	21,000
COOLING WATER	MGAL	0.116	126	15,000
ELECTRICITY	KWH	0.0261	476	12,000
FUEL	MMBTU	2.670	—	
				48,000
LABOR				
OPERATING				—
MAINTENANCE (2 1/2 % OF INVESTMENT/YEAR)				65,000
SUPERVISION (30 % OF ABOVE LABOR)				20,000
BENEFITS (20 % OF PAYROLL)				17,000
				102,000
MISCELLANEOUS				
OPERATING SUPPLIES (50 % OF OPERATING LABOR)				—
MAINTENANCE MATERIAL (1 1/2 % OF INVESTMENT/YEAR)				39,000
INSURANCE & TAXES (2 % OF INVESTMENT/YEAR)				52,000
PLANT OVERHEAD (20% OF PAYROLL)				17,000
				108,000
TOTAL OPERATING COST EX DEPRECIATION				(98,000)
DEPRECIATION (10 YR STRAIGHT LINE)				260,000
CAPITAL CHARGES (FOR 10 % DCF)				236,000
TOTAL OPERATING COST INCLUDING CAPITAL CHARGES				398,000

PRICE BASIS - MID 1981

SAL 000065004

TABLE IV
OPERATING COSTS
OXYGEN BASED OXY
OXY VENT GAS CLEANUP
LAKE CHARLES VCM PLANT

CAPITAL COST : $2,870,000 MECHANICAL COMPLETION 12-80

	UNITS	UNIT COST $/UNIT	M UNITS/YR	COST/YR $
RAW MATERIALS				
CHLORINE	LB	0.060	(6,350)	(381,000)
ETHYLENE	LB	0.161	(3,520)	(567,000)
OXYGEN	LB	0.030	104,370	3,131,000
EDC	LB	0.096	—	—
LIGHT ENDS	LB	0.015	—	
				2,183,000
PROCESSING SUPPLIES				
SOLVENT	LB	0.230	—	
CAUSTIC	LB	0.082	359	29,000
CATALYST	LB	1.550	(88)	(136,000)
CARBON	LB	0.600	—	—
				(107,000)
UTILITIES				
STEAM	MLB	4.240	(3)	(13,000)
COOLING WATER	MGAL	0.116	(280)	(32,000)
ELECTRICITY	KWH	0.0261	(13,247)	(346,000)
FUEL	MMBTU	2.670	—	—
				(391,000)
LABOR				
OPERATING				—
MAINTENANCE (2 1/2 % OF INVESTMENT/YEAR)				72,000
SUPERVISION (30 % OF ABOVE LABOR)				22,000
BENEFITS (20 % OF PAYROLL)				19,000
				113,000
MISCELLANEOUS				
OPERATING SUPPLIES (30 % OF OPERATING LABOR)				—
MAINTENANCE MATERIAL (1 1/2 % OF INVESTMENT / YEAR)				43,000
INSURANCE & TAXES (2 % OF INVESTMENT / YEAR)				57,000
PLANT OVERHEAD (20% OF PAYROLL)				19,000
				119,000
TOTAL OPERATING COST EX DEPRECIATION				1,917,000
DEPRECIATION (10 YR STRAIGHT LINE)				287,000
CAPITAL CHARGES (FOR 10 % DCF)				261,000
TOTAL OPERATING COST INCLUDING CAPITAL CHARGES				2,465,000

PRICE BASIS - MID 1981

SAL 000065005

TABLE 1
OPERATING COSTS
CARBON ADSORPTION
OXY VENT GAS CLEANUP
LAKE CHARLES VCM PLANT

CAPITAL COST : $3,170,000 MECHANICAL COMPLETION ~ 12-80

RAW MATERIALS	UNITS	UNIT COST $/UNIT	M UNITS/YR	COST/YR $
CHLORINE	LB	0.060	—	
ETHYLENE	LB	0.161	—	
OXYGEN	LB	0.030	—	
EDC	LB	0.096	(3,748)	(360,000)
LIGHT ENDS	LB	0.015	(3,602)	(54,000)
				(414,000)
PROCESSING SUPPLIES				
SOLVENT	LB	0.230	—	
CAUSTIC	LB	0.082	—	
CATALYST	LB	1.550	—	
CARBON	LB	0.600	50	30,000
				30,000
UTILITIES				
STEAM	MLB	4.240	10	42,000
COOLING WATER	MGAL	0.116	158	18,000
ELECTRICITY	KWH	0.0261	1,521	40,000
FUEL	MMBTU	2.670	—	—
				100,000
LABOR				
OPERATING			—	—
MAINTENANCE (2 1/2 % OF INVESTMENT/YEAR)				79,000
SUPERVISION (30 % OF ABOVE LABOR)				24,000
BENEFITS (20 % OF PAYROLL)				21,000
				124,000
MISCELLANEOUS				
OPERATING SUPPLIES (30 % OF OPERATING LABOR)				—
MAINTENANCE MATERIAL (1 1/2 % OF INVESTMENT / YEAR)				48,000
INSURANCE & TAXES (2 % OF INVESTMENT / YEAR)				63,000
PLANT OVERHEAD (20% OF PAYROLL)				21,000
				132,000
TOTAL OPERATING COST EX DEPRECIATION				(28,000)
DEPRECIATION (10 YR STRAIGHT LINE)				317,000
CAPITAL CHARGES (FOR 10 % DCF)				288,000
TOTAL OPERATING COST INCLUDING CAPITAL CHARGES				577,000

PRICE BASIS — MID 1981

TABLE VI
OPERATING COSTS
CATALYTIC OXIDATION
OXY VENT GAS CLEANUP
LAKE CHARLES VCM PLANT

CAPITAL COST: $3,420,000 MECHANICAL COMPLETION - 12-80

	Units	Unit Cost $/Unit	M Units/Yr	Cost/Yr $
RAW MATERIALS				
CHLORINE	LB	0.060	—	—
ETHYLENE	LB	0.161	—	—
OXYGEN	LB	0.030	—	—
EDC	LB	0.096	—	—
LIGHT ENDS	LB	0.015	—	—
				—
PROCESSING SUPPLIES				
SOLVENT	LB	0.230	—	—
CAUSTIC	LB	0.082	—	—
CATALYST	LB	1.550	10	16,000
CARBON	LB	0.600	—	—
				16,000
UTILITIES				
STEAM	MLB	4.240	(37)	(157,000)
COOLING WATER	MGAL	0.116	—	
ELECTRICITY	KWH	0.0261	860	22,000
FUEL	MMBTU	2.670	74	198,000
				63,000
LABOR				
OPERATING				—
MAINTENANCE (2 1/2 % OF INVESTMENT/YEAR)				86,000
SUPERVISION (30 % OF ABOVE LABOR)				26,000
BENEFITS (20 % OF PAYROLL)				22,000
				134,000
MISCELLANEOUS				
OPERATING SUPPLIES (30 % OF OPERATING LABOR)				—
MAINTENANCE MATERIAL (1 1/2 % OF INVESTMENT/YEAR)				51,000
INSURANCE & TAXES (2 % OF INVESTMENT/YEAR)				68,000
PLANT OVERHEAD (20% OF PAYROLL)				22,000
				141,000
TOTAL OPERATING COST EX DEPRECIATION				354,000
DEPRECIATION (10 YR STRAIGHT LINE				342,000
CAPITAL CHARGES (FOR 10 % DCF				311,000
TOTAL OPERATING COST INCLUDING CAPITAL CHARGES				1,007,000

PRICE BASIS - MID 1981

SAL 000065007

TABLE VII
OPERATING COSTS
OXYGEN PLANT
OXY VENT GAS CLEANUP
LAKE CHARLES VCM PLANT

BASIS: 200 T/D PLANT OPERATING @ 168 T/D
CAPITAL COST $6.6 MM (MECHANICAL COMPLETION [illegible])

				$M
UTILITIES -	ELECTRICITY	3800 KWH	29,184 MKWH @$.02[illegible]	762
LABOR -	OPERATING	1 MAN/SHIFT	8760 MH @ $14.00	1[illegible]
	MAINTENANCE	2 1/2 % of INVESTMENT		165
	SUPERVISION	30% of LABOR		96
	BENEFITS	20% of PAYROLL		75
				449
MISCELLANEOUS -	OPERATING SUPPLIES -	30% OPERATING LABOR		37
	MAINTENANCE MATERIAL	1 1/2 % of INVESTMENT		99
	INSURANCE & TAXES -	2% of INVESTMENT		132
	PLANT OVERHEAD -	20% of PAYROLL		75
				343

TOTAL OPERATING COST EX DEPRECIATION & CAPITAL CHARGES	1554
DEPRECIATION & CAPITAL CHARGES AT 15% DCF	1692
GROSS REVENUE FOR 15% DCF	3246
TOTAL OPERATING COST EX DEPRECIATION & CAPITAL CHARGES	1554
DEPRECIATION & CAPITAL CHARGES AT 30% DCF	3181
GROSS REVENUE FOR 30% DCF	4735

		RETURN ON INVESTMENT 15% DCF	30% DCF
OXYGEN PRICE WITH NO NITROGEN REVENUE	$/TON	60.40	88.00
NITROGEN PRICE WITH NO OXYGEN REVENUE	$/MSCF	0.690	1.000
OXYGEN PRICE WITH ONE HALF OF FULL NITROGEN REVENUE	$/TON	30.20	44.00
NITROGEN PRICE WITH ONE HALF OF FULL OXYGEN REVENUE	$/MSCF	0.345	0.500

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