TRI-STATE SYNFUELS COMPANY
Indirect Coal Liquefaction Plant
Western Kentucky

FLUOR ENGINEERS AND CONSTRUCTORS, INC.
Contract 835504

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PROCESS DEVELOPMENT STUDY NO. 15A

ETHANE/ETHYLENE TO SALES

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I. Introduction

In the feasibility study, the mixed C_2 gas stream (Ethane-ethylene mixture) recovered from the processing of the Synthol plant tail gas was treated in an Ethylene Plant to produce polymer-grade ethylene. The present study considers the sale of the mixed C_2 stream without additional processing.

The process description for the production and supply of the mixed C_2 stream is given in this report. The capital and operating cost estimates for the sale of mixed C_2 stream compared to the sale of polymer-grade ethylene are also reported.

II. Summary

Two cases are considered and compared for evaluation.

Case 1 - In this case, ethylene is made in the plant from the mixed C_2 stream.

This case was used for the feasibility study. Polymer grade ethylene is produced in the Ethylene Plant (Unit 24) by processing the mixed C_2 gas recovered in the C_2 recovery plant (Unit 23).

Case 1 is shown schematically below:

Synthol plant ⟶ C_2 recovery plant (Unit 23)
↓
H_2 rich gas
+
Methane rich gas
+
Mixed C_2 stream ⟶ Ethylene Plant (Unit 24)
+
C_3+ product

Ethylene product
+
C_3+ product
+
H_2 / CH_4 gas

Case 2 - For this case the Ethylene Plant (Unit 24) is deleted. The remaining units are similar to Case 1. The C_2 recovery unit (Unit 23) will produce a mixed C_2 stream (ethylene/ethane) along with the other products: methane rich gas, H_2 rich gas, and C_3+ product. The mixed C_2 stream will be marketed from the plant as such, probably to an existing ethylene producer.

Case 2 is shown schematically below:

Synthol plant tail gas ⟶ C_2 recovery plant (Unit 23)
↓
H_2 rich gas
+
Methane rich gas
+
Mixed C_2 stream ⟶ To Sales
+
C_3+ product

The flow schemes for the two cases show that the processing is identical for the treatment of the Synthol plant tail gas. The only difference lies in the further processing of the mixed C_2 stream. In Case 2, the mixed C_2 stream is sold without upgrading, while for Case 1 this stream is upgraded and sold as polymer-grade ethylene. This report indicates the outlines of the process for the recovery of mixed C_2 stream and emphasizes the incremental costs needed for Case 1 over Case 2.

III. Process Description

The recovery of the mixed C_2 stream from the Synthol plant tail gas is common to both Case 1 and Case 2 and the process is briefly outlined below.

The Synthol plant tail gas is first treated for the removal of CO_2. This may be done by scrubbing the gas in a CO_2 absorber with activated potassium carbonate solution or any other suitable solvent. The removal of CO_2 is necessary to avoid any CO_2 freezing at the low temperatures at which the gas is treated later in the process. The CO_2-free gas is compressed and chilled to a temperature above the hydrate formation temperature. The separated water will be removed and the condensed hydrocarbon stream will be fed to the oil workup facilities. The gas is then dried by passing it through a desiccant dryer.

The dry gas will be treated in the C_2 recovery section to produce the various products: Methane rich gas, hydrogen rich gas, C_3+ liquid product, and mixed C_2 gas.

The dew point for the mixed C_2 gas is -15° at 200 psig. As the pressure increases, the dew point will rise. At 380 psig, the dew point is 23°F. The pipeline supply pressure must be carefully studied to assure no condensation of C_2's in the line. The design of the mixed C_2 delivery system can be done only in consideration of the conditions of supply and the location where the supply is to be effected.

The process design of the Ethylene Plant used for Case 1 will be based on a conventional ethylene recovery system with steam cracking the ethane. The process description for the Ethylene Plant was included in the feasibility study.

IV. Comparative data for Sale of Mixed C_2 Stream and Ethylene

A. Product

Table 1 shows the product quantity and battery limit conditions for both cases.

TABLE 1

PRODUCT QUANTITY AND CONDITIONS

	Case 1	Case 2
Product	Ethylene	Mixed C_2 Stream
Quantity	40,055 lbs/hr.	51,606 lbs/hr.
Pressure	435 psig	350 psig
Temperature	85° F	Saturation

B. By-Products

The by-products and other products obtained from C_2 recovery unit (Unit 23) are the same for both Case 1 and Case 2. For Case 1, additional by-products will be obtained from the ethylene plant, the quantities are shown in Table 2. These by-products will be added to the feed to the oil workup units. Table 3 gives a listing of saleable products and their production rates for both cases.

TABLE 2

BY-PRODUCTS FROM ETHYLENE PLANT

Product	Quantity, lb/hr	Disposition
Propane	263	LPG
Propylene	3,315	Converted to Jet Fuel
C_4's	112	Added to Gasoline
C_5+	38	Added to Gasoline
H_2/CH_4 gas	1,956	SNG

TABLE 3

TOTAL PRODUCTS FROM THE PLANT WITH

CASE 1 AND CASE 2

PRODUCT	CASE 1, lb/hr.	CASE 2, lb/hr.
Ethylene*	40,055	-
Mixed C_2 Gas*	-	51,606
LPG*	8,900	8,637
Gasoline*	178,003	177,853
Jet Fuel*	52,289	48,974
Diesel (Grade 1-D)	39,087	39,087
Diesel (Grade 2-D)	3,259	3,259
Medium Fuel Oil	6,598	6,598
SNG*	156 MM SCFD	155 MM SCFD
Ammonia	18,125	18,125
Sulfur	47,125	47,125
Heavy Creosote	14,678	14,678
Medium Creosote	18,995	18,995
Phenol	3,709	3,709
Cresols	4,534	4,534
Ethanol	10,704	10,704
Propanol	3,087	3,087
Butanol	1,605	1,605
Pentanol and Higher Alcohols	1,530	1,530
Acetone	4,749	4,749
Methyl Ethyl Ketone	1,551	1,551
Higher Ketones	60	60

Notes:
1) *Indicates product rates that are different for Case 1 and Case 2.
2) Yields are shown on a stream day basis. To convert to calendar day basis, multiply by 340/365.

C. Utilities Consumption and Generation

The deletion of the ethylene plant has a minor effect on the facility utility costs. The consumption and production of utilities are shown on Tables 4 and 5. The dollar values assigned to these utilities are current estimates made for the Tri-State project.

TABLE 4

UTILITIES CONSUMED IN ETHYLENE PLANT

		Annual Cost, * $
1.	Fuel Gas** 167 MM Btu/hr. (HHV) @ $5/MM Btu	$ 6,813,600
2.	HP BFW 61,410 lbs/hr. @ $0.98/M gal.	58,929
3.	Cooling Water (circulated) 21066 gpm @ $0.53/M gal.	546,637
4.	HP Steam (600 psig) 6555 lbs/hr. @ $3.25/M lb.	173,839
5.	LP Steam (120 psig) 366 lbs/hr. @ $2.45/M lb.	7,317
6.	Electric Power 900 KW @ $0.055/Kwh	403,920
	Total Utility Cost	$ 8,004,242

* @ 340 days full production annually

**Internally produced in the Ethylene Plant and not obtained from an outside source (see also Table 5).

TABLE 5

	Annual Cost, * ($)
1. Fuel Gas (produced and consummed** in cracking furnace) HHV 167 MM Btu/Hr. @ 5/MM Btu	$ 6,813,600
2. HP Steam (600 psig) 56339 lbs/hr. @ $3.25/M lbs.	$ 1,494,110
	$ 8,307,710

* @340 days full production annually

** Consumed in Ethylene Plant (See Table 4)

D. Capital Cost (Plant Sales Price)

The estimated capital cost (plant sales price) of the Ethylene Plant (Unit 24) is 112.5 million dollars (Jan. 1980 dollars). This is the incremental capital cost (plant sales price) needed for Case 1 with ethylene production over Case 2 for sale of the mixed C_2 stream.

E. Plant Operating Cost

The annual operating cost, excluding the cost of feed gas for the Ethylene Plant, is given in Table 6. The gross operating cost has been estimated to be 3.57 million dollars.

This is the incremental operating cost for Case 1 (Ethylene) over Case 2 (Mixed C_2 Stream).

The comparative data between Case 1 and Case 2 are summarized in Table 7.

V. Conclusion

With the sale of Mixed C_2 stream (Case 2), the Ethylene Plant would be deleted with a saving in plant capital cost (plant sales price) of 112.5 million dollars(Jan. '80 cost).

The marketability and price of the mixed C_2 stream at the specific plant site compared to those of the polymer-grade ethylene will determine the cost economics for sale of the mixed C_2 stream in comparison with the production and sale of ethylene.

TABLE 6

OPERATING COST FOR ETHYLENE PLANT

(Excluding Cost of Feed)

	Annual Cost, ($)
Labor:	
Process Operating Labor (10 persons @ $29K avg. per year)	$ 290,000
Supervision (@ 20% of process operating labor)	58,000
Operating Supplies (@ 30% of process operating labor)	87,000
Catalysts and Chemicals	65,000
Utilities Consumed	(303,468)*
Maintenance Cost (@ 3% of capital cost)	3,375,000
Gross Operating Cost	$ 3,571,532

* Credit for utilities produced in Ethylene Plant over utilities consumed (Tables 4 & 5).

TABLE 7

COMPARISON OF DATA FOR CASE 1 AND CASE 2

Products: Case 1 - 40,055 lbs/hr. of ethylene

Case 2 - 51,606 lbs/hr. of mixed C_2 stream

	Case 1 (Ethylene)	Case 2 (Mixed C_2 Stream)
Incremental Capital Cost	$ 112.5MM	Base
Incremental Annual Operating Cost (Gross)	$ 3.6MM	Base
Incremental Annual Yield of Other Products:		
LPG	1073 Tons	Base
Jet Fuel	13525 Tons	Base
Gasoline	612 Tons	Base
SNG	1MM SCFD	Base

Note:

1) Data for Case 2 are taken as base, and incremental values of Case 1 are given.

APPENDIX I

SCOPE OF STUDY

PROCESS STUDY

PRODUCTION OF ETHYLENE/ETHANE CRUDE STREAM FOR DIRECT MARKETING

1.0 GENERAL

This study will provide economics for production of an ethylene/ethane stream for direct marketing.

2.0 WORK DEFINITION

2.1 Delete ethylene plant from the feasibility study.

2.2 Add storage for ethylene/ethane crude stream in the tank farm area.

2.3 Tri-State Synfuels to provide Fluor with requirements for storage volumes for the ethylene/ethane stream.

2.4 Redo plant mass balances.

2.5 Adjust capital cost estimate.

2.6 Redo the operating costs.

3.0 DELIVERABLE TO TRI-STATE

A formal report that contains the following:

3.1 Operating cost estimate.

3.2 Capital cost estimate.

3.3 Block Flow Diagram, material balance and process description.

4.0 SCHEDULE

It is estimated that the above work will be completed 8 weeks after the work is started by Fluor.