TRI-STATE SYNFUELS COMPANY
Indirect Coal Liquefaction Plant
Western Kentucky

FLUOR ENGINEERS AND CONSTRUCTORS, INC.
Contract 835504

August 14, 1981

PROCESS DEVELOPMENT STUDY NO. 18

NITROGEN COMPRESSION FOR ENHANCED OIL RECOVERY

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FOR
REVIEW AND COMMENT

Comments must be received by Tri-State Synfuels no later than _____ to preclude adverse impact on schedule.

DISCLAIMER

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SECTION I

INTRODUCTION

Tri-State Synfuels Company proposes to construct and operate an indirect coal liquefaction plant in Western Kentucky based on Sasol-type technology. The original feasibility study identified the availability of pure nitrogen from the air separation unit as a potential sales product for enhanced oil recovery (EOR). In June 1981, Fluor was authorized to proceed with a process study to develop an economic evaluation of this possibility. The scope of this effort included:

1. An estimate of the amount of available nitrogen.
2. A process design for compressing this gas to the same pressure used for CO_2 in similar EOR applications.
3. Estimate of capital costs and operating requirements for a "battery limits" operation.

SECTION II

SUMMARY

1. Plant battery limit conditions for the Sale of nitrogen gas have been defined as follows:

Pressure	2200 psia
Temperature	100°F
Oxygen	100 ppm (Max.)*

2. The amount of nitrogen available for sales is estimated at 78.1 MM SCF/SD. Nitrogen availability is discussed in Section IV.

3. A 5-stage compressor is required to pressurize nitrogen from 65 psia to 2005 psia. Intercoolers between stages and an after-cooler are provided. A single compressor train will accommodate the design flow rate at minimum cost.

4. The operating requirements for the battery limits nitrogen compression plant have been estimated as follows:

Production Data

Design Operations	340 days/year
Nitrogen Production Rate	78,121,906 SCF/SD

*The 100 ppm oxygen content of the nitrogen is based on the vendor's guarantee in the Sasol Air Plant. Actual experience has shown that it can produce as low as 40 ppm.

5. Capital Cost (Sell Price) Nitrogen Compression

Sell price for battery limits compression plant, based on January 1980 dollars with 10% contingency.	$8,300,000

6. Annual Operating Cost

Electricity	16,997 kw @ $0.055/KWH	$7,628,254
Cooling Water	4,325 GPM @ $0.053/M gal.	112,228
Operating Labor	No change to the air separation plant operators already included in Feasibility Study.	-
Maintenance Labor		116,200
Maintenance Material		174,300
	Total Annual Operating Cost	$8,030,982

SECTION III

PROCESS DESCRIPTION

The design configuration used for the nitrogen compressor plant is graphically described by the Process Flow Diagram on page 6-1.

Approximately 78.1 MM SCF/SD of 99.99% pure nitrogen from four air separation plants are compressed from 65 to 2205 psia in a single 5 stage compressor (40-C-1). Interstage coolers (40-E-1, 40-E-2, 20-E-3 and 40-E-4) are provided to minimize compressor work. An after cooler (40-E-5) is included to provide a moderate send-out temperature.

The total compressor brake horsepower is 20,480.

SECTION IV

DISCUSSION & CONCLUSION

Discussion

The air plant included in the feasibility study was designed to produce oxygen at minimum cost. As a result, only a fraction of the nitrogen fed to the plant emerges at sufficient purity to be suitable for enhanced oil recovery. Of the two high purity nitrogen streams, one is at 40 psig and is the one used in this study. The other is 81,808,703 SCF/SD at atmospheric pressure. Some of this nitrogen is used on an intermittent basis in the plant as inert gas with the aid of a booster compressor. The remaining portion of the nitrogen production is a mixture of nitrogen with 0.74 to 1.0% oxygen and is unsuitable for most nitrogen usages.

For this study it was assumed that land needed to accommodate this compressor installation (approximately 1-1/2 acres) would be available within the proposed plant site. Finally, if nitrogen sales should be indicated above the quantity of 40 psig high purity gas available, then a different air plant should be investigated.

Conclusion

There are no major problems in compressing large quantities of nitrogen to pipeline pressure. The compressor train shown in this report probably represents the maximum desirable size for a single train unit. Any substantial increase in export nitrogen should be handled with multiple trains.

SECTION V

DESIGN BASIS

The N_2 battery limit pressure was specified at 2200 psia by Tri-State.

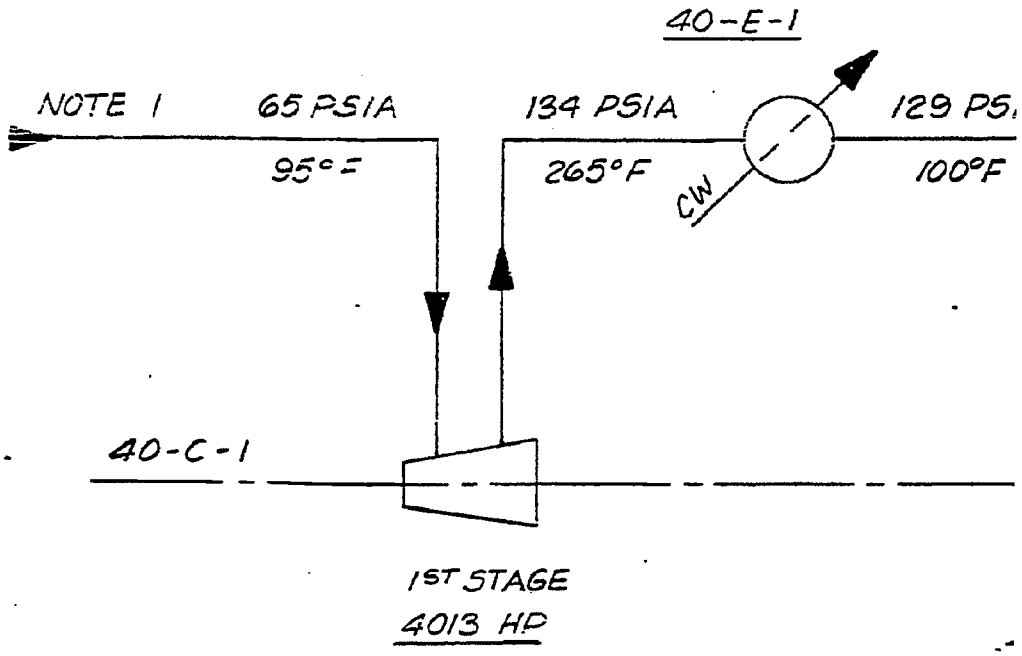
The amount of N_2 available was estimated at 78,121,906 SCF/SD by capacity factoring Sasol II data on the basis of their O2 requirements and those identified in the Feasibility Study.

The quality of N_2 available from the air separation plants was assumed to be the same as Sasol II, namely:

Temperature	=	95°F
Pressure	=	65 psia
O_2 Content	=	100 ppm (max.)

40-C-1
N_2 COMPRESSOR
20,479 HP TOTAL

40-E-1
1ST INTERCOOLE
10.00 MM BTU/HR

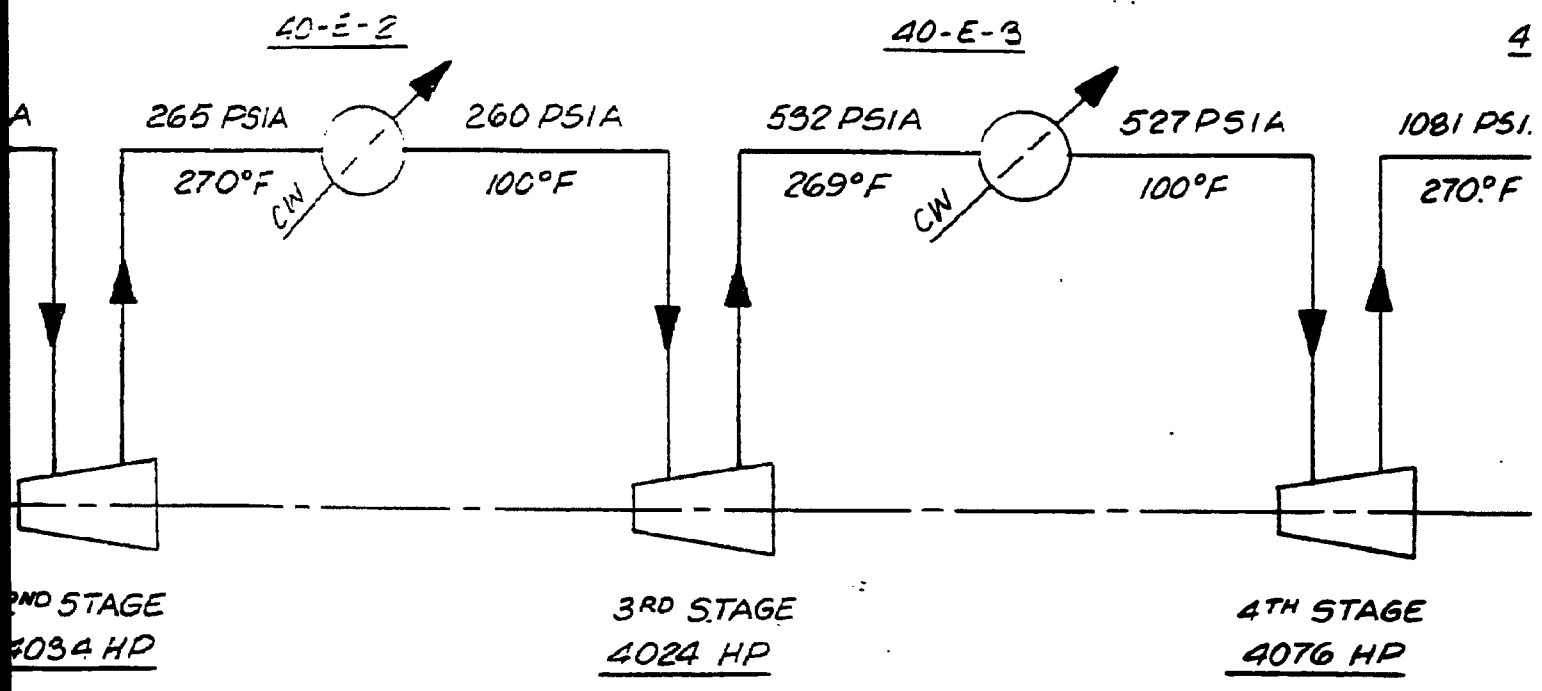


ER

40-E-2
2ND INTERCOOLER
10.45 MM BTU/HR

40-E-3
3RD INTERCOOLER
10.59 MM BTU/HR

40-E-4
4TH INTERCO
11.02 MM BTU

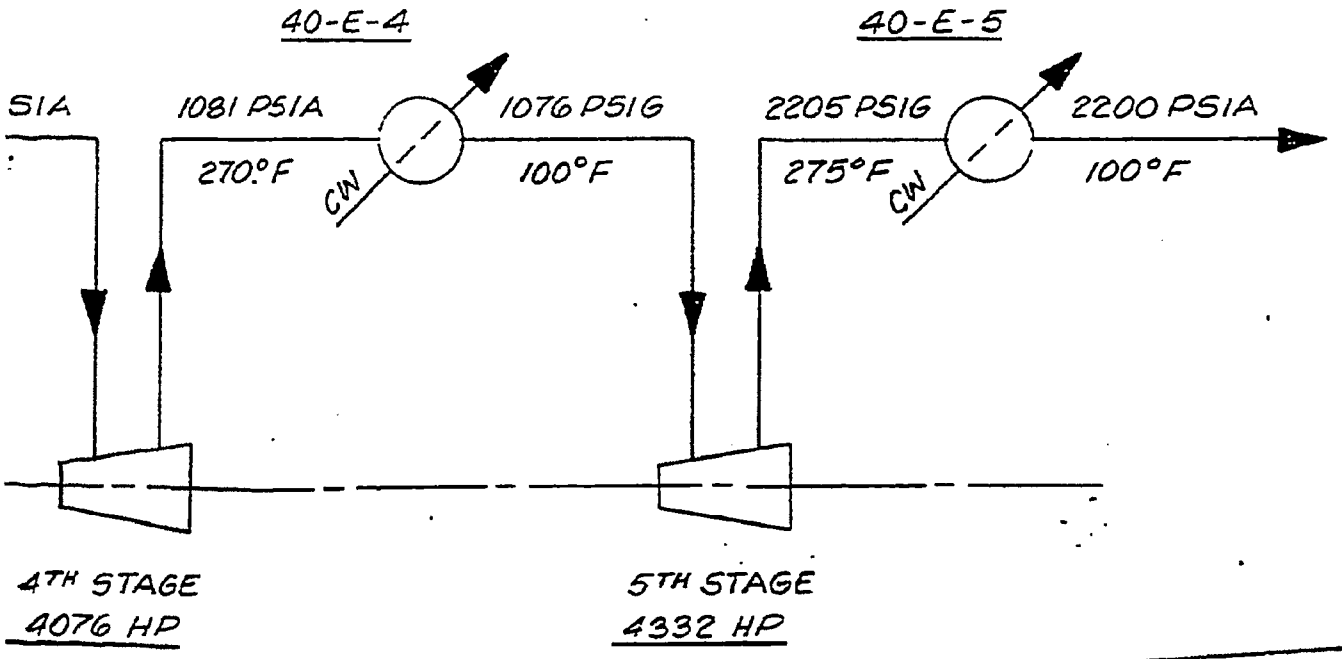


NOTE:

1. FEED IS 87,320 Nm^3/HR (8,588.60 *MOL/HR) OF 99.99% PURE N_2 CONTAING 100 ppm O_2 MAX. FROM 4 OPERATING AIR SEPARATION PLANTS.

40-E-4
4TH INTERCOOLER
11.02 MM BTU/HR

40-E-5
AFTERCOOLER
12.04 MM BTU/HR



38.60 # MOL/HR)
· 100 ppm O_2
SEPARATION

TRI-STATE SYNFUELS PROJECT

T. KING	NITROGEN COMPRESSION FOR ENCHANCED OIL RECOVERY STUDY-18
D. CRACKNELL	
NONE	

A
8-14-81

PROCESS STUDY

Nitrogen Compression for Enhanced Oil Recovery

1.0 GENERAL

This study will provide the data needed to perform the economic evaluation for compressing Nitrogen for EOR.

2.0 WORK DEFINITION

2.1 Determine the quantity of pure nitrogen available for EOR.

2.2 Compress this gas to the same pressure used for CO_2 compression.

2.3 Estimate capital and operating costs.

3.0 DELIVERABLES TO TRI-STATE

A formal report that contains the following:

3.1 Capital Cost Estimate.

3.2 Operating Cost Estimate.

3.3 Block Flow Diagram, material balance and process description.

4.0 SCHEDULE

The estimated time to complete this work is eight weeks after the start of work by Fluor.