9.0 OXYGEN PLANT

9.1 PROCESS DESCRIPTION

The Oxygen Plant will produce the gaseous oxygen required for Gasification (Unit 10) and Texaco POX (Unit 82). It will also supply nitrogen, instrument air, and startup air for the Gasification Unit.

The Oxygen Production Facilities consists of multiple parallel trains; each train having an air compressor, a cold box with separation columns, and an oxygen compressor. A spare oxygen compressor, common to all trains is included.

Oxygen is produced in an air separation plant by first cooling air to its condensation temperature and then fractionating it to separate it into its components. Filtered air is compressed to about 80 psig. This air is then cooled by heat exchange using feed-effluent exchangers to cool and condense the feed air. A portion of the cooling is accomplished in reversing heat exchangers. They are core exchangers. The feed air exchanges heat with a waste nitrogen stream. Periodically the air changes flow channels with the waste nitrogen. Piping manifolds are arranged so the flow of air into the fractionation section is not reversed. As the feed air cools, water, and carbon dioxide freeze in the flow passage. When the flow exchange occurs, the ice that was deposited melts and the vapors are carried out of the exchangers and vent to the atmosphere with the waste nitrogen.

Air at its dew point enters the lower column of a two column fractionation train. In this column the air is separated into a pure nitrogen stream and a second stream containing approximately 38 percent oxygen. The pure nitrogen stream is available as the nitrogen product. Heat exchangers recover the refrigeration value in this stream.

The 38 percent oxygen stream flows into the second fractionation column. In this unit the 98.5 percent oxygen product stream is produced. The waste nitrogen stream flows to the reversing exchangers for refrigeration recovery. The liquid oxygen product stream either flows into a cryogenic storage tank or it is vaporized in heat exchangers to recover the refrigeration value. Recovery of all of the refrigeration values is accomplished by cooling the incoming feed air.

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9.1 PROCESS DESCRIPTION (Continued)

The fractionation and heat exchangers are all located in cold boxes to minimize the leakage of heat into the system. The gaseous oxygen product emerges from the cold box at approximately 24 psia pressure and near ambient temperature. It feeds into the oxygen compressor and emerges at 465 psig pressure. There is one air compressor and one oxygen compressor for each oxygen plant train. A single spare oxygen compressor is also available to be used as a replacement for any of the oxygen compressors.

Reversing heat exchanger plants result in low power consumption while maintaining relatively low capital costs and plot space requirements.

A decision was not reached on whether liquid oxygen storage is needed to provide oxygen in the event of an oxygen plant failure. At Sasol II and III the oxygen is not stored as a liquid but a spare oxygen plant is available.

Another possibility that can be utilized for an air separation plant is the use of molecular sieve absorption beds to remove the water vapor and carbon dioxide from the feed air. This option offers a long service life with slightly higher energy consumption compared to the reversing exchanger approach. For a molecular sieve plant, the incoming air is cooled by a refrigeration unit. Next, it is purified in the molecular sieve unit where the water and carbon dioxide are removed and then the air is fed into the cold box. The molecular sieve unit has multiple columns - usually 3 - that are in service. The second column is on regeneration and the third column is on standby.

The cold box operation of the molecular sieve plant is identical to the reversing exchanger plant. Proper operation of the molecular sieve plant removes the necessity for the reversing exchangers and simplifies the cold box piping.

Safety is the prime consideration in the design, construction, and operation of oxygen plants. These facilities have a history indicating improper operation can result in an explosion. Pure oxygen is sampled on a frequent basis to determine the presence of combustible materials in the cold box. The level of organic material is controlled by purging of the sampled stream.

The air separation plant must be located so the plant is separated from adjacent units handling organic streams. If possible, the plant is located upwind of any of the plant facilities.

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9.1.1 Product Description

The products from Oxygen Plant include:

a) 98.5 volume percent pure oxygen at an operating pressure of 465 psig at the battery limits.

b) 99.99 volume percent pure nitrogen, with less than 100 ppmv oxygen at an operating pressure of 65 psig at the battery limits.

c) Instrument air with a dew point of -238°F at an operating pressure of 130 psig.

d) Air at 125 psig, for general plant use.

e) Air at 65 psig for use in the Gasification Unit for startup purposes.

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9.2 FLOW SHEETS

Flow Sheets for the Oxygen Plant area are proprietary with the licensors involved. Details of the processes cannot be revaled until a licensing agreement is signed.

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9.3 UNIT MATERIAL BALANCES

The vendor quotations for the oxygen plant were based on Case 7R, a nominal 3/4 size plant (compared to the feasibility study). The design basis for the project when design work was stopped was Case 13. This case was a nominal 1/4 size plant. There were many differences in design bases for these two cases. See Volume X to determine the extent of the differences.

9.3.1 Vendor Quoted Design Basis

Product	Production
Oxygen (98.5%)	7376 st/day (7.3 MMSCFH)
Pure Nitrogen	563 st/day (0.63 MMSCFH)
Instrument Air	287 st/day (0.31 MMSCFH)
Startup Air (Intermittent)	48 st/day (1.25 MMSCFH)

9.3.2 Requirements per Case 13

	Production (SCFH)	
	Normal	Maximum
Oxygen (98.5%)	2,884,972	3,029,220
Nitrogen	151,030	198,227
Instrument Air	350,860	-

NOTE: Maximum represents 5% over normal capability for oxygen.

9.3.3 Product Distribution Case 13

Distribution of Oxygen plant products is as follows:

Commodity	Destination	Design Flow Rate (SCFH)
Oxygen	Unit 10 (west)	1,442,486
Oxygen	Unit 10 (east)	1,442,486
Instrument Air	Unit 41	Not determined
Nitrogen	General plant service	151,030

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9.3.4 Startup Air - Case 13

Low pressure air is required for the initial startup of the gasifiers. A line is provided from the discharge of the oxygen plant air compressors (before aftercooling) to the vicinity of Unit 10. This line splits and feeds both the East and West groups of gasifiers. The line that feeds the startup air is sized to deliver 0.5 MMSCFH.

During period of emergency re-start, this same line can be used to transport high pressure air to the gasifiers. This high pressure air is produced by the spare oxygen compressor at a Unit 10 battery limits pressure of about 348 psig.

Low pressure air is also used during normal operations to supply motive power to the coal lock gas ejectors.

9.4 ACCOMPLISHMENTS AND DECISIONS MADE AND FINALIZED

Vendor quotes were received from Air liquide, Lotepro, Union Carbide, and Air Products. Summaries including number of trains, train size, utility requirements, and costs are included in Section 9.6.

9.5 CURRENT STATUS

Vendor quotes have been received for Case 7R and Fluor has established rough capacities for Case 13, but no design work has proceeded beyond this point.

9.6 LICENSORS AND EVALUATIONS

Preliminary proposals were received from four licensors to design and construct the turnkey facility to produce oxygen. These proposals were used to update oxygen plant costs for all subsequent studies performed for the Tri-State project.

No attempt was made to select a licensor from these proposals.

Summaries of these four proposals are given in the following table. They include number of trains, train size, compressor driver options, utility requirements, plot sizes , and costs. (Refer to Table 1). These proposals are based on Case 7R which requires 7376 ST/D of 98.5% volume purity oxygen, 563 ST/D of 99.99% volume purity oxygen required for Case 13 is 2877 ST/D. No attempt has been made to convert the information provided by the vendors to the Case 13 design base.

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9.6 LICENSORS AND EVALUATIONS (Continued)

The vendor proposals indicate that a field construction period of 24 to 30 months after site preparation is required for the construction of the air separation facilities. The plant is a mixture of shop fabricated and field fabricated items. For example, the cold box is field fabricated but most of the equipment in the cold box is shop fabricated. Three of the four vendors recommended liquid oxygen storage be included in the facility design. The LOX storage would be in a cryogenic vessel located external to the cold box.

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5-14-82
CONT. NO. 835504
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SHEET NO. 2/2

TABLE 1

SUMMARY OF TRI-STATE SYNFUELS OXYGEN PLANT BUDGET PROPOSALS

LICENSOR	NUMBER OF TRAINS	OUTPUT, O_2 T/TRAIN	COMPRESSOR DRIVER OPTIONS	UTILITY REQUIREMENTS	PLOT SIZE	COST
LOTEPRO REVERSING HEAT EXCHANGER OPTION	3	2459	STEAM DRIVER OPTIONS: 600 psig, 1500 psig	FOR STEAM DRIVERS STEAM: 1,050,200 lb/hr at 600 psig 877,900 lb/hr at 1500 psig COOLING WATER: 141,900 GPM at 600 psig 124,400 GPM at 1500 psig	330' x 480'	600 psig STEAM = $120,000,000 1500 psig STEAM = $123,000,000
LOTEPRO MOLECULAR SIEVE OPTION	3	2459	STEAM DRIVER OPTIONS 600 psig, 1500 psig	STEAM FOR DRIVERS 1,093,050 lb/hr at 600 psig 910,100 lb/hr at 1500 psig COOLING WATER 141,700 GPM at 600 psig 123,700 GPM at 1500 psig	330' x 480'	600 psig STEAM = $120,000,000 1500 psig STEAM = $123,400,000

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FLUOR

TABLE 1

SUMMARY OF TRI STATE SYNFUELS OXYGEN PLANT BUDGET PROPOSALS

LICENSOR	NUMBER OF TRAIN	OUTPUT O_2/TRAIN	COMPRESSOR DRIVER OPTIONS	UTILITY REQUIREMENTS	PLOT SIZE	COST, $
UNION CARBIDE	3	2459 ST/D	AIR COMPRESSOR ELEC DRIVER: 13.8 KV, 40,000 hp, 27,200 KV OXYGEN COMPRESSOR ELEC. DRIVERS 13.8 KV, 18,000 hp, 11,600 KV: STEAM TURBINE OPTION: 600 PSIG AT 750°F	FOR STEAM TURBINE DRIVERS: STEAM = 1,164,000 lb/hr COOLING H_2O = 133,000 GPM	650' X 420' (LOX STORAGE = 2500 TONS)	ELEC DRIVERS - $140,000,000 600 psi STM DRIVERS - 170,000,000 1500 psi - $143,500,000 2400 psi - $142,500 000
AIR LIQUIDE	3	2459	STEAM DRIVER OPTIONS: 600 PSIG, 1500 PSIG, 2400 PSIG ELECTRIC MOTOR DRIVERS	FOR STEAM TURBINES: STEAM REQUIRED = 981,300 lb/hr at 600 psig 852,600 at 1500 833,400 at 2400 ELECTRIC MOTORS - 107,217 KW COOLING WATER = 1,020,000 GPM	420' X 270' (LOX STORAGE = 2500 TONS)	ELEC. DRIVERS - $147,000,000. 600 psig STM - $153,100,000. 1500 psig STM - $154,000,000. 2400 psig STM - $155,000,000
AIR PRODUCTS	4	1850	STEAM DRIVER OPTIONS: 400 psig, 850 psig, 1500 psig ELECTRIC MOTOR DRIVERS	FOR STEAM DRIVERS - STEAM REQUIRED - 25 lb/KWH at 400 psig 39 lb/KWH at 850 psig 41 lb/KWH at 1500 psig AIR COMPRESSORS - 76,400 KW O_2 COMPRESSORS - 31,500 KW COOLING WATER = 43,200 GPM	720' X 320' (LOX STORAGE = 1850 TONS)	STEAM DRIVERS = $162,900,000 ELECTRIC DRIVERS $154,900,000

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