INCREASING GAS PROCESSING CAPACITY
AT TGS'S
GENERAL CERRI COMPLEX

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Abstract

Transportadora de Gas del Sur (TGS) desires to increase the cryogenic gas processing capacity and ethane recovery capability of its General Cerri Complex in Bahia Blanca, Argentina to the maximum capacity that can be achieved without adding compression horsepower. Current total capacity for the two existing cryogenic trains is 22 million standard cubic meters per day (MMSCMD) yielding 2600 metric tons per day (MTD) of NGL, including 1000 MTD of ethane. This paper describes how the two existing processing trains can be upgraded with Ortloff's proven technology to increase throughput to 24 MMSCMD while also improving ethane recovery using only two of the three existing compressor trains. The third compressor train then becomes available for use with a new third processing train, allowing ethane and heavier liquids recovery from an additional 16 MMSCMD of gas from a separate pipeline. The Ortloff technology which maximizes the throughput, recovery, and operating flexibility of the new train is also described. When all the modifications and additions to the Cerri Complex are completed, the cryogenic gas processing capacity will be increased to 40 MMSCMD with the capability to recover over 4500 MTD of NGL including 1900 MTD of ethane.

Introduction

TGS's Cerri Complex in Bahia Blanca, Argentina has two cryogenic gas processing trains to extract ethane and heavier hydrocarbon components from the Neuba I and San Martin gas pipelines. A small amount of gas from the Neuba II pipeline is also currently being processed. The total cryogenic processing train capacity is currently 22 MMSCMD with a nominal ethane recovery of 1000 MTD.

TGS desires to recover as much NGL as possible from all three pipelines without adding compression equipment. A preliminary study of the compression by TGS indicated that two of the three existing compressor trains could be re-staged and used with the two existing process trains, leaving a third compressor train available for service with a new process train designed to process the Neuba II pipeline gas. Ortloff and Tauro continued the study by determining the optimum process modifications and the costs to maximize the throughput and recovery of the existing cryogenic trains. Ortloff and Tauro then determined the optimum process design and the cost for the new third train.

Existing Cryogenic Gas Processing and Compression Trains

The two cryogenic processing trains were originally designed to process 9 MMSCMD of gas per train for a total design capacity of 18 MMSCMD. The two trains have common inlet separation, inlet compression, dehydration, and residue compression systems all sized for 18 MMSCMD. The original process design is an industry standard single stage (ISS) design without refrigeration, as shown in the simplified process flow diagram in Figure 1. The expander-driven booster compressor is in residue compression service, and shell and tube heat exchangers are used for all but air-cooled services. The original process design and the existing compression equipment have allowed operation at 22 MMSCMD (22% over the original design) with an ethane recovery of 73%, limited by the capacity of the expanders and by the compressor staging.

A comparison of original design data and current operating data is shown in Table 1. The trains were designed for a richer gas composition than is currently being processed. Current NGL production levels average close to the original design values but at higher gas volume throughput.

The current operation maximizes NGL production while meeting the nominal ethane recovery requirement of 1000 MTD. Higher ethane production is possible if the trains are operated at a total throughput less than 22 MMSCMD, but the total production of propane and heavier components is reduced proportionally. If the two trains are operated at a total throughput above 22 MMSCMD, the ethane recovery and production decrease and the 1000 MTD ethane production requirement cannot be met.

Table 1. Original Design and Current Operating Data for Trains A & B

	Original Design	Current Operation	Difference
Total Throughput, MMSCMD	18.0	22.0	4.0 22%
Throughput/Train, MMSCMD	9.0	11.0	2.0 22%
Ethane Recovery	76.5%	73.0%	-3.5 points
Propane Recovery	96.6%	97.8%	+1.2 points
Ethane Recovery, MTD	960	1031	+71
Propane Recovery, MTD	822	802	-20
Total NGL Recovery, MTD	2634	2596	-38

Each of the three existing compressor trains consists of a GE Frame 5 driver rated at 24,000 HP, an Elliot barrel compressor for residue compression, and an Elliot barrel compressor for inlet compression. Table 2 below summarizes the original design information and the current operating parameters for the existing compression equipment.

Table 2. Original Compressor Design and Current Operating Data

	Original Design	Current Operation	Difference
Compression Trains	3	3	—
Rate/Compression Train, MMSCMD	6.0	7.33	1.33
HP Required/Compression Train	16,900	19,855	2955
HP Available/Compression Train	24,000	24,000	—
HP Not Used/Compression Train	7,100	4,145	-2,955

Limitations of the Existing Equipment

TGS has identified several limitations in the existing plant design at the current 22 MMSCMD throughput:

- The expander inlet operating pressure is lower than design and the expander outlet pressure and demethanizer operating pressure are higher than design. The pressure ratio across each expander is, therefore, less than design and the expander nozzles and wheels are too small to handle the flow rate. As a result, the expander bypass valve (J-T valve) in each train is normally open at the current throughput. The bypass of gas around the expander reduces booster compressor horsepower and warms up the top feed to the demethanizer, resulting in lower ethane recovery.

- Pressure drops and velocities are high in the inlet and residue compression and separation piping systems.

- The molecular sieve dehydration system has already been modified to have five dehydrator beds in absorption cycle and one bed in regeneration at one time. The original design had four beds in absorption and two in regeneration at any one time. The practical limit to the throughput of the modified dehydration system is 24 MMSCMD.

Any redesign of the process trains must also address the expander capacity and pressure drop problems. The dehydration system limit of 24 MMSCMD effectively establishes an upper limit to the redesign throughput regardless of any process modifications or additional compression capacity.

Increasing the total facility throughput requires making the best use of the compression horsepower available from the three gas turbines. As shown in Table 2, there is approximately 21,300 horsepower available (3 x 7,100) which was not used in the original compressor specification and design. The maximum re-rated throughput, however, may be limited by the compressor mechanical design rather than the driver horsepower. Study of the compressor options was limited to, at most, replacement of the serviceable bundle assemblies while re-using the existing compressor bodies. Replacing the compressor bodies with the next larger size was not considered due to down time and cost considerations.

Elliot engineers identified the following constraints on the maximum possible re-rated capacity of the compressors:

- The original shaft diameter limits torque capacity, especially on the inboard residue gas compressor shaft, which transmits torque to the outboard inlet gas compressor.
- The existing nozzle sizes limit volumetric flow capacity.
- The existing barrel diameter limits the maximum wheel diameter.
- The barrel length limits the number of wheels that can be installed of a given width.

After many iterations to adjust process conditions and flow rates to best match the compressor and driver horsepower limitations, Elliot re-rated the two compressor trains to be used with the existing processing trains for 12 MMSCMD per compressor train. An increase in the residue compressor shaft size is required to achieve this capacity. The proposed compressor re-rated designs fully use all the driver horsepower. The number of impellers must be reduced to allow room for the wider impellers required at the higher flow rate, which results in less head available for the process. The reduction in available head will result in lower product recoveries at the higher inlet rate unless the process design can be improved.

Retrofit of Trains A and B with Ortloff's GSP Process

Ortloff has successfully upgraded many ISS plants with its Gas Subcooled Process (GSP) technology to increase throughput, reduce horsepower, and/or increase recovery.[1] This technology was evaluated for TGS's two existing cryogenic processing trains to determine the product recovery levels which could be achieved using the re-rated compressors.

The GSP design operates with a warmer cold separator temperature and demethanizer tower temperature profile than the standard design and can tolerate a higher plant inlet CO_2 content without freezing. More throughput or better ethane recovery is possible with this design (for a given horsepower) than can be achieved with the ISS design.[2] For these reasons, nearly all of the high ethane recovery plants built in recent years have used the proven Ortloff GSP technology and many older plants have been upgraded with the design.

The upgraded GSP design is shown in Figure 2. The GSP retrofit requires the following additions to the ISS design:

- Absorber column.
- Absorber bottoms pumps.
- Reflux exchanger.
- Associated piping and instrumentation.

The new absorber column effectively becomes an extension of the existing demethanizer column and provides several fractionation stages above the expander feed location. A portion of the cool inlet gas is condensed by cold residue gas and used for absorber column reflux.

The two compressor trains and the dehydration system limit the throughput of the GSP retrofit design to a maximum of 12 MMSCMD/train. The product recoveries and performance for the existing trains with and without the GSP retrofit are compared in Table 3 below (for the average inlet gas composition at the 12 MMSCMD/train rate). Note that the compressors, expander performance, and pressure drop problems identified earlier are assumed to have been addressed identically for both designs and that the only difference in the results is due to the addition of the GSP retrofit process design to the debottlenecked ISS design.

Table 3. Comparison of ISS Design to GSP Retrofit Design for Trains A and B			
	ISS Design	GSP Retrofit	Difference
Total Throughput, MMSCMD	24.0	24.0	—
Compressor Capacity, MMSCMD/unit	12.0	12.0	—
Ethane Recovery	63.0%	80.0%	17 points
Propane Recovery	95.9%	98.6%	2.7 points
Ethane Recovery, MTD	970	1,233	262 27%
Propane Recovery, MTD	858	883	25 3%
Total NGL Recovery, MTD	2,632	2,920	288 11%
HP per Compression Train	24,000	24,000	—

Note that the compressor re-rate and the debottlenecking modifications alone will allow total NGL production to be maintained at the current level of 2600 MTD with two compressor trains rather than three. The ethane recovery drops from the 73% level in Table 1 to 63% due to the reduction in the expansion ratio with the two re-rated compressor trains at the 12 MMSCMD throughput.

Ethane recovery improves significantly, however, when the GSP retrofit is installed. The 27% improvement in ethane recovery using the GSP design will permit TGS to easily increase its ethane product delivery in the future while also increasing total NGL recovery by 11%.

The recoveries and production figures presented in this paper for these comparisons are based on an average composition and on the horsepower available for the average ambient temperature at the plant site. Variations in gas composition normally occur throughout the year, with the leaner gas composition occurring in the cooler months when more horsepower is available and the richer compositions occurring in the warmer months when less horsepower is available. The ethane production requirement of 1000 MTD must be met throughout the year regardless of throughput or changes in the inlet gas composition. For example, the plant inlet gas can be lean enough in the cooler months to cause the ethane production to drop to 800 MTD for the ISS design. The third train, therefore, must always be able to recover enough ethane to make up the difference between the 1000 MTD requirement and the production from Trains A and B if the GSP retrofit is deferred.

Train C Process Design

The design requirements from TGS for Train C are summarized as follows:

- Compression limited to one existing gas turbine driving Elliot compressors re-rated for operation with the Neuba II pipeline conditions.
- Maximize propane and heavier recovery at all inlet rates up to the compression limit.
- Maximize ethane recovery for rates from 9 MMSCMD up to the compression limit.
- Variable and easily controllable ethane recovery from full ethane rejection to maximum ethane recovery so that the current and future total site ethane production requirements can be met by adding ethane production from Train C to that available from Trains A and B (initially without GSP retrofit).

The Neuba II pipeline operates at a higher pressure than the two pipelines feedingTrains A and B (45 kg/cm^2 abs vs. 36 kg/cm^2 abs). The process conditions for the third compression train are, therefore, very different from those used for re-rating the other two compression trains.

After several process condition and machine design iterations with Elliot, a throughput of 16 MMSCMD was determined to be the maximum re-rated capacity for the third compressor train. This re-rated design is limited by compressor case and nozzle sizes rather than by driver horsepower. Estimated compressor performance curves were then used for the process design simulations for Train C for inlet flow rates from 9 to 16 MMSCMD for three different process designs.

The most efficient cryogenic process available for propane recovery is Ortloff's Overhead Recycle (OHR) design. A simplified process flow diagram for the OHR design is shown in Figure 3. The reflux stream for this design is taken from the deethanizer overhead and condensed with the cold absorber overhead. This Ortloff process design has been used very successfully in many plants in recent years. The largest and most recent application of this technology is the 28 MMSCMD PanCanadian Empress Plant located in Alberta, Canada which commenced operation in September, 1996.

The industry standard single stage (ISS) design could also be used for Train C. A comparison of the product recoveries for the ISS and OHR designs operating in ethane rejection mode is shown in Table 4. For comparison purposes, the exchanger approaches, pressure drops, sizing, and machinery efficiencies were held constant for the two designs.

Table 4. Comparison of ISS and OHR Designs for Ethane Rejection

	ISS Design	OHR Design	Difference
Total Throughput MMSCMD	16.0	16.0	—
Ethane Recovery	0.6%	0.7%	—
Propane Recovery	84.0%	99.6%	15.6 points
Ethane Recovery MTD	5	6	—
Propane Recovery MTD	389	461	72 18.5%
Total NGL Recovery MTD	829	910	81 9.8%
Horsepower	22,200	22,035	—

The total NGL recovery improvement of 9.8% over the ISS design (including the 18.5% improvement in propane recovery) will easily pay out the additional equipment cost of the OHR design. Similar process studies for other applications have had similar results. The ISS design is rarely used for high propane recovery applications where it has been compared to the OHR design.

Recovering some ethane using the OHR design is also possible. But the amount of methane which can be tolerated in the NGL product off the deethanizer column typically limits the ethane recovery to about 40%. Although propane recovery remains very high as the ethane recovery is increased, ethane recoveries above the 40% level require a different process design.

The most efficient process design available for high ethane recovery is the same design proposed earlier for the upgrade of the existing trains, Ortloff's GSP design. A simplified process flow diagram for the GSP design for Train C is shown in Figure 4 and is functionally identical to that shown earlier in Figure 2 for the retrofit of the existing trains. The reflux stream for this design is taken from the inlet gas stream at inlet pressure, condensed and subcooled using cold residue gas, and then flashed to the top feed of the absorber column.

Again, the ISS design could be used for the third train for ethane recovery. A comparison of the product recoveries for the ISS and GSP designs operating in maximum ethane recovery mode is shown in Table 5. (Identical conditions, pressure drops, machinery efficiencies, compressor curves, and exchanger sizing criteria were used for both designs. An average inlet gas feed composition was also used.)

Table 5. Comparison of ISS and GSP Designs for Ethane Recovery			
	ISS Design	GSP Design	Difference
Total Throughput MMSCMD	16.0	16.0	—
Ethane Recovery	60.0%	76.9%	16.9 points
Propane Recovery	92.6%	97.1%	4.5 points
Ethane Recovery MTD	516	662	146 28%
Propane Recovery MTD	428	449	21 4.9%
Total NGL Recovery MTD	1,484	1,625	141 9.5%
Horsepower	21,600	21,490	—

The 28% increase in ethane recovery and 9.5% increase in total NGL recovery at constant horsepower over the ISS design result in extremely good economics favoring the GSP design. The results for Train C are typical of those seen in similar process studies for other applications. Ortloff's GSP design will always be superior to the ISS design for projects where high ethane recovery is desired.

The GSP design can be operated at ethane recovery levels from the maximum possible as shown in Table 5 above to full ethane rejection similar to the OHR and ISS designs shown earlier in Table 4. However, operating the GSP design in full ethane rejection mode results in lower propane recovery than can be achieved with the OHR design. The propane recovery is still higher, however, than can be achieved with the ISS design in full ethane rejection mode.

The GSP design is clearly optimum for the high ethane recovery operation. The OHR design is clearly optimum for full ethane rejection operation. There is no operating requirement which would favor the ISS design. But the design requirements include the capability to operate at a controllable and variable ethane recovery level to meet a specific ethane production requirement which may fall between the maximum ethane recovery point and full ethane rejection. The optimum process design for the intermediate operating points can be determined from a graph of ethane recovery versus propane recovery for both the GSP and OHR designs as shown in Figure 5. Since the OHR design can be operated at ethane recovery levels from 0% up to about 40% with superior propane recovery, the OHR design is optimum at ethane recovery levels up to 40%. When the required ethane recovery exceeds 40%, the GSP design is optimum but there will be a drop in propane recovery compared to the OHR mode. Note that the graph is for the design train throughput of 16 MMSCMD using the design gas composition.

A comparison of the flow diagrams in Figures 3 and 4 for the OHR and GSP designs shows that the new train can be built to easily accommodate either process design using the same columns, expander, and exchangers. The reflux stream can be piped and valved to come from either the inlet exchangers or the second column overhead. The overhead of the second column can be piped and valved so that it can be routed to the reflux exchanger or to the lowest feed of the absorber column. The exchangers, expander- compressor, and column internals can be specified for both operating modes. With the appropriate piping and valving installed, the operating mode can be changed on-line as needed.

The operating flexibility of the resulting dual mode design will allow TGS to maximize propane production while controlling ethane recovery to meet the daily production requirement. The dual mode design is, therefore, the optimum design for meeting the requirements for Train C.

Conclusions

All three of the existing compression trains at the Cerri Complex will be re-rated for maximum throughput, with two compression trains dedicated to Train A and B and a third dedicated to a new cryogenic processing train, Train C. Debottlenecking the existing facilities will improve throughput and recovery of the two processing trains using two compression trains. Significant additional improvements to meet future increases in ethane production are possible by upgrading the two existing cryogenic trains to Ortloff's GSP design.

The optimum process design for Train C is a dual mode design which combines Ortloff's OHR and GSP designs. The dual mode design will allow Train C to be operated in the optimum mode as necessary to meet the ethane recovery requirement whileTrains A and B are operated to maximize NGL recovery rather than ethane recovery.

The total processing capacity for the Cerri Complex can be increased from 22 MMSCMD to 40 MMSCMD with an ethane recovery capacity of nearly 1900 MTD using proven Ortloff technology. Very high propane recovery can be maintained as the ethane recovery is controlled over a range from 1000 MTD to 1900 MTD as needed to meet current and future ethane demand. Total NGL recovery can be increased from 2600 MTD to 4500 MTD without adding compression horsepower.

References

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2. "Improving Gas Processing Profits with Retrofit Designs for Better Ethane Rejection/Recovery", John D. Wilkinson, P.E. and Hank M. Hudson, P.E., Permian Basin Regional meeting of the Gas Processors Association, May 13, 1993, Midland, Texas.

Figure 1

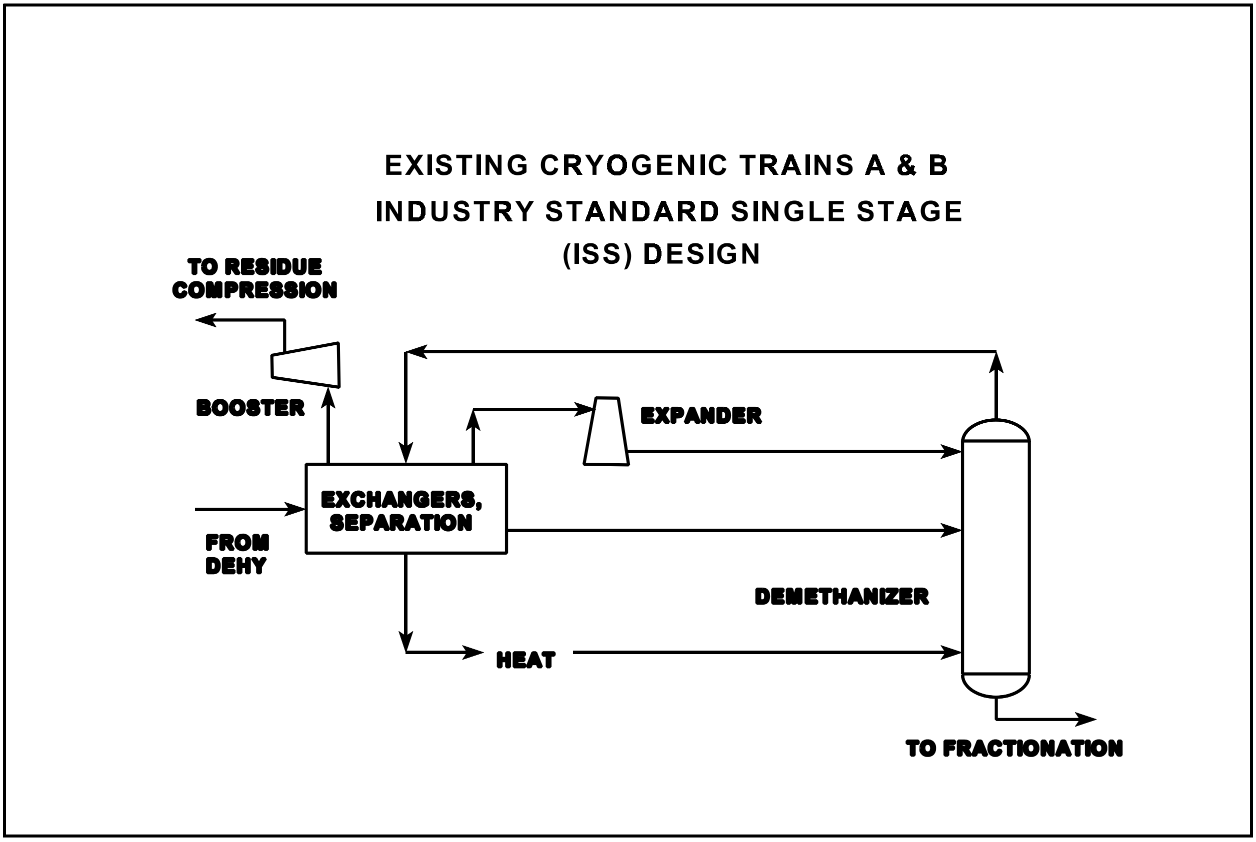


Figure 2

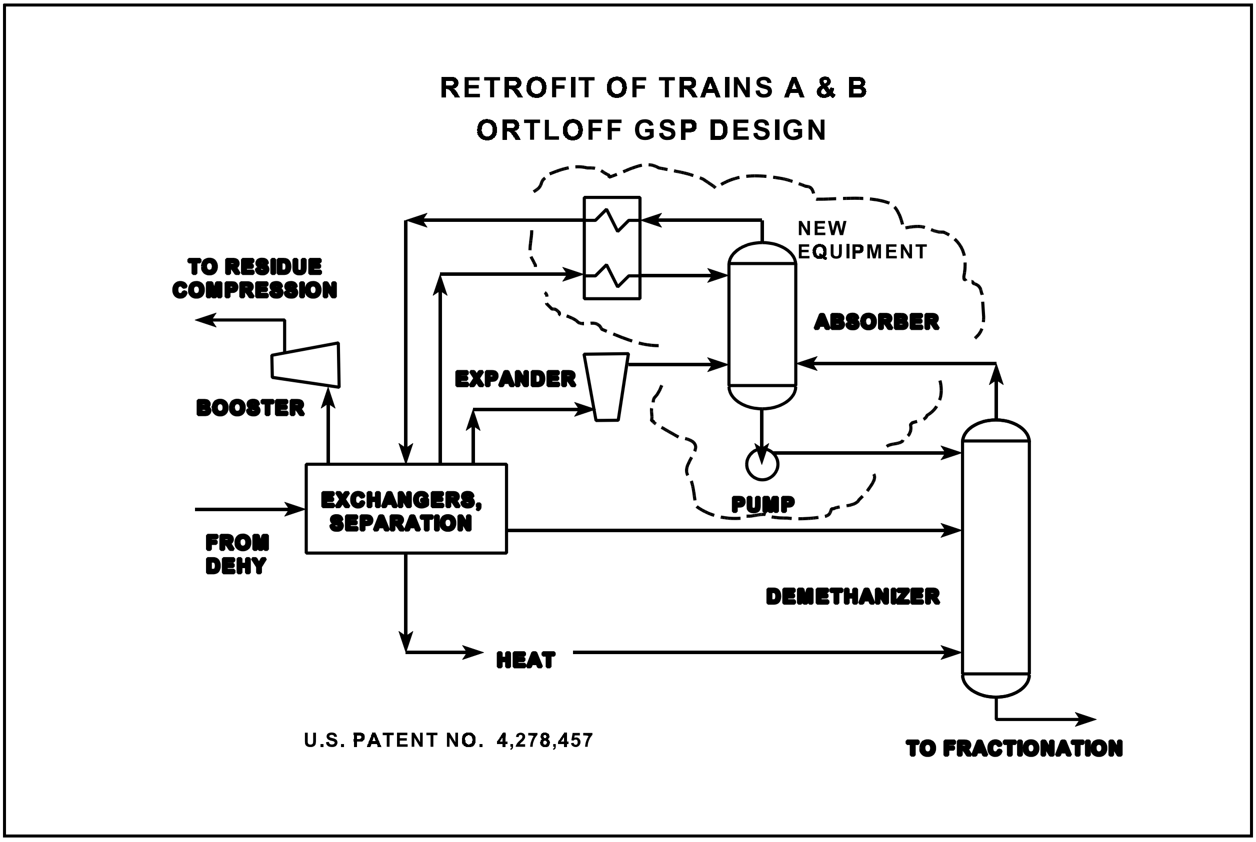
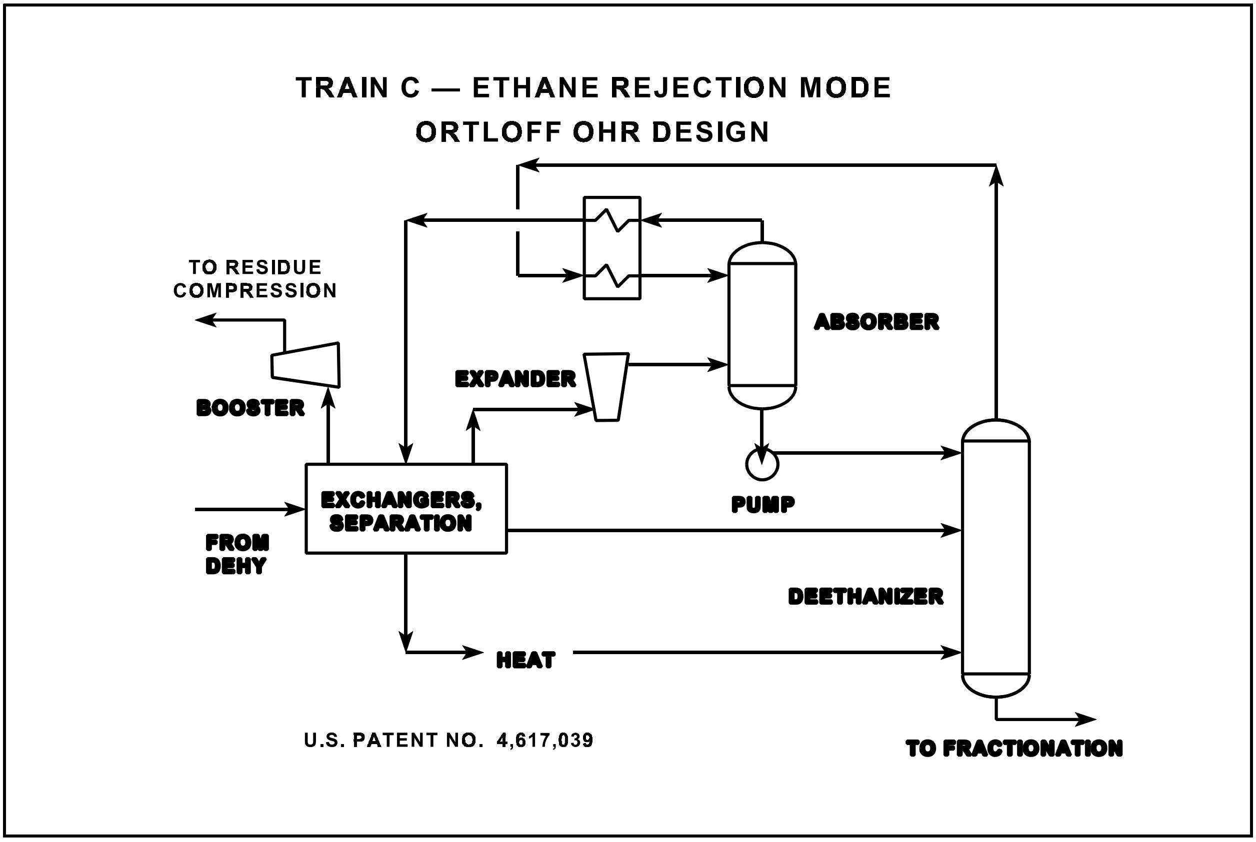


Figure 3

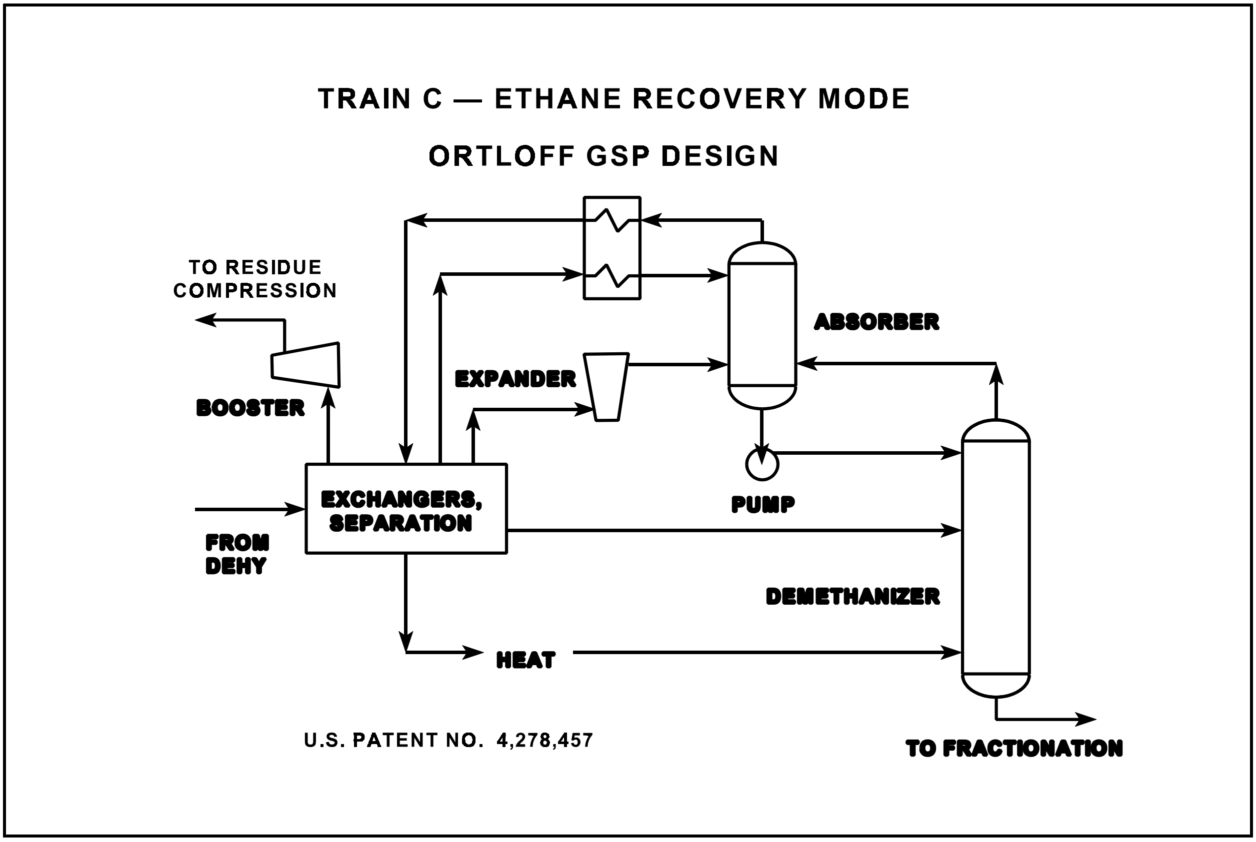


TRAIN C — ETHANE REJECTION MODE

ORTLOFF OHR DESIGN

U.S. PATENT NO. 4,617,039

Figure 4

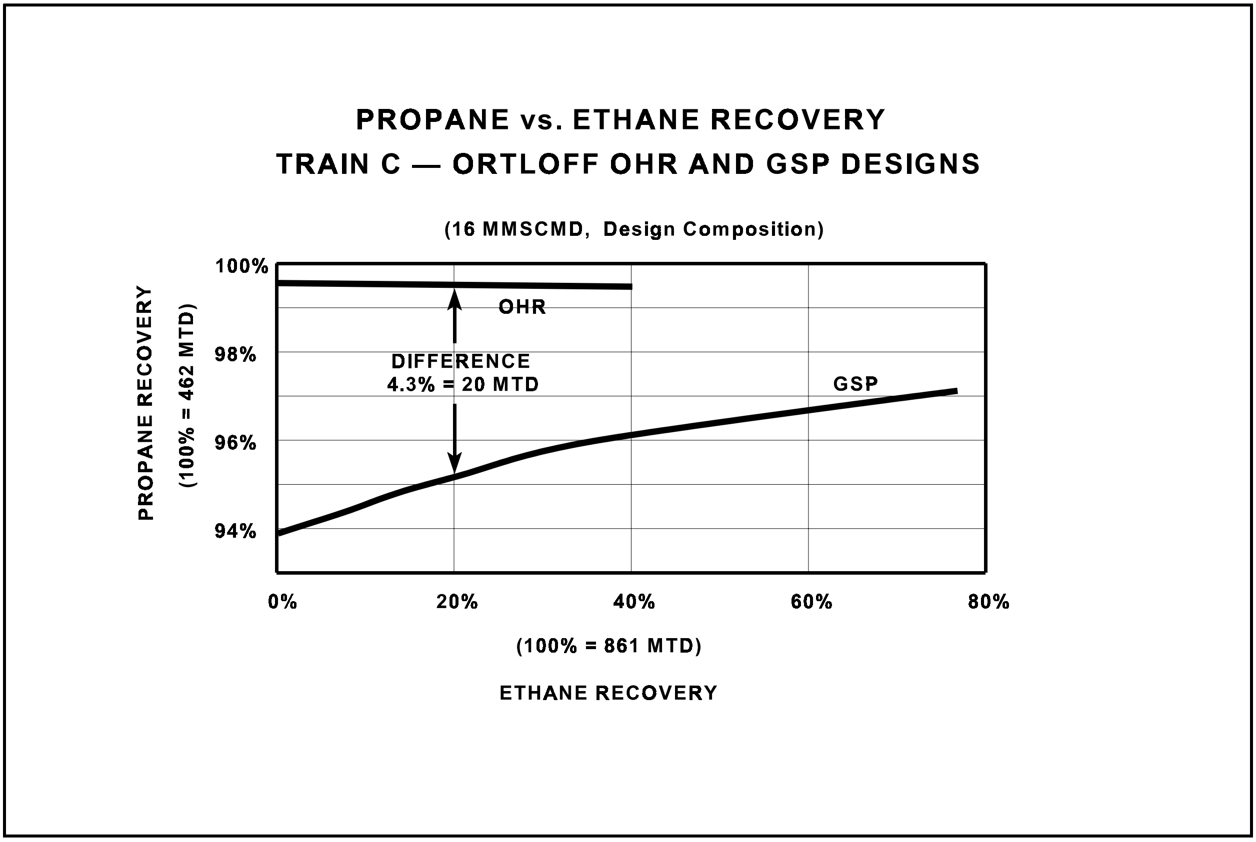


TRAIN C — ETHANE RECOVERY MODE

ORTLOFF GSP DESIGN

U.S. PATENT NO. 4,278,457

Figure 5


PROPANE vs. ETHANE RECOVERY
TRAIN C — ORTLOFF OHR AND GSP DESIGNS
(16 MMSCMD, Design Composition)
PROPANE RECOVERY
(100% = 462 MTD)
100%
98%
96%
94%
OHR
DIFFERENCE
4.3% = 20 MTD
GSP
0%
20%
40%
60%
80%
(100% = 861 MTD)
ETHANE RECOVERY