Retrofitting the Williams Energy Services Ignacio Plant for Higher Throughput and Recovery

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Abstract

The Ignacio Plant located near Durango, Colorado was originally designed to process 346 MMSCFD of feed gas and to recover approximately 82% of the contained ethane. Based on increasing volumes of available feed gas, Williams Energy Services undertook a study to investigate alternatives for increasing plant capacity and ethane recovery. This study led to the selection of Ortloff's **R**ecycle **S**plit-**V**apor (RSV) process for retrofitting the existing facility because it offered several very important advantages: maximum utilization of existing equipment, a 30% increase in plant feed handling capacity and an increase in average ethane recovery to 94% without adding residue compressors.

This paper presents the comparative case analysis that led to the selection of the RSV design. It also describes the modifications required for the retrofit, all of which can be accomplished with minimum plant down time. The modified Ignacio Plant is scheduled for startup in March 1999.

Background - WES Ignacio Plant

The Ignacio Plant was originally constructed in 1985 to process up to 346 MMSCFD of inlet gas using a single-stage expander process design with supplemental mechanical refrigeration. The facility also includes inlet gas compression, inlet gas treating, gas dehydration, residue compression, product fractionation, and a small LNG facility. These systems are shown schematically on the block diagram in Figure 1.

Residue compression is supplied by two 10,000 horsepower GE gas turbines driving Nuovo Pignone centrifugal compressors. Propane refrigeration is supplied to the cryogenic plant and to the deethanizer reflux condenser in the fractionation train by one 1700 horsepower electric motor driven centrifugal compressor.

The inlet gas contains 2.8% CO_2 but no H_2S. The CO_2 is removed using a proprietary amine solvent, and the water is removed using a TEG glycol dehydration unit followed by molecular sieve dehydration.

A local market exists for fractionated products, especially during the colder months. Thus a portion of the natural gas liquids are fractionated to meet local demand for propane, butane, and gasoline. Components which are not sold locally are recombined with the un-fractionated NGL product stream and delivered to a Mapco pipeline.

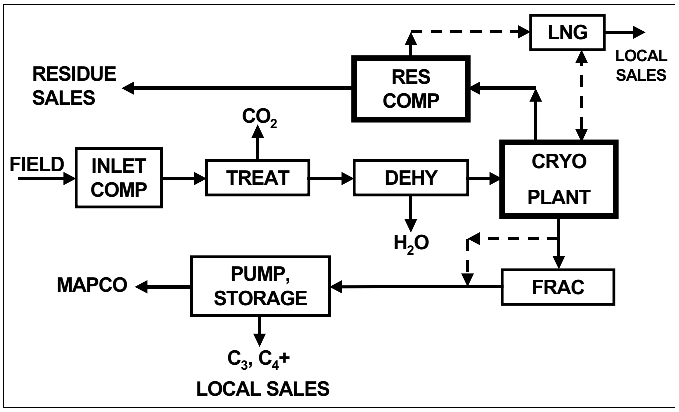

Figure 1. Ignacio Plant Block Diagram

Ten to twenty thousand gallons/day of LNG are produced by using a portion of the cold residue gas stream to condense methane. The LNG system is operated intermittently to meet local market demand.

Ethane rejection is achieved by routing the deethanizer overhead gas stream to the suction of one residue compressor. The feed stream for the LNG unit is taken from the interstage discharge piping of the other residue compressor. No ethane is rejected in the demethanizer when the LNG unit is in service.

A process retrofit feasibility study completed several years ago had confirmed that a GSP retrofit for the 450 MMSCFD rate was practical at Ignacio. Williams used that information in planning the modifications to the upstream systems and in determining the best economic use of the facility. Field development and the merger with Mapco in early 1998 created an additional incentive to proceed with the high throughput, high ethane recovery project.

The upstream inlet compression, inlet treating, and inlet gas dehydration systems were modified over the last two years to support the 450 MMSCFD cryo plant retrofit inlet rate in separate projects. The modifications included a new inlet gas glycol contactor column sized for 450 MMSCFD. (The molecular sieve dehydrators and outlet filters were found to be suitable for the 450 MMSCFD rate.) An existing glycol contactor (made available by the new glycol contactor) was converted to become a fourth parallel inlet gas amine contactor. In addition to the changes to the upstream systems, evaporative coolers were added to the air inlets of the residue gas compressor gas turbines.

Original Cryogenic Plant Design

The original cryogenic plant design was a traditional single-stage expander plant with external refrigeration. A simplified schematic is shown in Figure 2. After dehydration, the inlet gas stream is split between the gas/gas exchangers and the column reboilers before recombining at the expander inlet separator. The separator liquids are sent to the lower column feed point on level control. The expander outlet stream is routed to the top feed point of the demethanizer. There are no external reflux streams or column fractionation stages above the expander feed. The top section of the column acts as an expander outlet separator, with the vapor leaving the column with the residue gas and the liquids distributed as reflux above the top packed section of the column.

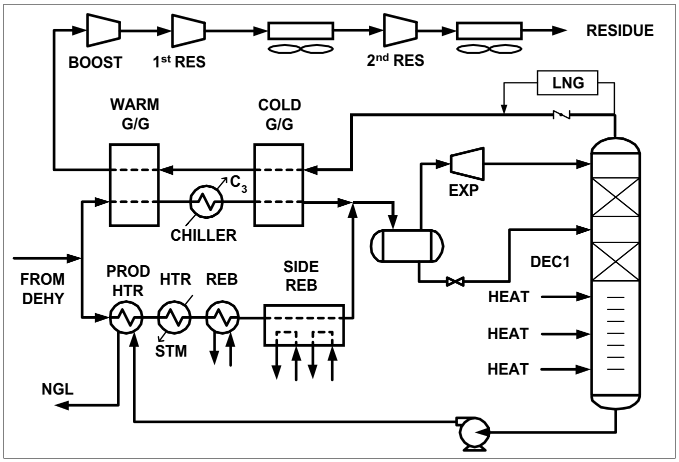

Figure 2. Original Design

The demethanizer column has packing in the top two sections and trays in the lower sections. The column has two side reboilers and a bottom reboiler for heat input by cross exchange with the inlet gas. A steam heater on the inlet gas stream upstream of the bottom reboiler can supply additional heat when the inlet gas temperature is low or the column pressure is high. The demethanized product passes through a product heater to cool a portion of the inlet gas and to preheat the liquids before they enter the deethanizer.

The demethanizer column overhead vapor is routed back through the cold and warm gas/gas exchangers to cool inlet gas before being partially re-compressed by the booster compressor on the turboexpander. Propane refrigeration is used for additional cooling of the inlet gas in a chiller located between the warm and cold gas/gas exchanger passes.

The residue gas is compressed to residue pipeline pressure with two parallel (2x50%) GE/Nuovo Pignone centrifugal compressors driven by GE Model 3142J gas turbines. Each compressor has two compressor stages, with air cooling on the interstage discharge. As originally supplied, the gas turbine drivers were rated at 10,000 HP each at 75°F ambient temperature. With the evaporative cooling in service, the horsepower increased to 10,500 HP each at 75°F ambient.

The plant has been processing up to 350 MMSCFD of inlet gas while achieving 75%-80% ethane recovery and 98% propane recovery. The actual recovery has been less than the original design value because the inlet pressure has been lower than design and the column pressure has been higher than design.

Process Modification Objectives

Due to an increase in feed gas availability, Williams desired to increase the throughput and the ethane recovery of the facility. This was to be achieved by modifying the process design and by adding compression, if necessary. The retrofit performance targets and design constraints were as follows:

Performance Targets:

1. Achieve throughput of 450 MMSCFD, an increase of 104 MMSCFD or 30% over the original design.
2. Target average annual ethane recovery of 95+% and propane recovery of 99+%.
3. Retrofit plant must be able to operate in ethane recovery or ethane rejection modes, with and without LNG production, without sacrificing throughput.
4. Minimum plant downtime for tie-ins to new equipment and for modifying the existing equipment.

Design Constraints:

1. Modifying the existing gas turbines and compressors was preferable to adding parallel units.

2. The demethanizer and low pressure (column or residue side) equipment design pressure is 365 PSIG.
3. The existing heat exchangers, expander feed separator, demethanizer column, and refrigeration system should all be reused with minimum modifications.
4. Reuse the existing expander and lube oil system. Re-wheel the turboexpander as needed.
5. Product pumping and fractionation systems needed to be de-bottlenecked.

Evaluation of Existing Cryogenic Plant

The design steps taken for this retrofit project are similar to those detailed in a previous paper [1]. Ortloff first simulated the original process design using the design compressor curves. The original equipment sizing was checked to see how much additional capacity existed. All heat exchangers were rigorously rated against the original design requirements. The expander feed separator and column internals were checked for capacity. Major line sizes were checked for velocity and pressure drop. The compressor curves and driver horsepower requirements were checked for surplus capacity. The refrigeration system and deethanizer column were included in this study.

Two design concerns were identified. First, the side reboiler plate-fin exchanger was oversized by a factor of three compared to the original design requirement. Second, the operating temperature of the expander feed separator was only 12°F warmer than the temperature at which total condensation occurs. This operating condition can cause unstable operation.

Next, Ortloff prepared a simulation to predict the expected plant performance for the current (March 1998) inlet composition and operating pressures. The current feed composition, feed rate, and pressures were used along with the exchanger ratings to calculate the expected expander feed separator temperature, column temperature profile, recovery, expander horsepower, and residue compressor horsepower. The predicted expander feed separator temperature was 14°F warmer than the total condensation temperature, even at the lower separator pressure and with the change in the feed composition from the original design. This simulation became the baseline case for a plant test.

Plant operating data were gathered and simulated at the plant site for comparison to the simulation of the expected performance. Analysis of this operating data resulted in the following findings:

1. The oversize side reboiler UA was confirmed and noted for the retrofit design. A result of the excessive side reboiler UA was that a higher than optimum percentage of the total column heat input was supplied by the side reboilers, and the trays below the side reboilers were underutilized.
2. The recompressor speed and head were less than expected, indicating that the gas turbine driver horsepower was less than design. The plant personnel immediately undertook a separate project to successfully restore the turbine horsepower to expected levels.

3. The existing exchangers were all performing as expected with no degradation over the years due to mole sieve dust, oil, or other fouling.
4. Several minor instrumentation problems were discovered and addressed by plant personnel. (For example, temperature indication errors were found which were not obvious without the heat balance data across the exchangers from the simulation.)
5. Plant operators confirmed that the cryo plant operating parameters were adjusted as needed to prevent the "snowball" event common to the standard single-stage expander design operating close to the phase envelope.
6. Actual pressure drops were recorded during the plant test. These were used later in the retrofit design, scaled up as needed for the new flow rates.

Armed with a good understanding of the original design and the equipment limitations, along with confirmation of the actual performance of the existing equipment, Ortloff proceeded confidently with the retrofit study.

Process Retrofit Options

The throughput of an existing plant can be increased until the demethanizer column floods, the expander feed separator carries over, or, as is the case at Ignacio, the expander capacity is reached and the J-T valve opens. One problem with simply debottlenecking the original design is that the limitations of the existing equipment are quickly reached, depending on how much safety factor was included in the original design. A second problem with retaining the original design is that the additional throughput requires a proportional increase in residue compressor horsepower, plus additional horsepower to overcome higher pressure drops. A third problem is that the ethane recovery will drop as the plant throughput is increased beyond the design point. The target 30% increase in throughput for Ignacio would require a 30-40% increase in residue compressor horsepower just to maintain the 80% ethane recovery level. The desired 95% ethane recovery level could not be reached with the standard single-stage design, regardless of the horsepower supplied. Debottlenecking the existing process at Ignacio without a process design change was not practical.

Three retrofit process designs were considered. Each required an extension to the existing demethanizer column so that several fractionation stages and a cold reflux stream could be added above the expander feed. Physically adding stages to an existing column above the expander feed is not practical for a large operating plant due to downtime constraints, so the physical column extension would require a separate absorber column with the demethanizer overhead and the expander outlet fed to the bottom of the absorber and with the absorber bottoms pumped back to the top feed point on the demethanizer. The top feed to the absorber would be a cold stream from a new reflux exchanger. The three retrofit designs differ in the source of the reflux stream, the number of passes in the reflux exchanger, and the number and location of the feed points to the absorber column. They also differ in their ethane and propane recovery levels, column operating pressures, and residue horsepower requirements.

Residue Recycle Retrofit Design

The residue recycle design shown in Figure 3 uses a recycle stream of 20-30% of the total residue gas that is routed through a reflux cooler and subcooler before being fed to the top of the absorber column. This design is capable of providing very high ethane recovery if sufficient horsepower is available. This process design is usually not optimum because the bulk ethane recovery in the demethanizer requires a large quantity of cold reflux, which means a high flow rate for the recycled residue gas stream.

The residue recycle design is not normally considered for retrofit projects when a throughput increase is desired for two reasons. First, the inlet exchangers, expander feed separator, and expander must be able to handle the entire retrofit design inlet flow rate. This prevents increasing the retrofit throughput above what can be achieved just by debottlenecking the original plant design. Second, the optimum demethanizer operating pressure for a residue recycle design is normally much higher than that used by the original industry standard single-stage design. Existing plants usually have a design pressure for the demethanizer column and low pressure equipment which is too low for an optimized residue recycle design. The Ignacio column operating pressure is limited to 340 PSIG for this reason, and the residue horsepower required to provide the recycle rate to achieve the 95% recovery level was estimated to be well over 20% higher than the latest process designs available. For these reasons, the residue recycle design was not considered seriously for the Ignacio retrofit.

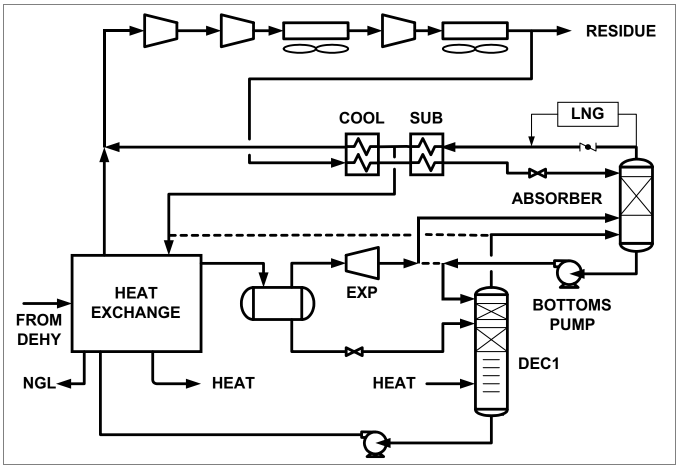

Figure 3. Residue Recycle Design

Ortloff GSP Design

Ortloff's **G**as **S**ubcooled **P**rocess (GSP) retrofit design is shown in Figure 4. The main difference from the residue recycle design is that the source of the reflux stream is relatively rich high pressure inlet gas rather than recycled residue gas. The inlet gas used for reflux (the split-vapor) bypasses the existing equipment and expander, thus effectively debottlenecking the existing plant by the amount of the split-vapor flow rate (typically 25-35% of the total inlet gas rate). The inlet gas reflux stream is cooled, condensed, and subcooled using residue gas from the overhead of the absorber column. Since some of the residue gas duty is used to cool and condense reflux, less duty is available to cool inlet gas. The expander feed separator temperature warms up significantly. This result of the GSP design moves the separator operating temperature away from the liquid line of the phase envelope to a more stable region, eliminating the "snowball" operating limitation of the original design. The expander horsepower also increases as the separator temperature increases, reducing the load for the recompressors.

The limitation of the GSP design for high ethane recovery results from the use of rich inlet gas as the top feed to the absorber column. The inlet gas contains much higher concentrations of ethane and propane than the residue gas. Significant amounts of ethane and propane are lost to the residue gas due to the equilibrium between the ethane and propane in the cold reflux liquid and the gas it contacts in the top of the absorber. These equilibrium losses prevent ethane recovery higher than 94% for the Ignacio feed composition at a reasonable horsepower level. The propane recovery is limited to about 99% for the same reason. Although the high pressure rich inlet gas is an effective source of reflux for bulk ethane recovery, it cannot rectify the absorber overhead to achieve high ethane recovery levels without an inordinate increase in residue compression horsepower. A graph of ethane recovery versus residue compressor driver horsepower for the 450 MMSCFD GSP Ignacio design is shown in Figure 5. Note how the ethane recovery curve starts flattening out as the recovery approaches the 94% level.

The Ortloff GSP design normally provides a good balance of recovery versus residue horsepower, and has thus become the industry standard design for all new plants and the starting point for all retrofit designs. However, the 95% ethane recovery target for the Ignacio retrofit could not be met with the GSP design alone.

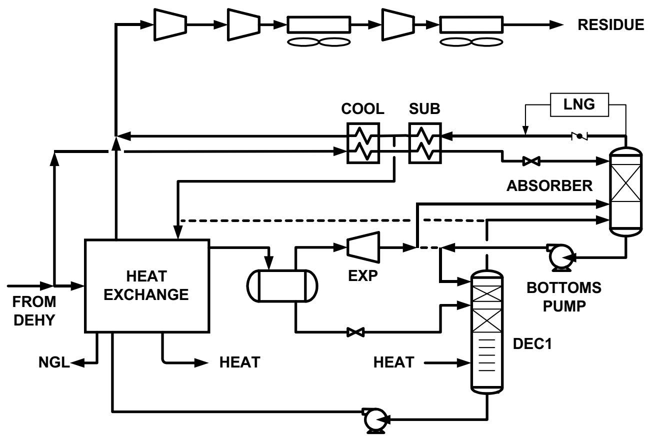

Figure 4. Ortloff GSP Design

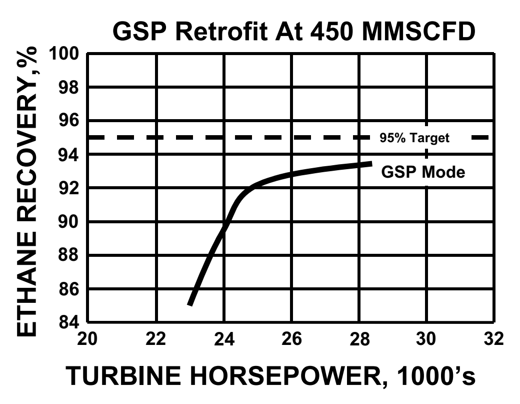

Figure 5. GSP Recovery vs. HP

Ortloff RSV Design

The advantages of the GSP design can be retained while overcoming its recovery limitation by using Ortloff's **R**ecycle **S**plit-**V**apor (RSV) design [2]. The RSV retrofit design is shown in Figure 6. A second feed point is added to a taller absorber column and a pass is added to the reflux exchanger. The split-vapor reflux path is retained from the GSP design but the feed point is moved to a new feed location at an intermediate point on the absorber. The top feed source is a recycle stream of lean residue gas that is condensed and subcooled in parallel with the split-vapor reflux stream. The source of this recycle stream is the residue compressor discharge, the same as for the residue recycle design.

The major advantage of the RSV design over the residue recycle design is the significantly lower recycle flow rate required to achieve the desired ethane recovery. The RSV design typically requires only 30-50% of the recycle rate required by the residue recycle design at the 98%+ ethane recovery level. The reason is that the split-vapor reflux stream provides bulk ethane recovery, while the recycle reflux stream is used only to capture the ethane and propane equilibrium losses at the split-vapor feed point. The result is an extremely efficient ethane recovery process [3].

The RSV reflux flow can be provided when the recompressor horsepower is available and when product margins justify high ethane recovery. The amount of ethane recovery above the 94% GSP equilibrium limitation is set by the recycle rate that can be provided by the available residue horsepower. When the residue recycle flow rate is set to zero, the RSV design reverts to the GSP design, and the ethane recovery and residue horsepower then decrease to GSP levels.

A graph of ethane recovery versus residue compressor driver horsepower for the 450 MMSCFD Ignacio RSV retrofit design is shown in Figure 7. Note how the ethane recovery increases rapidly up to the 98% ethane recovery level before flattening out as the recovery approaches 99+%. Above 93%, the ethane recovery for the RSV design is significantly higher than for the GSP design. The recycle rate required to

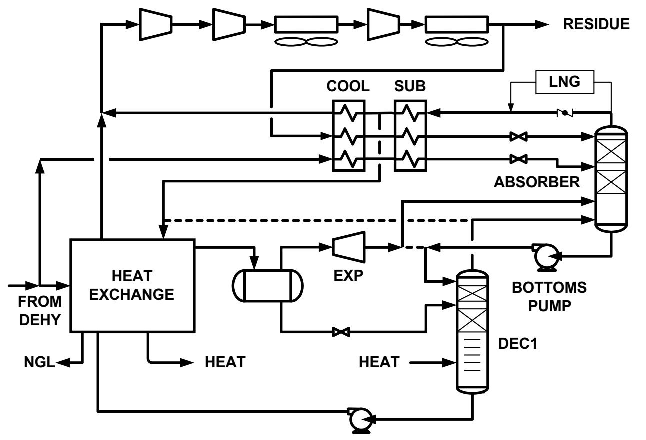

Figure 6. Ortloff RSV Design

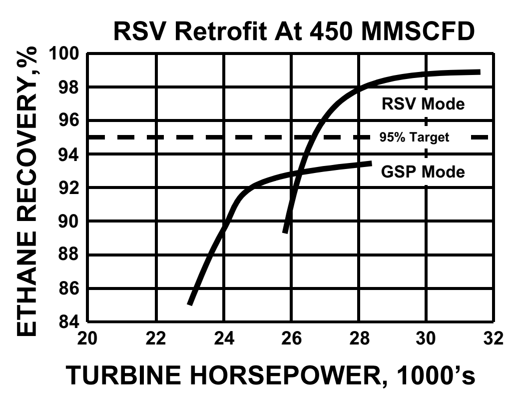

Figure 7. RSV Recovery vs. HP

achieve over 98% ethane recovery was only 10% for the Ignacio retrofit design. The RSV absorber column was only slightly larger in diameter than required for the GSP-only design.

The RSV design includes all the advantages of the GSP design, plus better propane recovery and higher ethane recovery. The RSV equipment can be operated with or without the residue recycle in service. Recovery can be traded off for throughput when market conditions do not warrant the highest possible ethane recovery or when additional recompression operating costs exceed incremental ethane revenue. For Ignacio, the flexibility and recovery advantages of the RSV design offset the higher cost over a GSP-only design (for the RSV technology fee, the additional absorber column height, and the additional pass in the reflux exchanger).

Williams selected the RSV design with the process equipment sized for the nominal 450 MMSCFD, 98.7% ethane recovery capability. A lower horsepower, off-design case for the RSV design operating in a GSP mode at 92.7% recovery was also developed. Equipment sized to accommodate these two cases will provide Williams with the maximum flexibility over the life of the plant. The ethane recovery will be very high at the 450 MMSCFD rate when the residue compressor horsepower is available. The throughput can be maintained with a decrease in ethane recovery when less horsepower is available. The absorber column diameter will allow operation well above 450 MMSCFD in a GSP mode at reduced ethane recovery.

Modifications to the Existing Cryogenic Plant Equipment

The existing cryo plant equipment items were then checked using the final retrofit process design requirements. Modifications included the following items:

1. A proprietary mist eliminator was added to the expander feed separator to help handle the additional volumetric flow to the expander (due to the warmer separator temperature).
2. The distributors and trays in the existing demethanizer were revised for the new process conditions.
3. The expander was re-wheeled on both ends, and the booster compressor case replaced along with some of the original booster compressor piping to allow efficient compressor operation at the higher compressor throughput.
4. The demethanizer bottoms pumps required additional stages and barrel length to pump the increased demethanizer bottoms flow. These changes required that the pumps be moved off their original skid so that new pump barrel holes could be drilled. The pumps were also lowered 18" to increase the NPSH available. New motors were required for the higher pumping rate.
5. Lower NPSH impellers were installed on the product pipeline pumps to accommodate the high ethane recovery case.

New Cryogenic Plant Retrofit Process Equipment

Some details on of the new equipment required for the 450 MMSCFD RSV retrofit process include the following:

1. The brazed aluminum reflux exchanger is a 3-pass unit with a side draw on the residue gas path to route a portion of the residue gas back through the existing gas/gas exchangers. The exchanger is supplied in a single core.
2. The RSV absorber column is made of 304 S.S. and contains two packed sections. The top feed is the residue reflux feed when operating in RSV mode. The second feed is the split-vapor feed. The expander outlet and the demethanizer overhead feeds are below the lower packed section.
3. The absorber bottoms pumps are standard single-stage 304 S.S. vertical in-line centrifugal pumps, with tandem seals using methanol as a seal barrier fluid. Historically, these pumps have been very reliable and trouble-free, even though operating at cryogenic temperatures.
4. A filter coalescer was provided on the residue recycle stream to minimize the chance of getting any lube oil into the cold reflux exchanger where it would cause pressure drop and heat transfer problems.

RSV Retrofit Final Process Design Results

The Ignacio Plant is located in a geographical area that has large variations in ambient temperatures. Summer temperatures can be over 90°F, while winter ambient temperatures can be -20°F or colder. The recompressor gas turbine horsepower that is available changes dramatically with the change in inlet air density due to these ambient temperature changes. Any process design for a plant in this location must accommodate and take advantage of the swings in available residue compressor horsepower. Williams' primary objective for the retrofit was a throughput increase to the 450 MMSCFD level. Absorbing the swings in available horsepower while holding throughput constant requires that the ethane recovery be allowed to vary with the available residue compressor horsepower.

Ortloff fine-tuned the 92.7% GSP mode design case to determine the residue compressor horsepower requirement for the summer conditions. Ortloff also adjusted the 98.7% RSV mode design case to cover the higher horsepower winter conditions, with appropriate changes to aerial cooler outlet temperatures and refrigerant condensing pressure. The deethanizer throughput and refrigeration load varied from summer to winter in order to match local propane market demand. Heat exchanger performance, pressure drops, and refrigeration system loads were all converged for each design case. The final results for the Ignacio design conditions and composition are shown in Table 1 below:

		Summer	Winter
1	Plant Inlet Rate, MMSCFD	450	450
2	Ambient Temperature	75°F	30°F
3	Ethane Recovery	92.7%	98.7%
4	Propane Recovery	99.0%	99.9%
5	Operating Mode	GSP	RSV
6	Inlet Gas Reflux, % of Inlet	28%	23%
7	Residue Reflux, % of Inlet	0%	10%
8	Expander Power	4,700 HP	5,500 HP
9	Absorber Column Pressure	315 PSIG	292 PSIG
10	Sep. Phase Envelope Margin	50°F	49°F
11	Residue Compression Flow Rate	402 MMSCFD	446 MMSCFD
12	Gas Turbine Power Required	26,000 HP	30,000 HP
13	Power Available (w/Evap. Coolers)	21,000 HP	24,000 HP
14	Power Shortage	5,000 HP	6,000 HP
15	Power Shortage / Machine	2,500 HP	3,000 HP

Table 1 — RSV Retrofit Final Process Design Results

If the additional 6,000 HP for compression could be installed or found, the average ethane recovery target of 95% could be achieved at the 450 MMSCFD throughput using the RSV design. At most, a parallel compressor package comparable to a Solar Taurus would need to be installed to make up the difference between the maximum capabilities of the existing equipment and the process requirements.

Note from Line 10 that the margin between the expander feed separator operating temperature and the temperature at which full condensation occurs increases to 49 - 50°F for the retrofit design. Operation at this temperature will be quite stable, eliminating the possibility of "snowball" episodes and allowing operation at inlet pressures determined by inlet compression limitations rather than by the phase envelope.

An off-design consideration unique to the Ignacio Plant is the effect of LNG production on ethane recovery. The Williams patented LNG process uses the cold residue gas from the RSV absorber column overhead to cool a side stream of residue gas in the LNG unit. The column overhead gas is heated a few degrees before it enters the reflux exchanger. This reduces the amount of subcooling applied to the reflux streams, resulting in warmer feed temperatures to the absorber and higher flash vapor losses. For the summer operating conditions, the impact is a six percentage point reduction in ethane recovery when producing 25,000 gallons/day of LNG. Although the ethane recovery is reduced when producing LNG, plant throughput can be maintained at 450 MMSCFD without increasing the residue compression power requirements.

Presently, the CO_2 in the inlet gas is removed down to the 100 ppm level ahead of the cryo unit. This prevents CO_2 freeze problems in the cryo unit and in the LNG unit. The RSV retrofit design has a much higher CO_2 tolerance than the original design. The LNG unit, however, cannot tolerate any CO_2 in its feed.

If a small amine contactor and dehydrator were added to the residue gas side stream ahead of the LNG unit, some CO_2 could be left in the RSV cryo plant feed gas. The resulting reduction in treating costs may justify the equipment costs to treat and dehydrate the small LNG unit feed stream. This possibility will be evaluated in 1999.

Compressor and Gas Turbine Modifications

The two initial design cases were developed assuming a third compressor could be installed in parallel with the two existing compressors. However, an "Advanced Technology" (AT) gas turbine upgrade was available from GE which, when combined with steam injection, would significantly increase the horsepower of the Ignacio gas turbines. This option was evaluated before committing to additional machines. A comparison of the gas turbine horsepower versus ambient temperature with and without this upgrade option is shown in Table 2 below:

	Season	Summer	Winter
1	Ambient Temperature	75°F	30°F
2	Power Available w/Evap. Cooling Only	21,000 HP	24,000 HP
3	Power Increase for Hot Path Upgrade + Steam Inj.	+3,800 HP	+3,600 HP
4	Power w/Evap. Cooling + Hot Path Upgrade + Steam Inj.	24,800 HP	27,600 HP
5	Power, Process Requirement, Target Cases	26,000 HP	30,000 HP
6	Power Short of Target Requirement	-1,200 HP	-2,400 HP
7	Ethane Recovery with Modified Turbines	92.1%	97.1%
8	Ethane Recovery from Target Cases	92.7%	98.7%
9	Difference	0.6%	1.6%

Table 2. Gas Turbine Modification Results

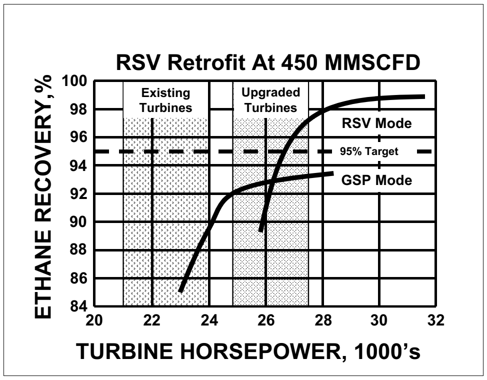

Figure 8. RSV Recovery vs. HP

The existing turbines with the Advanced Technology upgrade and steam injection would provide 95% of the summer and 92% of the winter target horsepower. The retrofit design simulations were then adjusted to determine the recoveries using the horsepower available from the modified turbines. The results are shown on line 7 of Table 2 and again graphically in Figure 8. Deferring additional compressors would result in only a 0.6% point decrease in the summer ethane recovery and a 1.6% decrease in the winter ethane recovery. The average annual ethane recovery would be about 94% rather than the target 95%. Since the throughput target could be met with the upgrade and steam injection, the slightly lower ethane recovery level was accepted and the project team proceeded with determining if the compressors could be modified to handle the increase in throughput and driver horsepower.

The compressor manufacturer conducted a retrofit study and confirmed that the compressors could be re-wheeled for the required throughput and pressure ratio without exceeding nozzle velocity or shaft torque limits. The seven-impeller compressor rotor would be replaced with a new rotor with six wider impellers, designed for the lower head, higher flow rate retrofit conditions. The final retrofit compressor performance was a good match with the upgraded gas turbine performance, so the equipment was placed on order for installation in 1999.

The process equipment is in place to support 98% ethane recovery at the 450 MMSCFD rate year round if compression is added. The RSV mode recovery versus horsepower graph in Figure 8 indicates that 98% ethane recovery can be achieved at the 450 MMSCFD rate if 28,000 horsepower is available. A nominal 4,000 horsepower parallel compressor can be added in the future if and when justified by ethane product pricing economics.

Project Schedule

Major process tie-ins were made during a May 1998 shutdown. The final tie-ins, equipment modifications, and startup of the retrofit process will occur by March 1999. The steam injection systems for the gas turbines will be installed during the 1999 shutdown for tie-ins. The compressors will not be re-wheeled until a shutdown in May 1999. Throughput will be limited to about 425 MMSCFD and ethane recovery will be around 93% until the compressors are re-wheeled.

Conclusions

The Ignacio Plant process retrofit using the RSV process design will allow processing 450 MMSCFD of gas (30% over the original design) with ethane recoveries ranging from 92% in the summer to 97% in the winter. The throughput and recovery increases are possible without adding residue compressors. Propane recovery will be 99+% year round. The retrofit process is very flexible and stable. The Ortloff RSV process retrofit will allow the most profitable use of all the plant equipment over a wide range of product pricing and local market conditions.

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