IMPROVING THROUGHPUT AND ETHANE RECOVERY AT GPM'S GOLDSMITH GAS PLANT

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Abstract

GPM's Goldsmith Gas Plant was successfully converted from a nominal 90% ethane recovery 86 MMSCFD design capacity two-stage expansion process to a 95% ethane recovery 135 MMSCFD capacity plant by upgrading to Ortloff's Gas Subcooled Process (GSP) design. The conversion required modification of the existing expanders and chillers and the addition of a plate-fin exchanger, an absorber column, and a set of pumps. Time from project approval through startup was five months. NGL production was interrupted for ten days while the plant was down for tie-ins and checkout. The plant throughput was compression limited to operation at 130 MMSCFD through late 1995. Compression to allow throughput above 130 MMSCFD was operational in late 1995.

The demethanizer column and six of nine heat exchangers were reused in the Ortloff process retrofit. The demethanizer internals were changed out in 1995 in anticipation of higher throughput with the new compression. The two expanders were modified for parallel expander and booster compressor operation. Expander replacement was not necessary.

The project team included area contractors and GPM maintenance and technical personnel. Careful coordination of the conceptual design, detailed design, procurement, HAZOP, operator training, shutdown planning, and startup phases resulted in a successful fast track project.

Background - GPM Goldsmith Plant

A block diagram of the Goldsmith Plant is shown in Figure 1. The facility includes inlet compression from 5 PSIG and 50 PSIG gathering systems, DEA treating to remove CO_2 and H_2S, Cold Bed Adsorption (CBA) sulfur recovery, dehydration, treated gas compression to 860 PSIG, cryogenic NGL recovery, residue recompression to 620 PSIG, and the supporting utility systems.

The original refrigerated single-stage expansion cryogenic plant was installed in 1976 for an inlet rate of 78 MMSCFD. It was changed to a two-stage expansion design for processing 86 MMSCFD of gas in 1982. The two-stage plant allowed operation at rates up to 110 MMSCFD, but with a relatively poor ethane recovery of 70%. At 110 MMSCFD, the throughput exceeded the capacity of the expanders so the J-T valves around both expanders were always partially open. Excessive pressure drop existed across one plate-fin exchanger.

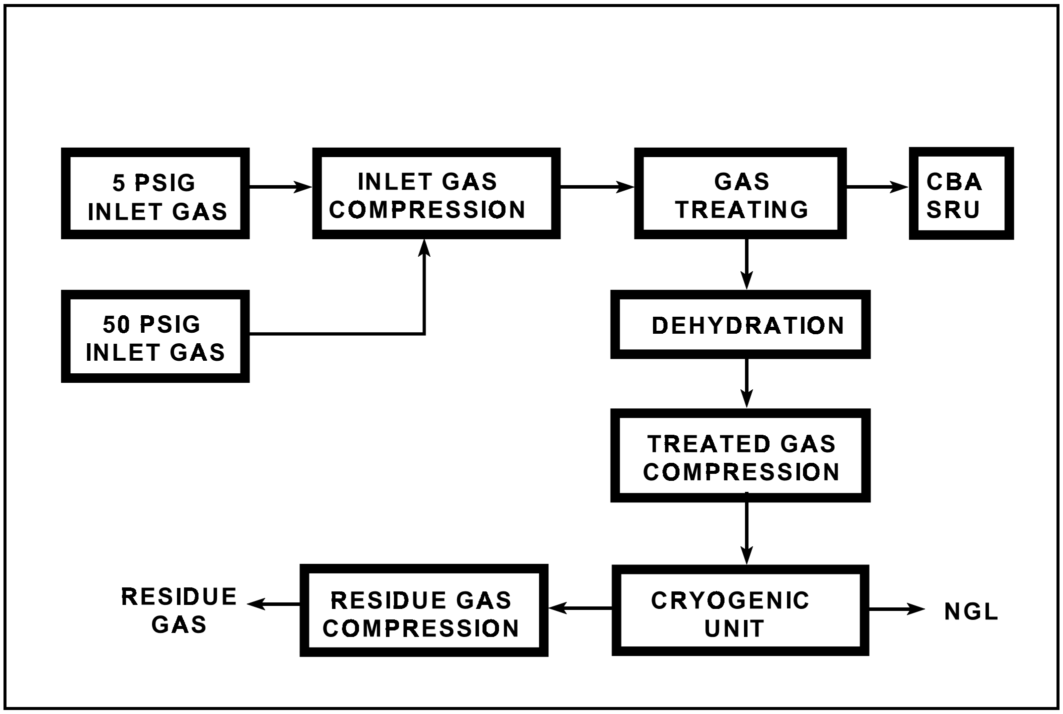

Figure 1. Goldsmith plant block diagram

GPM desired to increase the facility throughput and to substantially improve product recovery at minimum cost. This paper describes the design review process and the changes that were made to the two-stage cryogenic plant to increase the design throughput from a nominal 86 MMSCFD to a nominal 135 MMSCFD. Of course, changes were planned for the other systems in the plant to support the higher cryogenic plant throughput. Only the changes to the cryogenic plant and the resulting operation are discussed here.

Cryogenic Plant Redesign Checklist

In many cases, the ultimate capacity of the cryogenic unit will set the design rate for modification of all the other plant systems. Some of the details which must be checked during any cryogenic plant redesign study are listed below:

1. Equipment design pressures.
2. Piping and equipment metallurgy and original cold and hot design temperatures.
3. Demethanizer sizing and internals.
4. Expander frame size and lube oil system limitations.
5. Expander feed separator separation capacity and liquid surge time.

6. Demethanizer side heater and thermosiphon reboiler hydraulics.
7. Heat exchanger pressure drops, heat exchange surface area limitations, and potential for tube vibration in shell and tube exchangers at higher throughput.
8. Pressure drops and/or velocities in the existing piping.
9. Pressure relief system capacity, control valve sizing, orifice plate sizing, and instrument ranges.
10. Compression capacity and horsepower limits.
11. Existing equipment performance problems or known maintenance items.
12. Availability of surplus equipment.
13. Economic basis for recovery vs. throughput vs. capital cost decisions.

A retrofit for increased recovery alone is generally much simpler than one for both increased recovery and throughput because equipment sizing and pressure drop are less of a constraint. However, the economics of most projects are improved if increases in both recovery and throughput can be achieved.

Assuming that the goal is to increase both the throughput and the ethane recovery of the existing facility, the study will generally include the following steps. First, the original process design is simulated using the original inlet gas composition to establish a check on the original design basis and provide baseline design data if information on the existing equipment is not readily available. Any process equipment changes made since the plant was built are then incorporated into the simulation and the design changes confirmed. Good agreement with all available data sheets should be obtained or any deviations explained and noted.

The next step is to model the current plant operation. The feed composition is updated, current pressures and temperatures are input, and the resulting simulation is checked against current field test data to identify any equipment items which do not match the expected performance. The simulation is then adjusted until the best agreement between the field data and the model is obtained. After this step, the resulting exchanger performance and pressure drops can be used as a starting point for the redesign. Any significant differences between the actual equipment performance and the original design must be analyzed and resolved before the study can proceed. For example, current heat exchanger performance may not meet the original design specifications. A decision must be made to use either the current heat transfer capability for the redesign or to plan on restoring the original exchanger performance during a shutdown.

For a given process redesign, a trial flow rate and recovery must first be simulated using appropriately factored exchanger heat transfer (UA) values and pressure drops. The compression requirements are checked to be sure they are reasonable. The existing tower sizing is checked and the flow rate and/or recovery changed to accommodate the available tower capacity, if necessary. The performance of the expanders and expander feed separators are then checked. If there are no limitations identified at the trial flow rate, then the trial flow rate and/or recovery is increased incrementally until the compression, expander, or tower size becomes limiting.

At this point, a design rate and recovery are established and each equipment item is rigorously checked. The expanders and plate-fin exchangers are best rerated by the suppliers. Each shell and tube exchanger must be checked for thermal performance, pressure drop, and tube vibration. The demethanizer bottoms pumps and pipeline pumps must be checked for the higher product rates. All the major process lines must be checked for pressure drop and velocity. The tower side reboilers and reboiler hydraulics are checked. Vessels are checked for adequate separation and liquid surge capacity.

The design case simulation is then updated with the heat transfer, pressure drop, and efficiency data from the detailed equipment checks and a list of items which must be either replaced, modified, or reused is compiled. The external plant systems are checked for the higher rates and a cost estimate is generated so that the overall project economics can be evaluated. Additional iterations may be needed to determine the optimum overall plan for the facility as decisions are made regarding compression and throughput trade-offs and the limitations of upstream and downstream plant systems are determined.

The general sequence of events described above was conducted for GPM's Goldsmith facility in late 1993. GPM desired to maximize the throughput of the existing facility and to improve the ethane recovery. The original DEA gas treating system was capable of treating 300 MMSCFD. The limit on sulfur dioxide emissions required that the sulfur plant be converted to Amoco's CBA process for higher sulfur recovery before the plant throughput could be increased. (The conversion to Amoco's CBA process was also designed by Ortloff as a separate project.)

GPM's specific guidelines for debottlenecking the Goldsmith cryogenic plant included:

1. Rework (but do not replace) the existing expanders.
2. Keep the demethanizer tower. Change internals as necessary.
3. Do not add refrigeration compression.
4. Determine the maximum achievable throughput allowing for additional inlet and residue compression.
5. Be ready for tie-ins during a scheduled facility shutdown in May 1994.
6. Have the modified unit up and running by June 1, 1994.
7. Minimize the loss of NGL production by minimizing time required for tie-ins and restart of the modified unit.
8. Specify any new instruments for use with future DCS equipment.

The redesign of the Goldsmith cryogenic plant took place in two phases. The first phase was to determine the limitations of the existing facility without changing the process design. The second phase was to evaluate retrofitting the plant using Ortloff's patented GSP design.

Limitations of the Two-Stage Design and Equipment

The process flow diagram for the two-stage cryogenic unit prior to retrofit with the GSP design is shown in Figure 2. The design included two levels of refrigeration and two expansion stages. The Demethanizer, C-1, had a trayed upper section and packed middle and lower sections. The Side Heater, E-8, and Reboiler, E-7, were combined into one plate-fin exchanger. The Cold Gas Exchanger, E-5, and the Cold-Cold Gas Exchanger, E-6, were also plate-fin exchangers. All remaining exchangers were shell and tube type. The propane refrigeration system included three 880 HP reciprocating compressors.

The two-stage design and equipment were first checked at a 110 MMSCFD inlet rate (28% over the original design) and the following changes were determined to be necessary to achieve reasonably good ethane recovery:

1. Replace both expanders. In the two-stage process, each expander sees the full cryogenic plant inlet rate (less separator liquids) and each would need to be replaced in order to permit the J-T valves to remain closed at the 110 MMSCFD inlet rate.

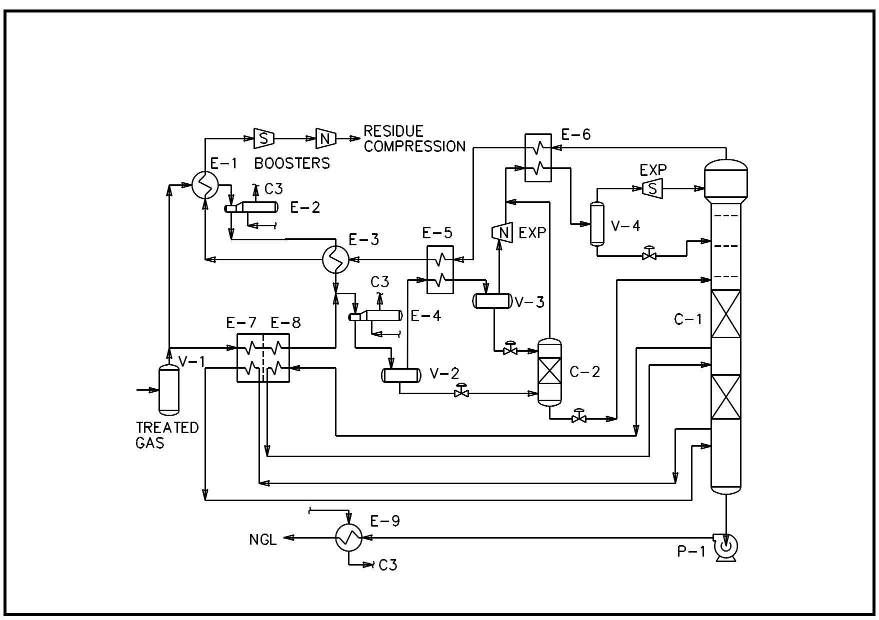

Figure 2. Goldsmith two-stage process flow diagram

2. Replace both expander feed separators with larger vessels to avoid liquid carryover into the expanders at the higher rate.
3. Replace the plate-fin Cold-Cold Gas Exchanger, E-6, to eliminate a 40 PSI residue gas side pressure drop.
4. Replace two piping runs in the residue gas piping with larger piping to minimize pressure drop at the higher rate.
5. Replace the Intermediate Gas Exchanger, E-3, with a new shell and tube exchanger to avoid tube vibration and possible fatigue failure from the much higher than design shell side residue gas flow rate.
6. Add refrigerant vapor nozzles to both chillers to reduce the vapor velocity. The kettle diameters on both chillers were found to be marginal even for the original process conditions. The additional nozzles would reduce the carryover problem.
7. Add a booster compressor discharge cooler between the boosters and the residue gas recompressors.

Plant operating experience confirmed the bottlenecks determined from calculations. The plant had been operating at 110 MMSCFD, but with a higher than desired tower pressure resulting in poor ethane recovery. Recovery could be improved if the pressure drop problems were eliminated and compression was added to support a lower tower pressure.

If all the above changes were made to the two-stage plant, the estimated ethane recovery would increase from 70% up to 87% at the 110 MMSCFD rate. However, these changes did not meet the constraints defined by GPM for the project. Increasing the throughput for the two-stage design above 110 MMSCFD was not practical due to pressure drop and tower capacity limitations. Since the debottlenecking changes involved replacing existing equipment, the changes would all have to be made during an extended facility shutdown.

After determining the limitations of the existing two-stage process and equipment, Ortloff evaluated the application of the GSP technology to the Goldsmith Plant.

Ortloff's GSP Process

Ortloff has previously described the retrofit of its patented Gas Subcooled Process (GSP) technology to industry-standard single-stage plants.[1] The GSP process[2,3] has been used extensively in new cryogenic plants built recently and has been, by far, the most widely used process in new plants built since 1990. Simplified process flow diagrams for both the typical industry-standard single-stage (ISS) design and the

GSP design are shown in Figures 3 and 4, respectively. The differences between the standard single-stage plant and the GSP process include:

1. Several fractionation stages, usually a 12'-15' packed bed, are used above the expander feed in the GSP design. The GSP design's column top feed or reflux is obtained by condensing and flashing a portion of the high pressure feed gas. In the single-stage design, any ethane which is not condensed in the expander outlet is lost to the residue stream, as the upper section of the demethanizer is simply a vapor/liquid separator with the vapors becoming part of the residue stream.

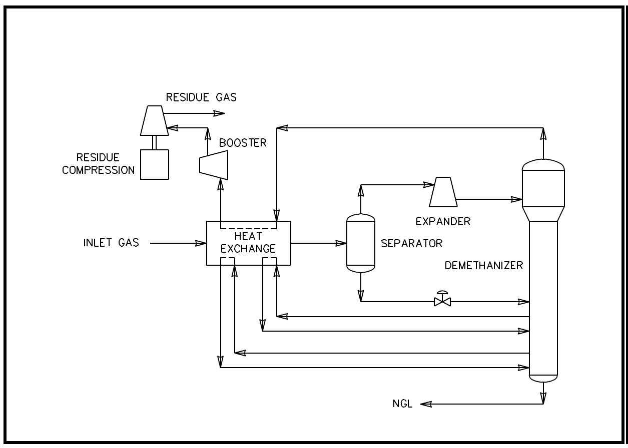

Figure 3. Industry standard single-stage (ISS) design

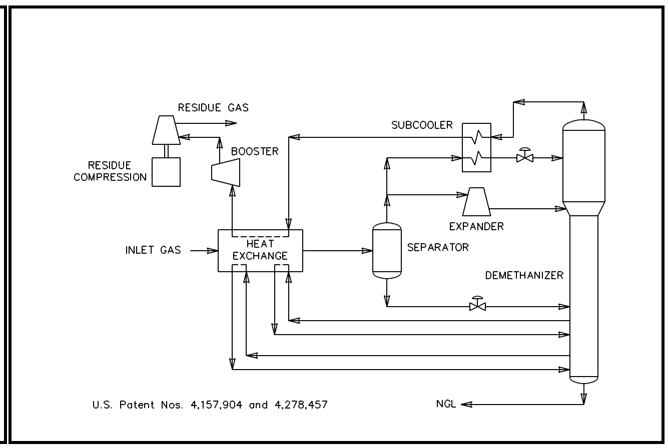

Figure 4. Ortloff GSP process

2. The reflux stream for the GSP design is controlled to maintain a constant flow ratio in relation to the inlet gas flow rate. Cold residue gas from the demethanizer overhead is used to condense the reflux stream. The refluxed fractionation stages above the expander feed increase ethane recovery by condensing ethane vapors from the expander outlet that would have escaped to the residue stream in the ISS design.
3. In the GSP design, the flow through the expander is no longer the total plant inlet vapor (less separator liquids) because a portion of the inlet gas is split off ahead of the expander to provide the reflux stream. The flow through the expander is 60-80% of the total plant inlet flow rate for the GSP design.
4. The cold separator temperature is warmer for the GSP design than in the ISS design since some of the cooling available from the residue gas in the ISS design is used to condense the reflux stream in the GSP design.
5. The expander horsepower will typically be higher for the GSP design than for the ISS

design due to the warmer cold separator temperature. This is true even though the mass flow through the expander is less. Therefore, when compared to the ISS design, either the external residue horsepower required for a given throughput and recovery will be less for the GSP design, or the throughput capacity for a given external horsepower and recovery will be higher for the GSP design.

6. The introduction of heavier components at the top feed contributes to ethane retention and the resulting warmer temperature profile increases the tolerance of CO_2 in the column.

Results of retrofitting a typical 100 MMSCFD industry standard single stage (ISS) plant are shown in Table 1 below. The results for a constant inlet rate are shown by comparing columns A and B. For a constant inlet rate of 100 MMSCFD, residue compression horsepower can be reduced by 1200 HP or 20% while improving NGL recovery by 13 percentage points. The results at constant residue horsepower are shown by comparing columns A and C. Throughput can be increased by 25.6% while achieving an increase in NGL recovery of 13 percentage points.

Table 1 Comparison of Typical ISS and GSP Retrofit Designs

	A	B	C
	STANDARD PLANT	GSP RETROFIT AT SAME INLET RATE	GSP RETROFIT AT SAME RES. HP
INLET RATE, MMSCFD	100	100	125.6
ETHANE RECOVERY, %	75	88	88
NGL INCREASE, GAL/DAY	---	14,400	57,000
RESIDUE HORSEPOWER	6,000	4,800	6,000

A retrofit of a single-stage plant with the GSP design can be accomplished as shown in Figure 5. In smaller plants, the additional packed bed absorber section can sometimes be added to the top of the existing demethanizer, precluding the need for the cold pumps. Larger plants are usually retrofit with a separate absorber column and a pair of pumps. (The pumps can be deleted at a cost of around 4% in ethane recovery.) The absorber functions as an extension of the existing demethanizer and the bulk of the fractionation traffic is moved from the existing demethanizer to the new absorber section. The existing demethanizer becomes significantly unloaded in the GSP retrofit design.

The inlet gas split to the subcooler exchanger can be taken at the cold separator as shown if the upstream equipment can handle the new design throughput. If the inlet heat exchange equipment is too small for the desired plant inlet rate, the split can be taken at the front end of the plant and another exchanger added to the process which parallels the existing equipment. This approach is illustrated in the retrofit of the Goldsmith plant.

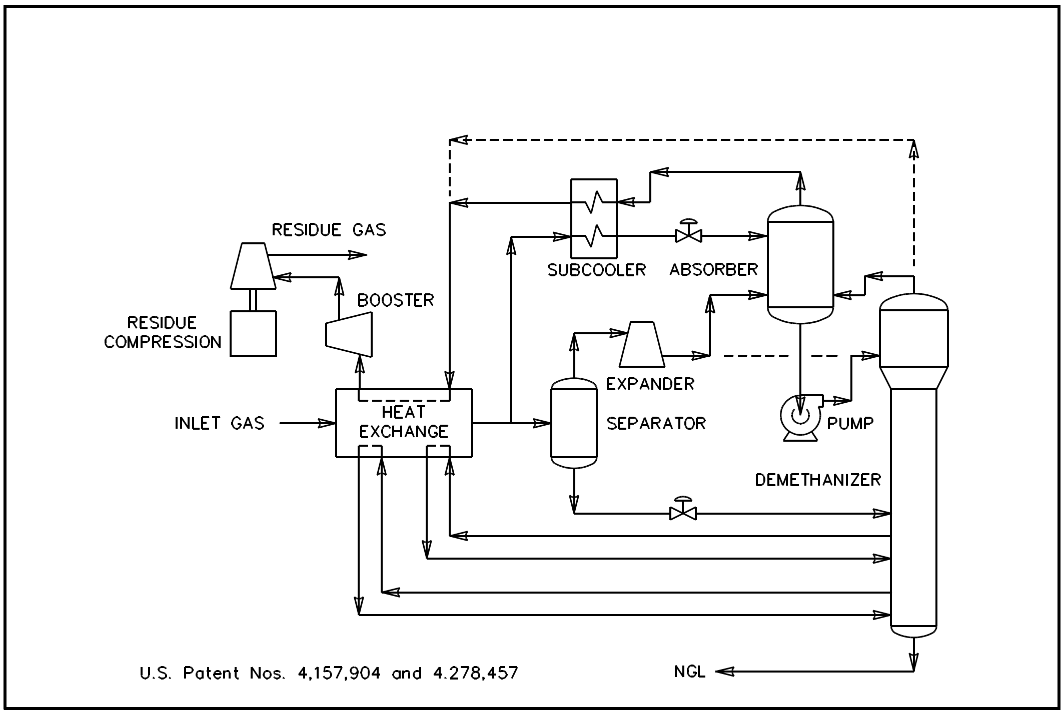

Figure 5. GSP retrofit of ISS plant

Retrofit of the Goldsmith Plant with Ortloff's GSP Process

The flow diagram for GSP retrofit of the Goldsmith Plant is shown in Figure 6. In the design effort, first, the plant configuration was converted back to a single-stage design, then the GSP retrofit previously described was applied. For the Goldsmith Plant, a separate absorber column and pumps were used for the fractionation stages above the expander feed. The expander outlet piping was routed to the bottom of the new absorber, as was the demethanizer overhead. The absorber liquids were pumped to the top of the existing demethanizer through the old expander outlet line.

The Cold Gas Separator, V-2, Cold-Cold Gas Exchanger, E-6, Cold Gas Exchanger, E-5, and the Feed Flash Separator, C-2, were removed from service. The Cold-Cold Gas Exchanger, E-6, was not needed for the single-stage GSP design and was too small to be reused in the subcooler service. The Cold Gas Exchanger, E-5, added pressure drop to both gas paths without resulting in any significant cooling of the inlet gas due to changes in the plant temperature profile. This exchanger was also too small for the subcooler service. The expander feed separators serve the same function as the Cold Gas Separator, V-2, in the two-stage design, so this separator was deleted in the GSP retrofit design.

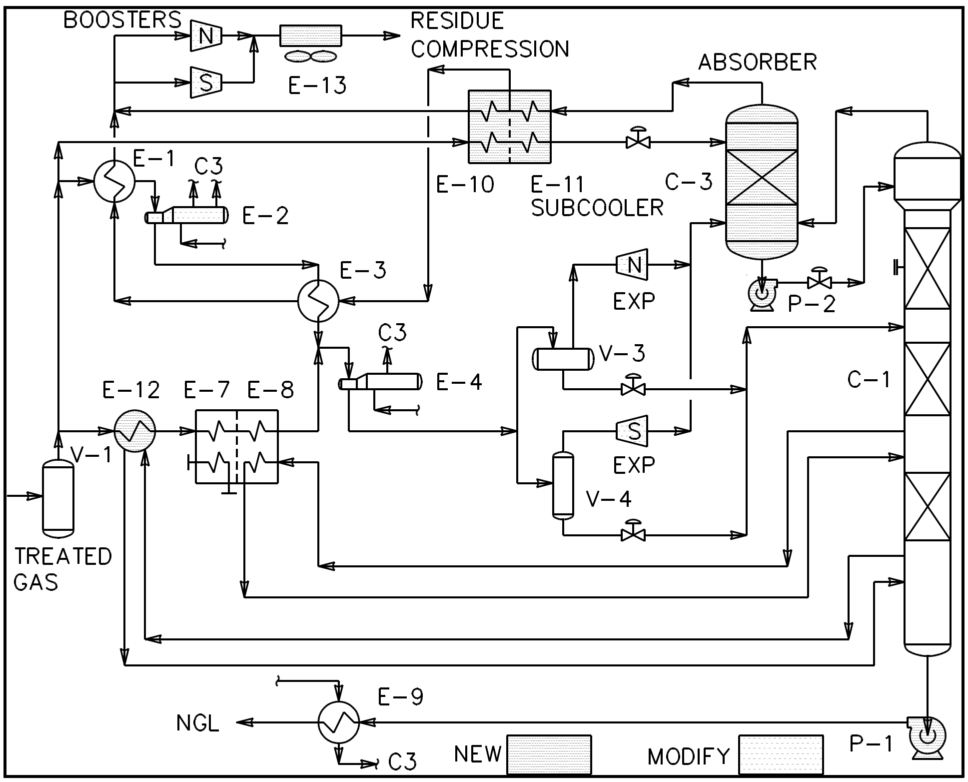

Figure 6. GSP retrofit of the Goldsmith plant

The two expanders were converted for parallel operation for both the expander and booster compressor services, splitting the inlet flow equally between the two modified machines. Flow to the expanders was split just ahead of the two expander feed separators. Paralleling the two expander feed separators and expanders allowed reuse of the existing expanders, piping, and separators. Note, however, that paralleling the equipment was possible because all the intermediate pressure equipment and piping added during the conversion to the two-stage process in 1982 had a design pressure equal to the existing high pressure equipment. Had the equipment design pressure been set at an intermediate pressure level, re-piping the equipment for parallel operation would not have been possible.

For the Goldsmith retrofit, the inlet gas split to the Subcooler was taken from the warm plant inlet stream ahead of the inlet exchangers rather than at the expander feed separators. This arrangement reduced the flow rate through the existing exchangers by the amount of the Subcooler flow, 27% of the inlet for the Goldsmith gas composition. An additional Warm Gas/Gas Exchanger, E-10, was required to cool the inlet gas down to the desired subcooler inlet temperature. This exchanger was physically combined with the Subcooler, E-11, in a single new plate-fin exchanger. A sidestream was withdrawn from the residue gas side between the two exchanger sections and routed through the old residue gas flow path consisting of E-3 and E-1 to provide some inlet gas cooling in addition to that required for the reflux stream. Since the residue gas flow rate through these exchangers was only a fraction of the original design flow rate, tube vibrations were no longer predicted and the E-3 exchanger was reused without modification in the GSP retrofit design.

When this GSP retrofit design was first applied to the Goldsmith process at a 110 MMSCFD rate (i.e., the highest practical throughput rate for the two-stage design) significant additional capacity remained. After several more iterations, a design rate of 135 MMSCFD at 95% ethane recovery was selected as the optimum design point for the Goldsmith GSP retrofit. This design point inlet flow rate was an increase of 57% over the nominal two-stage 86 MMSCFD design capacity at comparable inlet and tower pressures, and 23% higher than could be achieved by debottlenecking the two-stage design alone. The increase in throughput was possible while significantly increasing the ethane recovery over what was being achieved with the unmodified plant operating at a 110 MMSCFD inlet rate.

Rigorous checks of the existing equipment at the 135 MMSCFD inlet rate resulted in identifying the following required changes in addition to the new GSP equipment:

1. Replace the expander and booster compressor wheels, shafts, and variable nozzle assemblies in both expanders. For parallel operation, modify the two machines to be as similar aerodynamically as possible even though the machines originated from two different manufacturers. Modify the lube oil system of one of the expanders for increased shaft speed by installing a larger lube oil cooler and changing the 1800 RPM lube oil pump motors to 3600 RPM motors.
2. Install two new vapor outlet nozzles on the shell of the Intermediate Level Chiller, E-2, to reduce the vapor velocity in the kettle.
3. Reuse the Cold Gas Separator vessel, V-2, as a low level chiller vapor separator to avoid welding additional nozzles to the low-temperature carbon steel shell of the Low Level Chiller, E-4.
4. Replace the existing plate-fin Reboiler exchanger, E-7, with a larger shell and tube Reboiler exchanger, E-12. (Reuse the Side Heater, E-8, section of the existing exchanger as-is.)
5. Replace the trays in the upper section of the existing Demethanizer, C-1, with packing and increase the packing size in the middle and lower packed sections.
6. Replace the Demethanizer Bottoms Pumps, P-1, to accommodate the substantial increase in NGL product flow.

Debottlenecked Two-Stage or GSP Retrofit?

The GSP retrofit had significant advantages over debottlenecking the two-stage plant:

1. The GSP retrofit had much higher plant throughput capability--135 MMSCFD versus 110 MMSCFD.
2. The GSP retrofit had higher ethane recovery at all flow rates.
3. The cost of the GSP retrofit was not significantly higher than debottlenecking the two-stage design. The capital cost of the new absorber and plate-fin exchanger for the GSP retrofit were balanced against the cost of two new expanders, two feed separators, and the replacement Cold-Cold Gas Exchanger required for debottlenecking the two-stage design.

GPM chose to proceed with the GSP retrofit using the nominal 135 MMSCFD design plant inlet flow rate. The 135 MMSCFD rate was then used as the minimum required flow in specifying the future compression requirements. In a separate project, GPM sized and designed the required molecular sieve dehydration system modifications to accommodate up to 160 MMSCFD inlet gas rate.

Detailed Design and Procurement Phase

The final cryogenic plant retrofit conceptual design, scope, cost, and schedule were defined by Ortloff in late December 1993. The project was approved by GPM on December 30, 1993 with the "must complete" date set at June 1, 1994. All tie-in work was scheduled for completion during a total facility maintenance turnaround scheduled for mid-May 1994. This was a tight schedule considering the design work yet to be done and the lead times for the plate-fin exchanger and the stainless steel piping and equipment.

The basic engineering package provided by Ortloff included the process design and process engineering, management and review of all detailed engineering tasks, equipment specifications, requisitions, drawing reviews, mechanical flow sheets, operator training and operating manuals, and startup assistance.

GPM and Phillips purchased and expedited all equipment and materials. The new Absorber, C-3, and new plate-fin Subcooler exchanger, E-10/E-11, each had 12-14 week deliveries and were ordered immediately upon project approval. Three 50% capacity stainless steel Sundyne pumps were purchased for the absorber bottoms pump service rather than two longer delivery 100% capacity pumps. This was necessary to meet the construction schedule requirements. Reconditioned multistage centrifugal pumps were provided from GPM surplus for the demethanizer bottoms service to meet delivery requirements.

The civil/structural and detailed piping design work was done through Ortloff by HPF Consultants, Inc. of Midland with review and approval by Ortloff. The complexity of the piping tie-ins required several plant visits to check dimensions and interferences. Instrument and electrical design was done through Ortloff by Lauren Engineers, Inc. of Abilene with review and approval by Ortloff. After the long delivery major equipment items were placed on order, the stainless steel pipe, valves, and fittings were identified and placed on order. A very accurate material take-off had to be done by HPF before the detail design was complete to allow receipt of the piping, valves, and fittings in time to meet the construction schedule.

GPM's operating, engineering, and maintenance personnel actively reviewed the design documents as soon as they were issued. Questions were resolved very quickly to avoid any late changes. All the detailed engineering and design personnel were located within 35 miles of the plant, so communication between the project design team members was not a problem. The number of people involved in the project was also kept to a minimum by all parties.

The Goldsmith Plant's cryogenic process unit was originally installed with plenty of open area surrounding the unit. The cryogenic unit is separated from the compressor buildings and there are no adjacent processing units. The available plot area permitted the new equipment to be safely installed adjacent to the existing operating cryogenic unit.

All piping was designed to be run as close to tie-in points as possible before the shutdown. The piping within the process skids was fairly compact, however, making for some difficult pipe routing for tie-ins to the existing piping and equipment. Eighty-two piping and instrumentation tie-ins were identified during the detailed design, including many maintenance items which were in addition to the retrofit scope of work. The maintenance items, conversion of the expanders and booster compressors to parallel operation, and removal of the existing second stage equipment from service increased the number of tie-ins over what would be expected for a more typical retrofit.

Construction Phase

Ref-Chem Corporation of Odessa was awarded the construction contract. Ref-Chem moved onto the site on March 1, 1994 to begin foundations and pipe fabrication. All equipment suppliers met or beat their promised deliveries and construction proceeded on schedule working 50 hour weeks, with an average manpower of 20 people.

It was possible to complete construction around the Absorber, Subcooler, Absorber Bottoms Pumps, Reboiler, and switchgear before the facility shutdown. One expander was shut down for one day and disassembled for measurements and inspection before the facility shutdown.

The installation of the new equipment progressed per plan and preparations were completed for the tie-ins and the facility shutdown which occurred on schedule on May 15, 1994.

Shutdown Phase

Modifications to the cryogenic unit began on May 15, after GPM personnel had depressured, purged, and isolated the cryogenic unit for tie-ins. During the shutdown, all tie-ins were completed, the product pumps were changed out and re-piped, and both expanders were removed and reworked. The tube bundle was removed from the Intermediate Level Chiller, E-2, so that the additional nozzles could be installed in the shell. All tie-ins proceeded per Ref-Chem's construction plan based on two 10 hour shifts per day, leaving four hours for radiography each night. The new instruments were checked out and calibrated for startup by GPM instrumentation and automation personnel.

The only surprise during the shutdown resulted when an internal leak was discovered in the Side Heater plate-fin exchanger, E-8. A decision was quickly made to abandon the existing exchanger and to substitute the Cold Gas Exchanger, E-5, which had been taken out of service. The piping design revisions were completed on an emergency basis by HPF and the additional stainless steel piping and fittings were located and purchased by GPM. Revising the Side Heater piping added one day to the shutdown duration.

All tie-in welds were 100% radiographed instead of hydrotested to prevent water from entering the system. All the new piping up to the tie-in points had been hydrotested and dried out prior to the shutdown.

The Demethanizer was not entered during the 1994 shutdown because the original internals were acceptable for the conditions that were expected before the new compressors were commissioned in late 1995.

Commissioning Phase

Work in the other Goldsmith facility units was completed on schedule and the modified cryogenic unit was unblinded, purged, and pressurized for dryout flow on May 25. J-T operation and NGL delivery were resumed on May 26, eleven days after shutdown. Both modified expanders were commissioned on May 28.

Problems encountered during restart of the plant included trash in the Absorber Bottoms Pumps screens, two gasket leaks, and miscellaneous instrument tuning and electrical interlock corrections. Two process shutdowns were required to repair gasket leaks. The trash in the Absorber Bottoms Pump screens appeared to be pieces of the "super-sac" material similar to that in which the Absorber packing material was delivered to the site. The pump screen plugging problems persisted and the packing was changed out in 1995 to solve the problem. There were no significant problems with the cold Absorber Bottoms Pumps themselves or their seals. Both expanders were also operated without design related problems.

The molecular sieve dehydrators must perform well to avoid freeze-ups and pressure drop problems in the plate-fin exchangers and columns at the cryogenic temperatures. There were some problems initially with achieving consistently low water dewpoints at the dehydrator outlet. The dehydration system performance has since been improved by increasing the regeneration cycle heating time and by replacing one leaking switching valve.

Operating Results

Initial operation was limited to the same 110 MMSCFD inlet gas rate available before the shutdown. The facility inlet rate was increased to 125 MMSCFD seven days after startup, and this rate has been fairly constant since mid-1994. With the reciprocating compression, the cryogenic plant inlet pressure was 50 PSIG lower and the tower pressures were about 35 PSIG higher than the retrofit design. Ethane recovery has been 91% with the existing compression at the 125 MMSCFD average inlet rate. The measured ethane recovery is consistent with the calculated recovery for the pressures available with the reciprocating compression.

There were intermittent problems from treated gas compressor lube oil. The reciprocating treated gas compressors boost the inlet gas pressure to 800 PSIG after dehydration at 500 PSIG. Any lube oil in the inlet gas stream that is not removed by the existing discharge lube oil coalescers collects on the new plate-fin Subcooler exchanger and reduces the heat transfer, thus raising the reflux temperature, and reducing the recovery. The operators are very careful to make sure the coalescers are working well at all times. Methanol is injected ahead of the new Subcooler plate-fin exchanger any time the cold end temperature approach widens or the pressure drop increases. (The lube oil problem was eliminated when the new centrifugal compressors with dry gas seals were commissioned in late 1995.)

The expander/compressors work very well in their new parallel arrangement. Due to differences in the piping, nozzles, and nozzle actuators between the two machines, a unique control system was included in the retrofit design to keep the flow rates evenly split between the two machines. The process pressure controller output is sent to both expander nozzle positioners, but the signal to one unit is biased ±10% with a speed controller to maintain a speed match with the other machine. The speed match keeps the compressor-end head curves matched so that the compressor-end flow rates split evenly. Should the speed of one machine drop much below the speed of the other machine, its discharge check valve would close and its recycle valve would open, effectively taking the slower machine off-line. The speed controller keeps the speeds equal, resulting in successful parallel operation of the two similar machines.

The changes to the chiller vapor nozzles have greatly improved the operation of the refrigeration system by reducing the fouling of the economizer exchanger and eliminating liquid carryover back to the compressor suction scrubbers.

The operators report that plant operation is much simpler since the GSP modifications were made, especially during startups. Recovery from externally caused shutdowns, such as power outages, treating system upsets, or compressor problems, is very straightforward.

One advantage of a retrofit over a new plant is that operators only have to learn the new equipment and process changes and not an entire new unit. Most of the plant control loops, shutdowns, etc. were not modified during the retrofit and the operators' experience with the existing plant was beneficial during restart of the modified unit.

Changes Made During 1995

The following changes were made during a scheduled July, 1995 shutdown in preparation for operation at the higher plant inlet rates possible with the new compressors:

1. Piping and valved tie-ins for the new compressors were installed.
2. The demethanizer trays and packing were replaced with all new packing suitable for the higher rates.
3. The absorber packing was replaced with new, clean packing. The new packing was not contaminated with any "super-sac" material and the pump screen plugging problems were eliminated.

Future Plans for the Goldsmith Plant

GPM completed the major modifications to all the Goldsmith Plant systems in 1995 with the installation of two large gas turbine driven inlet/treated/residue gas compressors. With the new compressors in service, the plant inlet rate can be increased to 135-150 MMSCFD, as needed. The ethane recovery at the 150 MMSCFD rate is expected to decrease to 92% from the design recovery of 95% at 135 MMSCFD.

GPM will complete the move of all the cryogenic plant controls to a new DCS system in 1996. GPM may also install a GC analyzer on the residue gas stream to measure the ethane concentration. The ethane content of the residue gives a very responsive indication of the ethane recovery.

Conclusions

GPM's Goldsmith Plant was successfully and economically retrofitted with Ortloff's GSP technology. The retrofit increased plant capacity dramatically while using the existing equipment to the greatest extent possible. After the retrofit, an increase in ethane recovery of 20 percentage points was measured. The interruption of plant production to install the retrofit was minimal. NGL recovery and plant performance have matched the calculated values. Similar retrofits of other GPM plants using the GSP process are currently under study. The Goldsmith Plant retrofit project is a good example of how significant improvements in throughput and recovery can be achieved by retrofitting the GSP process to existing plants. Retrofit projects of this size can be successfully executed by a small professional project team consisting of operating company experts and experienced consultants and contractors.

References

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