

OMNI-FIT™ Revamp of a Texas C3 Splitter

Eric T. Cole

Koch-Glitsch LP

Douglas J. Little

Koch Hydrocarbon SW LLC

Scott Schingen

Koch Hydrocarbon SW LLC

Veada Colic

Process Consulting Services, Inc.

Presented in the Distillation Symposium of the 2003 Spring AIChE Meeting,
New Orleans, Louisiana March 31 to April 3, 2003

UNPUBLISHED

AIChE shall not be responsible for statements or opinions contained in its publications.

Introduction

Technology advances can offer opportunities for plant operators to improve profitability. An example is utilizing high-capacity tray technology to expand a plant at a lower capital cost per unit of throughput than new construction. In planning such a revamp, the design engineer seeks to maximize the value of the improvements by optimizing the gain in plant performance against capital cost and turnaround impact. Any new technology that increases the flexibility available to the designer increases the opportunity to get more production from existing equipment. This case history will describe a revamp in which greater throughput was achieved by the combination of using a high-capacity tray and changing tray spacing in the limiting sections of the towers. In one tower, the tray spacing was reduced to increase the tray count. In the other, it was increased in the stripping section to enhance tray capacity. These changes in tray spacing were made practical through the use of advanced installation technology.

Since their introduction by Koch-Glitsch, SUPERFRAC® trays have been widely used for revamping columns from conventional trays to high-capacity trays to increase capacity while maintaining tray efficiency. In columns such as propylene fractionators or "C3 splitters", this is especially true. Because the tray efficiency of these high-capacity trays is often as good if not higher than conventional trays, relatively simple revamps are often possible.

The challenges and goals of some operating companies can require more complicated revamps. In these cases, there are often changes to the downcomer sizes, number of passes, or even tray spacing. Koch-Glitsch has developed a technology called OMNI-FIT™ that is used to reduce the downtime and cost of these types of revamps. In this case, the revamp involved 3-for-2 (3 new trays for each 2 existing ones) and 4-for-5 (4 new trays for each 5 existing ones) modifications.

SUPERFRAC Trays enhance the performance over conventional trays in three areas. MINIVALVES™, bubble promoters, and proprietary design techniques enhance the effective bubbling activity and eliminate froth stagnancies to allow operation at higher tray efficiencies. Advanced downcomer technologies provide the capability to maximize the active area available for vapor/liquid contacting. Inlet area enhancements promote better froth initiation and provide for greater active area for improved capacity and efficiency. All of the enhancements and improvements offered by SUPERFRAC Trays result in a high-capacity tray that can increase capacity and efficiency. Figure 1 shows a setup of a typical 2-pass SUPERFRAC Tray in a standard configuration.

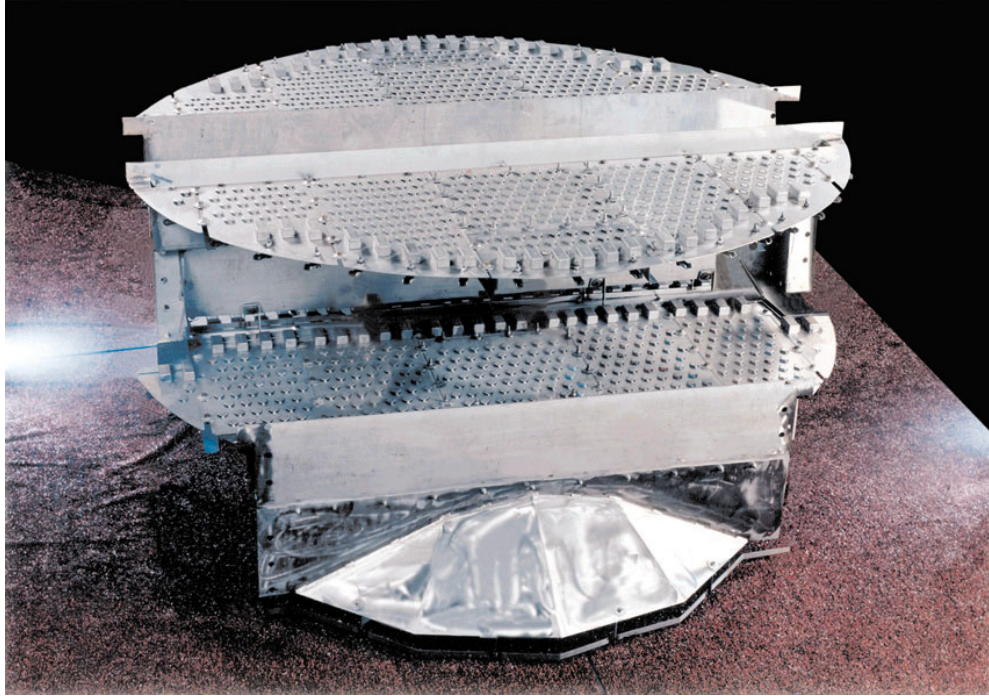


Figure 1. Setup of Typical 2-pass SUPERFRAC Tray

Enterprise (formerly Diamond-Koch) C3 Splitter Revamp

The Enterprise C3 splitter facility (formerly Diamond-Koch) in Mont Belvieu, Texas, has three world-class C3 splitters producing polymer grade propylene as the primary product. The Splitter 1 started operation in 1990. Subsequently, two additional units with similar equipment were installed. The Splitter 3 was the first of these to utilize high-capacity SUPERFRAC Trays. Based upon the additional production that was possible with these trays, the operator decided to revamp the #1 unit to gain the benefit of high-capacity trays. Once again, SUPERFRAC Trays were selected for this revamp.

Description of Facility

The main columns in the unit are the deethanizer and the splitter. Both columns utilize vapor recompression to supply reboiling and condensing duties, driven by centrifugal compressors. The deethanizer is upstream of the splitter and is used to limit the ethane and ethylene in the propylene product. The deethanizer bottoms feeds the splitter and the deethanizer overhead is mixed with the propane product from the splitter.

Because of the appreciable number of stages involved in this propylene / propane separation, the splitter is actually two columns. The feed is to the middle of the lower column, which has both a stripping and a rectifying section. The upper column has just rectifying trays. Figure 2 is a simplified process flow diagram of the unit.

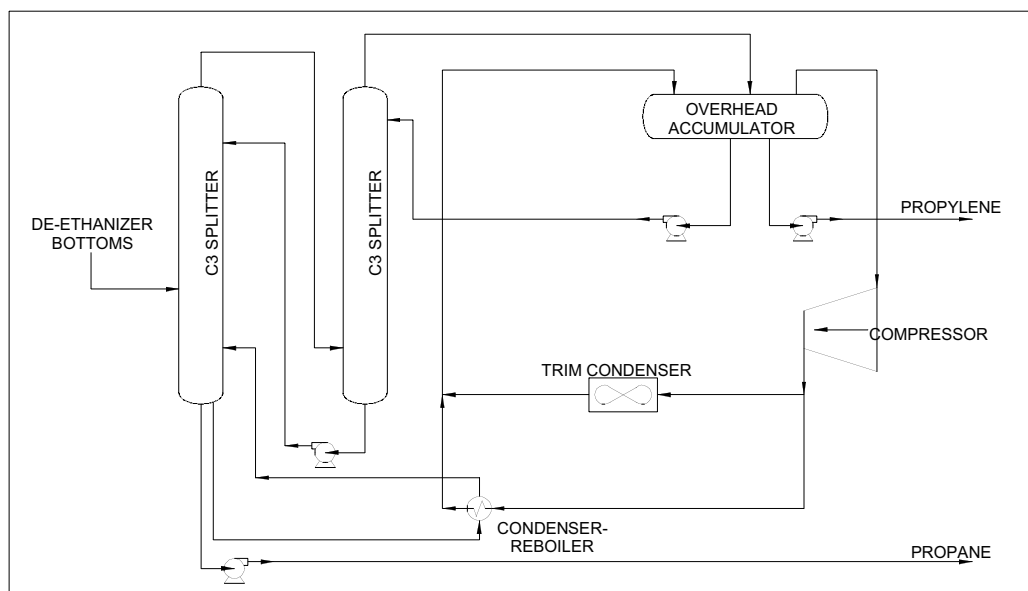


Figure 2. Simplified Process Flow Diagram

The feed to the Mont Belvieu facility is from pipeline and rail cars, and as such, there can be a substantial amount of fluctuation in the feed composition and quality. For the purposes of the revamp, the feed composition was assumed to be about 23.5% propane, 75.0% propylene and less than 1.5% other hydrocarbons. The main target product specifications were less than 0.4% propane in the polymer grade propylene and an HD-5 propane specification.

Based on the existing operation, a revamp strategy was developed to optimize unit performance. Revamp of the deethanizer and splitter trays was required to meet the revamp goals. In addition, several other modifications to the unit were required such as piping modifications, installation of a new heat pump compressor, and an additional trim air cooler.

Deethanizer Revamp

The optimum deethanizer revamp strategy required a 3-for-2 tray replacement. Table 1 shows the pre-revamp and post-revamp configurations of the deethanizer. See Figure 3 for a schematic representation. Other revamp options were considered with even more trays, but this did not reduce reflux and internal vapor/liquid loads significantly enough to justify the incremental cost and complexity.

	Pre-Revamp	Post-Revamp
Total Number of Trays	60	87
Number of Passes	1	2
Rectification Section	11 (#1 to #11)	15 (#1 to #15)
Diameter	60"	60"
Typical Tray Spacing	24"	16"
Stripping Section	49 (#12 to #60)	72 (#16 to #87)
Diameter	84"	84"
Typical Tray Spacing	24"	16"
Feed Location	Above Tray #12	Above Tray #16

Table 1. Configurations of the Deethanizer

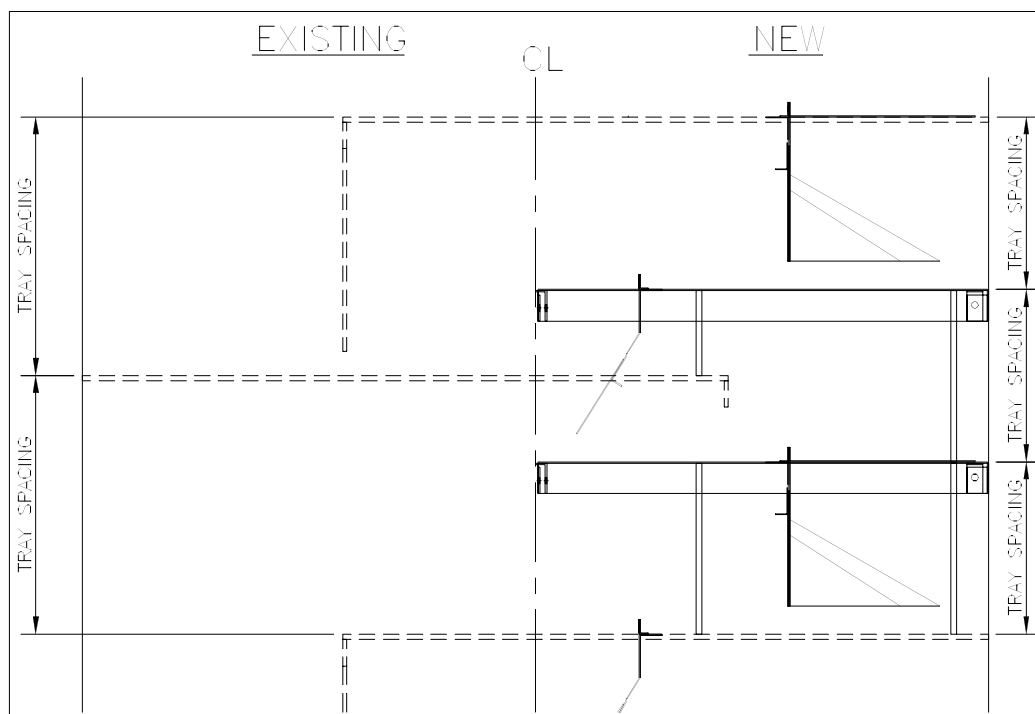


Figure 3. 3-for-2 Deethanizer Revamp

Splitter 1 Revamp

Based on the incremental capacity experienced with SUPERFRAC Trays in Splitter 3, the operator decided to revamp the Splitter 1 to also utilize high-capacity trays. Glitsch had supplied the existing trays in Splitter 1. These trays were not SUPERFRAC Trays, but did include some of the features of high-

capacity trays and could be considered an early-version high-capacity crossflow tray. The final tray design was optimized based on the previous installation.

The trays were designed using all of the SUPERFRAC 3 tray enhancements with six passes. A study was carried out that determined the optimal number of trays in both the stripping and rectification sections. That resulted in the recommendation to move the feed higher on the lower column and increase the tray spacing below the new feed. Table 2 shows the pre-revamp and post-revamp configurations of Splitter 1. See Figure 4 for a schematic representation.

	Pre-Revamp	Post-Revamp
Total Number of Trays	240	227
Number of Passes	4	6
Rectification Section	196 (#1 to #196)	178 (#1 to #178)
Diameter	16'-0"	16'-0"
Typical Tray Spacing	22"	22"
Stripping Section	44 (#197 to #240)	49 (#179 to #227)
Diameter	16'-0"	16'-0"
Typical Tray Spacing	22"	27.5"
Feed Location	Above Tray #197	Above Tray #179

Table 2. Configurations of Splitter 1

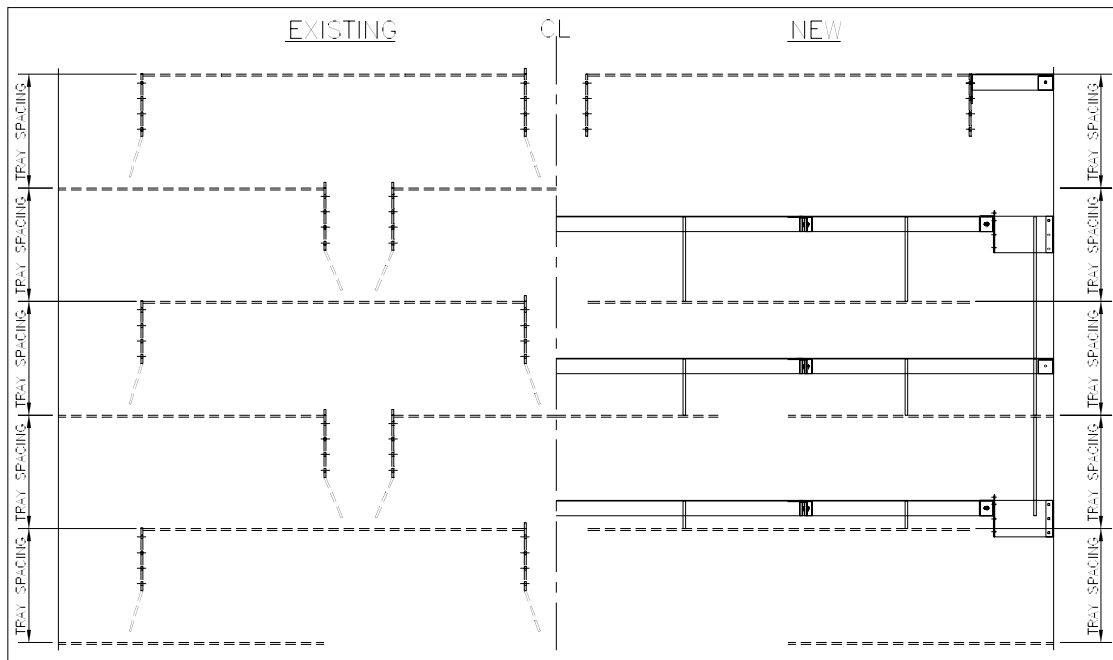


Figure 4. 4-for-5 Splitter 1 Revamp

Omni-Fit Technology

The Omni-Fit Technology is a toolbox of patent-pending and proprietary mechanical engineering designs for reducing the cost and downtime of revamps. The toolbox includes techniques such as expansion rings, pedestal supports, downcomer adapters and innovative tray mechanical designs. Using the Omni-Fit Technology techniques, the expensive and time consuming operation of welding can be minimized or often eliminated completely during revamps. This toolbox is filled with many different techniques and brings together the best practices of Koch-Glitsch.

The use of the Omni-Fit Technology for this revamp eliminated the need to weld new tray support rings and vertical downcomer bolting bars to the column shells. As discussed earlier, the tray spacing for the deethanizer and the stripping section of splitter were changed. Both of these types of revamps, a 3-for-2 and a 4-for-5, normally would require the welding of new tray support rings and vertical downcomer bolting bars. Tools from the Omni-Fit Technology toolbox allowed, without welding, the revamps including the conversion of the splitter trays from 4-pass to 6-pass and the deethanizer trays from 1-pass to 2-pass to completely optimize the column designs. Figure 5 below shows an overview of the trays in the shop prior to installation.

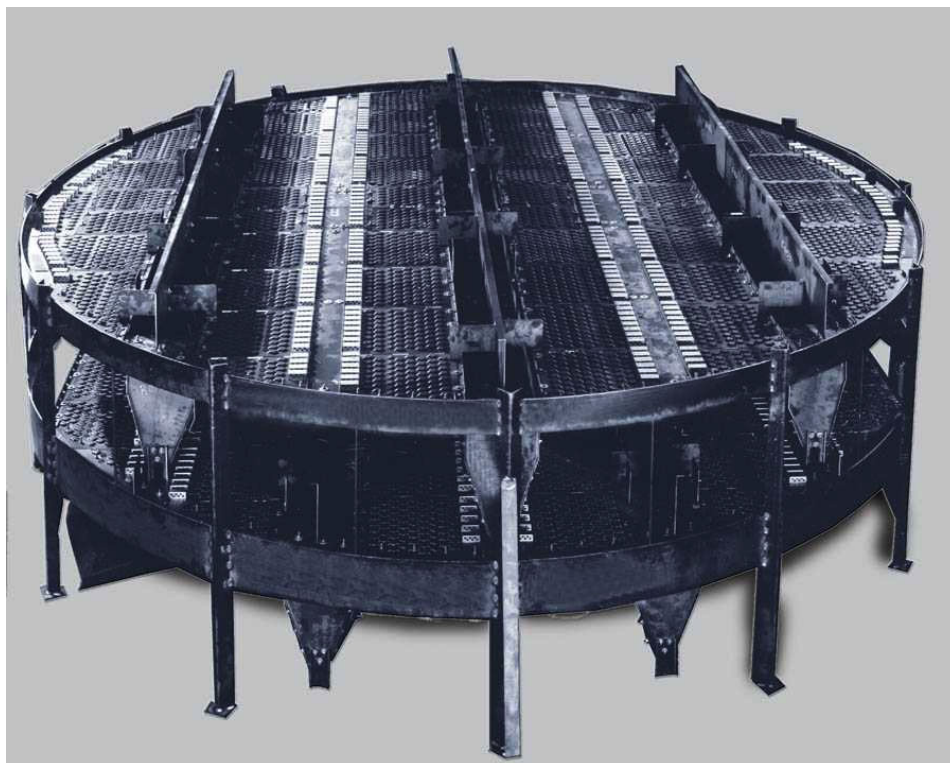


Figure 5. Overview of 6-Pass SUPERFRAC Trays for Splitter 1

Principal techniques used to support the trays in their new locations were expansion rings and pedestal supports. Expansion rings require no welding to the column shell. They are fast to install and provide full insurance against vapor

bypass, liquid leakage, thermal expansion cycles, etc. They also allow a completely safe installation. The pedestal supports hold in place the expansion ring from the existing tray support ring or from other expansion rings. Figure 6 below shows both the expansion rings and the pedestals. Figure 7 is a closer view of the expansion ring.

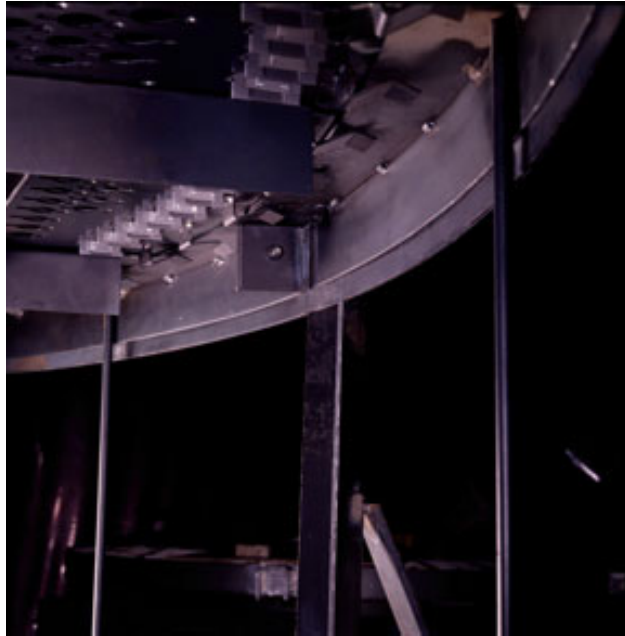


Figure 6. Close-up of Omni-Fit Pedestal Supports



Figure 7. Close-up of Omni-Fit Expansion Ring

Omni-Fit includes a number of unique additional features ensuring a fully reliable installation intrinsically safe with respect to the tray critical functioning parameters. Such features not only minimize the necessity of time-consuming and difficult-to-perform inspections, but also substantially eliminate very expensive potential rework. Besides expansion rings and pedestal supports some other Omni-Fit features used in these revamps are listed below:

- Self-locking joint with panels designed for a “one-way-only” installation
- Integrated beam and deck design (minimizing the number of parts to install)
- Downcomer boxes with self-setting locators to guarantee an exact configuration
- Quick operating manways

The adopted self-locking joint provides faster installation while ensuring that tray sections are installed in the correct orientation. Koch-Glitsch offers more than one type of self-locking joint; shown below in Figure 8 is the one utilized on these revamps. This figure also shows both the VG-0 fixed Minivalves and VG-9 “push” valves. The “push” valves are used to improve the uniformity of liquid flow on the crossflow trays.



Figure 8. Close-up of Omni-Fit Joints

Revamp Results

July 2001 Installation

Working with multiple crews, the tray installation was completed in about two weeks. Given the size of the three columns and the complexity of the revamps, this installation time is an excellent example of how the Omni-Fit Technology techniques can reduce downtime and revamp costs.

Inspection personnel from Koch-Glitsch were at the plant around the clock to assist with the installation. They did not supply the quality control for the tray installer or sign-off on the inspections, but were available to help ensure the drawings and installation procedures were understood.

Fall 2001 Performance Testing

After the unit had been operating for a few months, performance tests were carried out in October and November of 2001. Both of these tests successfully demonstrated the performance of the revamp. The goal was to achieve the highest rates while maintaining a stable operation for 24 hours. Given the size of the propylene splitter and the liquid inventories in the columns, changes to operation often required several hours before the effects of the changes were fully stabilized.

Both tests demonstrated that the tray efficiency of the 6-pass SUPERFRAC Tray design was still quite high. Based upon the data taken at both tests and Koch-Glitsch's time-tested thermodynamic model for low-pressure C3 splitters, it was determined that the tray efficiency was consistently about 93%. Table 3 below shows the material balance for one of the tests and includes the external flow rates and the molar compositions for the inlet and outlet streams.

The capacity of this unit increased more than 15% over the previous configuration, which utilized an early-version high-capacity tray. If conventional trays had been replaced, the percentage increase would have been even more. In addition, some of the optimization opportunities identified could further increase the capacity.

	Feed	DeC2 Ovhd	C3S Ovhd	C3S Btms
Liquid Rate, BPD	19,823	99	14,754	4,600
Composition, Mole%				
Ethane and lighter	0.4%	50.9%	0.0%	0.0%
Propylene	78.2%	45.9%	99.7%	4.5%
Propane	21.1%	3.2%	0.3%	93.2%
Butanes+	0.3%	0.0%	0.0%	2.3%

Table 3. Material Balance Table for Performance Test

Optimization Opportunities

One of the advantages of the performance testing was to identify opportunities to further optimize the process and improve the performance of the unit. Several of these were demonstrated during the tests.

The reflux rate varied consistently by $\pm 3\%$ while the level in the reflux accumulator was maintained at a constant level. This meant that within minutes, the reflux rate would often swing by as much as 6%. Such wide fluctuations were certainly limiting the total capacity of the column. An alternative control scheme was recommended.

The flow rate of the bypass to the trim coolers also varied significantly. It was recommended that this control loop be improved since the unit performance was improved when the control valve was placed in manual and held at a constant valve position.

Another key variable was the column pressure. During the first performance test, the difference between the minimum and maximum column pressure was almost 12%. This was reduced to about 1.5% during the second test. It was demonstrated that the unit had more capacity at a lower operating pressure.

The control of the column bottoms flow was very erratic. There were significant fluctuations in the bottoms level, which should not be an important factor, but there were also fluctuations in the bottoms temperature of about 10%. Once again, an improved control scheme was recommended.

Conclusions

The use of high-capacity SUPERFRAC Trays in column revamps continues to be popular, beneficial, and proven. Even when replacing early-version high-capacity

trays, SUPERFRAC Trays provide capacity gains and maintain high efficiencies. In addition, when revamps are complex, the Omni-Fit Technology can be used to minimize downtime and installation costs. This technology often allows a complex revamp to appear to be a simple revamp. The combination of the SUPERFRAC Trays and Omni-Fit Technology gives plant operations an excellent option to revamp towers for more capacity with limited downtime.

Acknowledgements

This was a very significant project and required a team to effectively execute it. The authors wish to thank all those involved but specifically point out the efforts of several people and groups. Special thanks to Ian Buttridge, Paul Morehead and Daryl Hanson for their team work during the process design, to Gary Gage for his help with innovative designs, to Deepak Thakker for his project management of the tray fabrication, to Louis Verbick for his on-site project management, to Mike Woltemath and his team for the on-site inspection services, to the entire Diamond-Koch operations team for their expertise during start-up and performance testing, and to John Einwich and Jim Nye for their assistance during the performance testing.

References

1. Polymer Grade Propylene Operations, D-S Splitter, Inc. Diamond Shamrock, San Antonio, Customer Brochure, 1997.
2. Hanson, D. W., Einwich, J. M., and Pratt, W., "Debottlenecking Superfractionators for Capacity and Efficiency", Presented at the AIChE Spring National Meeting, 1999, Houston, Texas.
3. Hanson, D. W. and Hartman E. L., "Gas Plant Revamps for Higher Capacity and Efficiency", *Petroleum Technology Quarterly*, Summer 2000.