AFPM
114th American Fuel & Petrochemical Manufacturers
ANNUAL MEETING

DAY ONE Sunday–Monday | March 13–14, 2016 | #AM16
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Creating a realistic and effective regulatory environment

CHET THOMPSON, President, American Fuel & Petrochemical Manufacturers

Thank you for joining us at the 114th Annual Meeting of the American Fuel & Petrochemical Manufacturers (AFPM). We are happy to welcome you to San Francisco, home to the Golden Gate Bridge, the famous Fisherman's Wharf, Alcatraz Island and, most importantly, five refineries—all important facilities and structures benefiting this wonderful city.

I am honored that you have entrusted me to lead this great organization, and even more proud to represent the fuels and petrochemical industries. Few industries, if any, have done more than ours to improve the quality of life here and abroad. Indeed, our products heat homes, power cars, trucks, tractors and planes, and they serve as the core building blocks for countless goods that make modern life possible. Our facilities employ millions of workers and contribute billions in federal and state taxes that are used to build roads, schools and hospitals. The bottom line is that AFPM's members make the world a better place.

We are very excited about this year's program and hope you will find it informative and entertaining. We have brought together a number of industry and subject matter experts to address the key political, technical, economic and environmental issues that confront our industries.

With this being an election year, we could think of no better way to kick off the program than with an up-close look at the political world. The General Session promises interesting commentary from Mark Halperin and John Heilemann, co-authors of *Game Change: Obama and the Clintons, McCain and Palin, and the Race of a Lifetime,* and *Double Down: Game Change 2012,* co-managing editors of *Bloomberg Politics* and co-hosts of Bloomberg TV's *With All Due Respect.* They will provide their professional views on this year's rather unusual presidential campaign.

You also will hear from Alex Epstein, author of the *New York Times* best-selling book *The Moral Case for Fossil Fuels,* and an expert on energy and industrial policy. Mr. Epstein will provide his insights on the role that fossil fuels have played globally.

Tuesday begins with the Industry Leadership Breakfast and a keynote address from Joe Gorder, Chairman, President and Chief Executive Officer of Valero Energy Corp., a Fortune 20 company. Mr. Gorder will share his perspective on the opportunities and challenges facing US refineries.

Finally, the Annual Luncheon has proven to be a must-attend event, and this year will be no exception. We are honored to have as our guest speaker retired General Colin Powell, the former US Secretary of State and former Chairman of the Joint Chiefs of Staff. Few have the experience and are as widely respected and trusted as General Powell. He will provide his assessment of the many challenges confronting the United States and the world.

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INSIDE THIS ISSUE

Leave your heart in San Francisco

There are few cities in the US that have a unique and eclectic character that can match San Francisco. Our city sits on the tip of a peninsula surrounded by the Pacific Ocean and San Francisco Bay. It is known for its hilly landscape, cold fog and wind, glorious sunshine and sparkling water, the iconic Golden Gate Bridge (**FIG. 1**), cable cars, shopping and some of the finest restaurants anywhere.

The city and surrounding areas offer something for everyone. Pristine Lake Tahoe, nestled in the heart of the Sierra Mountains, is only 205 miles to the northeast. Some of the finest wine in the world is produced in Napa and Sonoma counties, just an hour north of the city. Drive 75 miles south on the famous Pacific Coast Highway and you hit the laid-back vibe of Santa Cruz; drive another hour and you can see Monterey and Carmel-by-the-Sea, home of the Pebble Beach golf course. Venture 30 minutes to the south and you are in the heart of the Silicon Valley, the technology innovation capital of the country.

FIG. 1. The gateway to the San Francisco Bay. When it was built, the Golden Gate Bridge was the longest suspension bridge in the world.

A brief history. San Francisco became part of the US when California was claimed on July 7, 1846 during the Mexican-American War. The city's history and development as a center of maritime trade were shaped by its strategic location at the entrance to one of the world's best natural harbors. Beginning almost overnight as the base for the gold rush of 1849, the city immediately became the largest and most important immigration, commercial, naval and financial center in the West. Between January 1848 and December 1849, the population of San Francisco increased from 1,000 to 25,000.

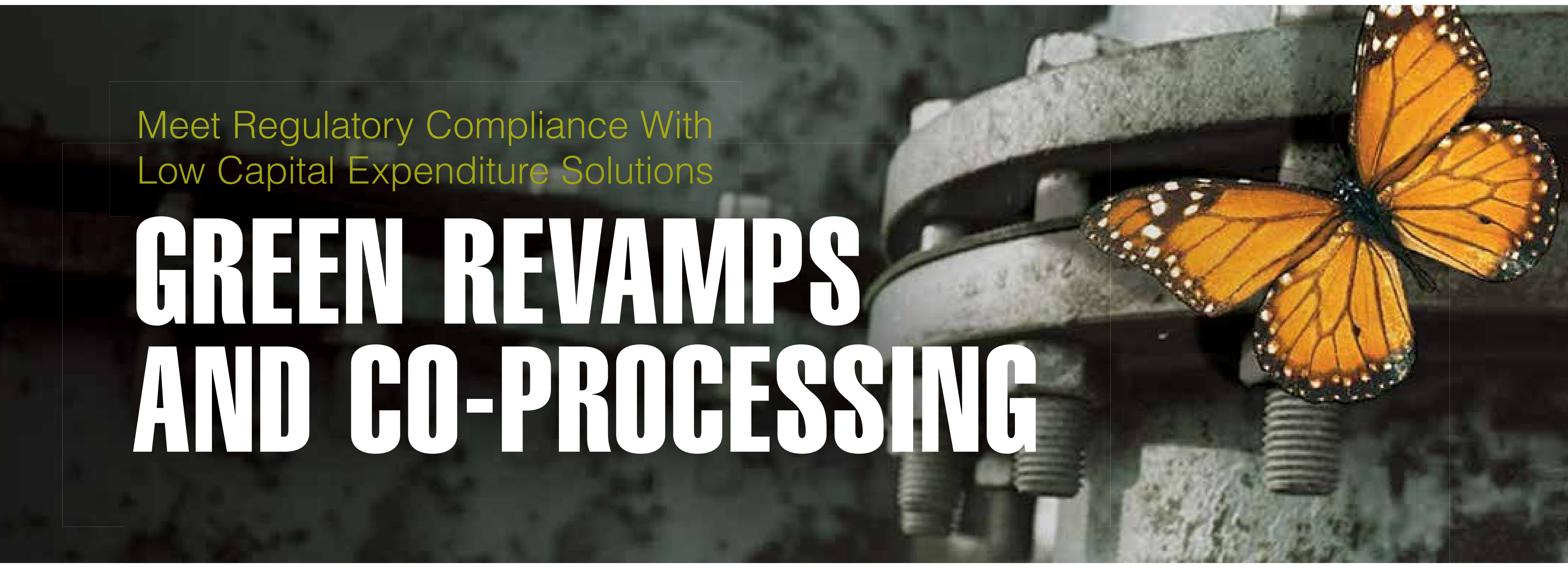
The quake of 1906. The San Francisco earthquake struck with an estimated "moment magnitude" of 7.8. There was significant damage, but it was the ensuing fires, which lasted several days and were fueled by broken underground natural gas supply pipes sparked by downed electrical poles, that destroyed 80% of the city. An estimated 3,000 people were killed in one of the worst natural disasters in US history.

The city's iconic activities. Ask anyone about the "must-see-and-do" activities, and **riding a cable car** up the city's steep hills is near the top of the list (**FIG. 2**). The cars are moved by an underground cable and are the only public transport system to be declared a historic monument. The city boasts the largest **Chinatown** outside of Asia and the oldest of its kind in North America. This city within a city is best explored on foot. Its temples, theaters, workshops, small businesses, stores, antique and souvenir shops, teahouses, restaurants and pharmacies give visitors the chance to buy ancient potions from herb shops, relax and enjoy a "dim sum" lunch or witness the making of fortune cookies.

► See SAN FRANCISCO, page 3

Meet Regulatory Compliance With Low Capital Expenditure Solutions

GREEN REVAMPS AND CO-PROCESSING



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Envergent Technologies
(UOP/Ensyn JV)

Biomass

Biocrude

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To learn more about UOP renewable fuel technologies, visit **uop.com/renewables.**

AFPM

114TH ANNUAL MEETING CONFERENCE NEWS

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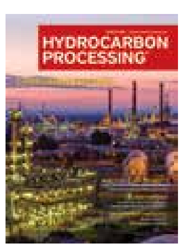

SCHEDULE OF SESSIONS AND SPECIAL EVENTS

SUNDAY, MARCH 13, 2016

9 a.m.–7:30 p.m.	Registration
5:30–7:30 p.m.	Opening reception

MONDAY, MARCH 14, 2016

7 a.m.–5 p.m.	Registration
7:30–9 a.m.	Government relations breakfast* *Open to registered member attendees only Networking breakfast* *Open to registered member attendees only
9–11:30 a.m.	General session featuring: Alex Epstein, Author, *The Moral Case for Fossil Fuels* Mark Halperin and John Heilemann are the co-managing editors of *Bloomberg Politics;* co-hosts of *With All Due Respect* on Bloomberg and MSNBC; and co-authors of the runaway bestsellers: *Game Change: Obama and the Clintons, McCain and Palin, and the Race of a Lifetime* (2010); and *Double Down: Game Change 2012* (2013).
2–5 p.m.	**Breakout sessions:** Hydroprocessing, Process Safety, FCC Operations, Gasoline Processes, Resid Conversion, Workforce Development

TUESDAY, MARCH 15, 2016

7 a.m.–12 p.m.	Registration
7:30–9 a.m.	Industry Leadership Breakfast featuring*: Joseph W. Gorder, Chairman, President and CEO, Valero Energy Corporation *Open to registered member attendees only
9–11:30 a.m.	**Breakout sessions:** Petrochemicals, Reliability, Environmental, Operations and Turnaround, Strategic Issues
12–2 p.m.	Annual Luncheon featuring*: General Colin Powell, USA (Ret.) is one of the most admired and respected leaders in America today. A four-star general, General Powell's numerous awards include two Presidential Medals of Freedom. He is the author of his best-selling autobiography, *My American Journey,* and his second book, *It Worked For Me.* *Open to registered member attendees only
2–4:30 p.m.	**Breakout sessions:** Plant Automation, Margin Improvement, Crude Oil Supply, Water Issues, Regulatory and Legislative Issues

SAN FRANCISCO, continued from page 1

Alcatraz Island, home to one of America's most notorious prisons, sits alone in the middle of the bay. It operated for almost 30 years before closing in 1963. Catch a ferry to the island at Pier 33 and get an interactive glimpse into life at the prison. Though many tried, no inmate ever made a successful escape from "The Rock." The icy water, strong currents and a guard population that exceeded the prisoners' made sure of that.

The **Golden Gate Bridge** first opened in 1937 and is perhaps San Francisco's most recognized landmark. The stunning 1.7-mile span can be crossed by car, bicycle or on foot. More than 9 million visitors cross the bridge every year, and the views of the city and the bay are unparalleled. **Fisherman's Wharf** is home to **Pier 39,** a festive waterfront marketplace with over 130 stores and unique dining. It's a short walk to the **San Francisco Dungeon, Madame Tussauds, Ripley's Believe It or Not!,** and the famous crab vendors selling walk-away crab and shrimp cocktails. Twisted **Lombard Street** is a visitor favorite.

Serious shoppers flock to **Union Square,** which boasts the largest Bloomingdale's outside of New York and the second largest Nordstrom in the US. Luxury boutiques, hotels, art galleries, restaurants, theaters, taverns and a popular nightclub scene make Union Square a bustling attraction.

Another popular area is **Ghirardelli Square,** which is located in a restored factory area surrounded by shops, galleries and restaurants. The **Exploratorium,** in its brand-new home at Pier 15 on the historic **Embarcadero** waterfront, is more than a museum—it's an interactive discovery destination with more than 600 exhibits.

Between Fisherman's Wharf and the Golden Gate Bridge is the **Palace of Fine Arts,** which was built to resemble an old Roman structure. Originally slated for destruction, it was renovated and largely rebuilt in the 1950s. Locals and visitors alike praise the serene atmosphere (FIG. 3).

If you're tired of the tourist track, the **Japanese Tea Garden** is a great place to take a stroll, get your bearings and relax. The tea garden, the largest of its kind in the US, is located in the sprawling **Golden Gate Park,** right in the heart of the city. The park includes a network of walking trails, cycling paths, lakes, bridle paths, museums, greenhouses and a botanical garden. Bike rentals are available and recommended.

Dining. Quite simply, dining in San Francisco is an attraction in itself. Chefs combine the freshest local ingredients, authentic international flavors and a touch of creative genius. Choose your cuisine—Chinese, Japanese, French, Italian, Spanish, Moroccan, Indian, Malaysian, Mexican, Greek, Russian or "fusion," a combination of any or all of these influences. Sample some of the local wines and microbrews, and enjoy one of America's best restaurant cities.

There are a great many things to do and see in the city, and we hope you will try to take advantage of everything San Francisco has to offer. Welcome, and enjoy your stay. ●

FIG. 2. A cable car crests one of the city's many steep hills. Alcatraz Island is in the background. (Photo courtesy of David Yu Photography).

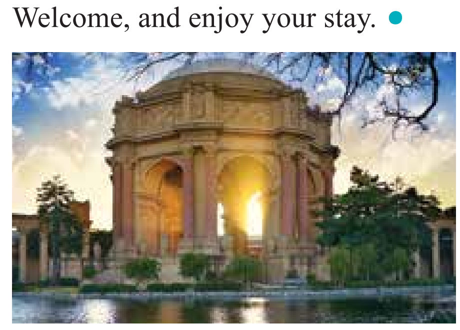

FIG. 3. The Palace of Fine Arts offers a calming oasis in the heart of San Francisco. (Photo courtesy of Darvin Atkeson).

Global trends in energy saving

JUAN GOMEZ PRADO and **DOUG HUTTON,** KBC Advanced Technologies

In spite of low energy prices, energy conservation continues to be an important part of business strategy in the heavy chemical and oil refining industries. Driven globally by the need to increase operating margins or meet government mandates, operating companies are seeking new solutions to improve energy performance.

Energy efficiency is a mature area of operational optimization in refineries and petrochemical complexes. The tools, techniques and technologies have become very familiar to the industry, and a consequence of this familiarity may be the perception that all of the usual avenues for improvement have been exhausted. Two seemingly contradictory trends have been apparent in recent years: a focus on no/low-cost improvements driven by low energy prices; and increased discussion about new technologies driven by the perception that these are among the few remaining avenues for reducing energy use.

Experience shows that, across the refining and petrochemicals industries, significant energy reduction and margin improvement can still be achieved through no/low-cost improvements. By comparison, the contribution made to overall energy savings by the bulk of what can be considered new technologies is relatively small. It is, therefore, worth evaluating where the real value in energy reduction can be found.

General industry trends. Analysis of over 30 years of energy studies shows:

- The best energy performance in the refining sector has not improved in absolute terms in the last 20 years. However, overall average performance has improved.
- New refinery units are generally not optimized for energy performance on a stand-alone basis.
- New units are seldom optimally integrated from a site-wide perspective.
- There is a general reluctance to implement new technologies for energy improvement in refining. In contrast, acceptance of new technology has been better in petrochemicals.

These various trends have been consistent, even through the recent period of high energy prices and low investment costs. Currently low energy prices have not changed the industry's fundamental approach to energy performance. They are, however, putting off investment and placing the focus on no/low-cost improvements and sustaining the resulting benefits. Specific areas receiving significant attention are:

- Benchmarking against industry best practices to set performance targets
- Using software tools to attain and sustain top performance—Metric tracking, utility optimization, advanced process control (APC), real-time optimization (RTO)
- Energy management systems (EMS)—Implementing the processes and organization to manage and continually improve energy performance.

Developing energy management systems. Constrained capital budgets and the drive to improve operating margins provide the business case to develop an EMS. **TABLE 1** shows the elements of a refining/petrochemical industry best practice EMS, which must be considered together to capture opportunities and sustain the benefits.

The development of such a system must not be taken lightly. A best practice EMS is like an iceberg. The reporting system (dashboards, reports) is the visible tip of the iceberg, while other elements are the mass below the surface:

- Skills development
- Organizational development and alignment with corporate strategy
- Work processes
- Data reconciliation/validation
- Smart target setting
- Asset optimization
- Targeting against technology standard.

The business case can be hard to define. This is due in part to the difficulty in estimating the benefits of a well-planned and implemented EMS in advance. Similarly, given the extent of a comprehensive EMS, as shown in **TABLE 1,** it is difficult to evaluate the cost of implementation. It is often the case that an energy monitoring software application saving 2%–3% is preferred over a full EMS that could lead to improvements of up to 15%.

Return on investment. Many operating companies have restricted capital budgets to focus performance improvement on asset optimization. Studies have shown that, on average, energy consumption can be reduced by 4% through operational improvements alone. This doubles to 8% if investment projects with a simple payback of less than one year are considered, and further increases to 13% if investments with a simple payback of less than three years are included. Therefore, there is a good case for investing in energy performance improvement.

Three broad definitions are used here to discuss new technologies for improving energy performance:

- Standard technologies, widely implemented across the industry
- Leading technologies, widely implemented by leaders in energy performance
- Emerging technologies, limited but increasing application.

The examples in **TABLE 2** are by no means exhaustive.

Relying on standard technologies provides a high degree of confidence that a solution will work and, usually, it means that implementation is relatively inexpensive. Projects with a low cost and high return will always take precedence. In addition:

- Real technological "game-changers" have been few in recent years, with most advances being evolutionary changes to "standard" pieces of equipment.
- Many operating companies are reluctant to embrace new technologies until they have seen it elsewhere.
- New technologies have to be accepted first by licensors before they will see widespread application within process designs.
- Margin improvement through yield improvement is still seen as more attractive than energy savings. Unfamiliar energy technology will lose in competition for financial resources.

The implication is that emerging technologies are years or decades old. For example, low-grade heat recovery has long been an area of research and development because the

► See **KBC,** page 13

TABLE 1. Three elements of a refining and petrochemical industry best practice EMS

People	Methodologies	Technology
Senior managers	Operations	Energy metric tools
Energy team	• Online performance monitoring	• Tracking application
• Corporate	• Online utility system optimization	• Unit monitoring
• Sites	Technical support	• Equipment monitoring
Plant team	• Opportunity identification and investment planning	Opportunity identification
• Plant manager	• Operational scenario planning	• Simulation
• Plant engineers	• Production planning support	• Pinch analysis
• Supervisors	• Design	• Utility modeling
• Operators	Maintenance practices	Scenario planning
Technical support team	Knowledge management	• Steam system simulation
Utilities support team	• Capability development	• Steam system optimization
	• Technology awareness	Subject matter expertise
	• Documentation	• Best practices
	• Innovation	• Leading technologies

TABLE 2. Examples of standard, leading and emerging technologies

Standard technologies	Leading technologies	Emerging technologies
• Condensate returned to boiler plant	Gas turbines for cogeneration	Online utility optimization
• Steam trap and leak repair programs	Hot water loops	Integrated fuel management
• Optimal insulation thicknesses	Absorption refrigeration	Organic Rankine cycle
• Minimize pump redundancy		Kalina cycle
• Optimized furnace stack O_2 and temperature		Renewables (wind, solar)
• 75%–80% efficient back pressure turbines		Fuel cells
• Turbine/motor auto start facilities		
• DCS systems	Monitoring and targeting	Site-wide integration
• Simulation	Predictive modeling	Trigeneration
• Pinch analysis on all new designs	Pinch analysis for retrofit	
	Advanced process control	
• Distillation feed conditioning	Variable-speed drives	Heat exchanger fouling monitoring
• Distillation reflux optimization	Liquid expanders	Heat pumps
• Equipment level optimization	Advanced heat exchangers	Dividing wall distillation
• Heat integrated design	Thermocompressors	Dual-effect distillation
		High-efficiency distillation column internals

A new furnace management playbook

SCOTT W. SEXTON, Haldor Topsoe Inc.

Similar to a sports team, hydrocarbon processing furnaces come in all shapes and sizes. It is a good day when furnaces work correctly, and a not-so-good day when they do not. Often, the difference between a good and not-so-good day is a burner adjustment here, or a process adjustment there. Furnace management can be compared to the daily challenge of developing a playbook, but without the benefit of game film. The furnace firebox is static, and other factors induce significant changes: personnel change, process conditions change, and change occurs in the weather and raw materials. As a consequence, the equipment begins to change. Burners foul, process piping gets hot, insulation degrades and people become frustrated, all of which can quickly turn into a bad day.

Just as blocking and tackling are fundamental to football, time and temperature are fundamental to furnace operations and furnace tube life. The Larson-Miller (L.M.) parameter (P) quantifies the relationship between the time-to-rupture for metals relative to the temperature of operation, shown in Eq. 1.

$$P(L.\,M.) = T\,[\log t_r + C] \qquad (1)$$

T = Temperature, K or °R
t_r = Stress-rupture time, hr
C = Constant, usually of order 20

According to the L.M. parameter, at a given stress level, the log time-to-stress-rupture plus a constant of the order of 20 multiplied by the temperature remains constant for a given material. The equation is used to relate the difference in rupture life, based on metal creep rate, to differences in temperature for a given stress. Typically, a 5% increase in absolute temperature will increase the rate of creep by a factor of ten.

For furnaces, it is simple to accurately measure time in operation. However, measuring temperature in operation for metal surfaces in a furnace firebox is not simple.

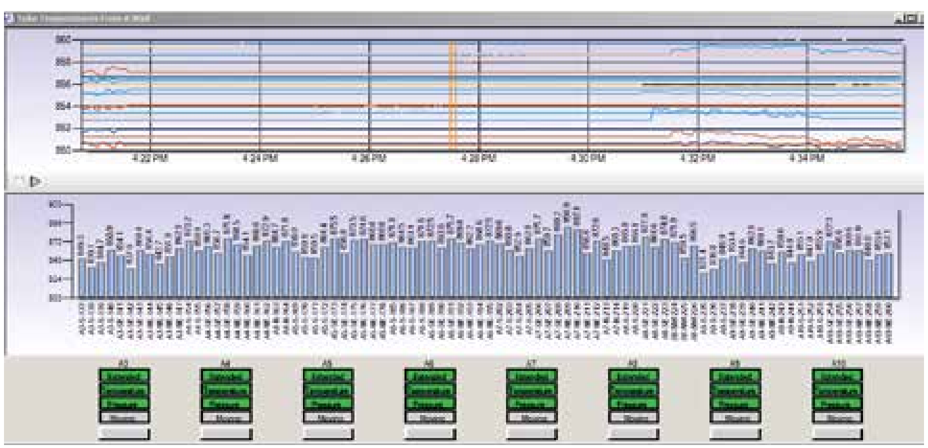

FIG. 1. Temperature correlated data from the raw image and color-coded image.

FIG. 2. The TFM image acquisition unit and data acquisition unit.

Real-time decisions with correct data. Haldor Topsoe is offering its Topsoe Furnace Manager (TFM) technology, which enables furnace owner-operators to make decisions in real time, with the correct information. TFM is an image-based system providing continuous, real-time furnace tube temperatures and firebox information (**FIG. 1**) to the local control room and, remotely, to the support team. By viewing the same data from the same source, operations, maintenance and turnaround planners will be on the same page, achieving operational excellence for all furnace operations. Engineers will literally see what is happening in the firebox; the safety team will know that its personnel are safe; and reliability teams will choose the right direction for continuous improvement.

TFM is a permanently mounted system (**FIG. 2**), directly accessing the firebox with image collectors that continuously transmit several outputs to the furnace owner-operator. Raw images, similar to X-rays, are collected and typically feature a constant view of 100% of all burners and 45% of heat transfer surface area. The images can be evaluated as-is, as charted temperature data and as a color-coded graphic. The image collectors swivel to obtain a larger viewing area, if desired, and can also automatically retract for their protection. The information is available both in the local control room and remotely, via standard communications protocols, to anyone with an internet connection.

Personnel-intensive furnace activities. Furnace operations invariably involve a lot of human effort. From a safety perspective, some administrative activities involved in typical hydrocarbon processing furnace operations include:

- Lighting burners
- Checking burner flames and fuel/air mixing
- Examining process tubes and piping for hot spots
- Investigating insulation and arch integrity
- Inspecting for firebox leaks.

Furnace maintenance also involves a great deal of effort, and the first step is to gather the correct information about the furnace status from operations. This information is usually exchanged verbally, followed with written work orders that are communicated via a computerized maintenance management system. A few snapshot photos or infrared (IR) scans might be available, or temperature data recorded manually, or a few spot temperature data points recorded from installed thermocouples. It is difficult to perform the correct maintenance with spot information.

Long-term furnace reliability is another challenge. Reliability teams are challenged to coordinate turnaround and outage requirements working with the same basic information as the maintenance team. Longer-term lifecycle considerations are subject to judgement calls, relying heavily on experience. Most reliability lifecycle information is collected during outages, when milestone and benchmark measurements are made while the furnace is shut down. Interpolation of the outage data then provides the basis for predictive judgements about future maintenance and reliability requirements.

Furnace-related personnel safety considerations are difficult. Extensive and often cumbersome personal protective equipment (PPE) is invariably required. PPE requirements can become an issue around a hot furnace in hot climates. Personnel need direct firebox understanding, which has typically involved direct interaction with the firebox to actually look at the combustion chamber while in operation. This activity is best limited.

Continuous monitoring and team collaboration. With TFM, personnel can constantly view the firebox from many angles during all phases of operation, both locally and remotely, without directly interfacing with the furnace firebox. Burner light-off, heat up, normal operation, abnormal operation and shutdown conditions inside the firebox can be monitored from the control room and remotely from a personal computer.

Furnace operational excellence lifecycle management improves, since all functional support groups literally see the same furnace information. Collaborative dialog is promoted, and group decisions are quicker and better-informed. Benchmarking with actual real-time imagery and data is possible, and corrective actions occur more often.

Other TFM furnace benefits include:

- Accurate time and temperature status of firebox metal surfaces
- Avoidance of catastrophic overheating events with alarms
- Improved fuel efficiency
- Improved reliability with longer run times
- Reduced maintenance costs over lifecycle
- Improved productivity, collaboration, personnel safety and training.

TFM is expandable from a single image collection unit for smaller furnaces, up to 50 or more image collection units for larger furnaces.

Commercial catalyst success at a US refinery

GARY CHENG, KEVIN BURTON, KENT TURNER, CHIP SCHAEFFER and **ROSANN SCHILLER,** Grace Catalysts Technologies

A US refiner processing crude from the Permian Basin, including both sweet (WTI) and sour (WTS) crude oil, underwent a major fluid catalytic cracking unit (FCCU) turnaround. Following this major revamp and re-baseline of the unit, the refinery sought to increase profitability via a catalyst change. The FCC objectives were to:

- Increase liquefied petroleum gas (LPG) olefin yield, preferably C_4 olefins
- Reduce dry gas make
- Improve slurry upgrading
- Increase light cycle oil (LCO) yield
- Advance coke selectivity
- Improve conversion, all at constant fresh catalyst addition rates.

An additional operating objective was to keep the downstream alkylation unit full year-round using a combination of FCC operating parameters, an optimized catalyst formulation and traditional ZSM-5 additive, as needed. The FCC feed is comprised primarily of a vacuum gas oil (VGO) feedstock, plus a combination of various side streams.

Combating octane debts. Refiners are continually challenged to respond to changing market dynamics. For example, a common challenge for refiners operating on unconventional feeds, such as shale or tight oil, is a loss of gasoline pool octane caused by reduced volume of alkylation feedstock. Grace launched the first product in its ACHIEVE series, ACHIEVE 400, to address these octane debits. This technology has delivered economic benefits of \$3 MM/yr–\$7 MM/yr in multiple commercial applications due to the boost in slurry conversion, FCC naphtha octane and butylene yield.

During the ACHIEVE research and development (R&D) program, five key catalytic functionalities were developed to provide the yield flexibility desired by refiners:

- Increase distillate yields with high-diffusivity matrices
- Reduce dry gas with advanced metals traps
- Drive conversion with ultra-high activity zeolites
- Maximize resid processing with leading coke selectivity
- Boost refinery octane with dual-zeolite technology.

Formulated for wide range of activities. ACHIEVE catalyst is formulated to include each of these five critical functionalities. High-diffusivity matrices maximize distillate yield from the bottom of the barrel and provide resistance to poisoning from unconventional metals. The catalyst can be formulated over a range of activity, rare-earth exchange and isomerization activities. Grace's capability to modulate hydrogen (H_2) transfer activity in its self-manufactured zeolites affords each refiner the optimal LPG-to-gasoline ratio for their operation. ACHIEVE 400 also features multiple zeolites—specifically, traditional Y-zeolite and pentasil-type zeolite—to selectively enhance LPG olefinicity by preferentially cracking gasoline olefins at C_7 and above into butylenes.

Incorporation of isomerization activity into the catalyst particle itself results in a more desirable yield pattern than would be realized by the use of a traditional octane boosting FCC additive. The company's catalyst yields higher octane with an improved butylenes-to-propylene ratio when compared to ZSM-5 additives. The zeolite isomerization activity increases the yield of FCC butylene and iso-butane, keeping the alkylation unit full and maintaining refinery pool octane.

With traditional ZSM-5 technology, cracking of gasoline-range olefins continues on into the C_6 range, generating a disproportionate amount of propylene relative to butylenes, as shown in **FIG. 1.** ACHIEVE 400 catalyst, however, works to selectively crack gasoline olefins at C_7 and above into preferentially more butylene, thus generating a higher ratio of C_4 to C_3 olefins than separate light olefins additives.

US refiner trial. The refiner began a trial of ACHIEVE 400 over a competitor's traditionally formulated high-activity base catalyst. The refinery previously utilized an approximately 1.5 wt%–3.5 wt% ZSM-5 additive to attain the desired olefinicity and octane shift.

Throughout the catalyst trial, fresh catalyst addition rates were held constant, and Ecat activity remained at 74 wt%, on average. Total LPG olefin yield increased by ~3 vol% (**FIG. 2**). The alkylation unit remained at full capacity despite a gradual reduction in additions of a separate particle ZSM-5 additive. The site eventually stopped adding ZSM-5 additive and was still able to keep the alkylation unit full.

► See GRACE, page 12

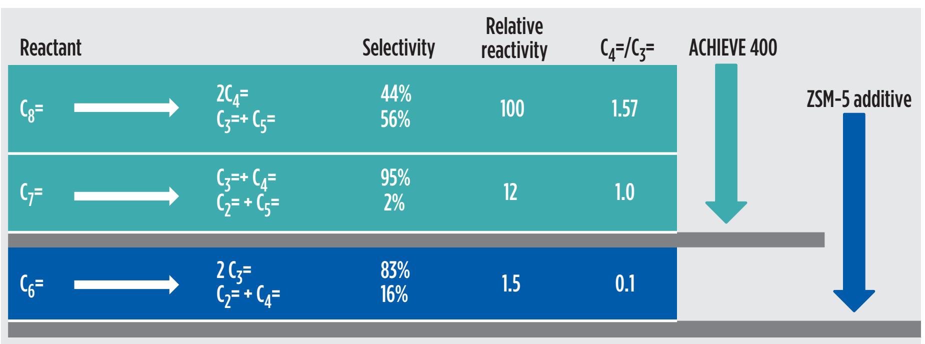

FIG. 1. Selectivity comparison between ACHIEVE 400 catalyst and traditional ZSM-5 additive.

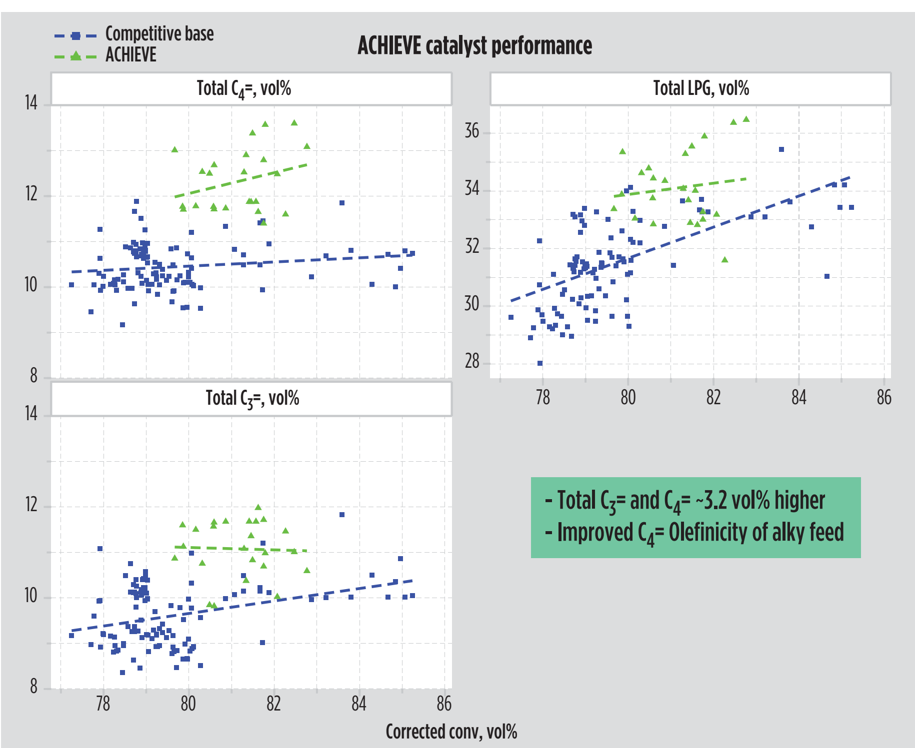

FIG. 2. Total LPG, C_4 olefins and propylene yield at constant conversion.

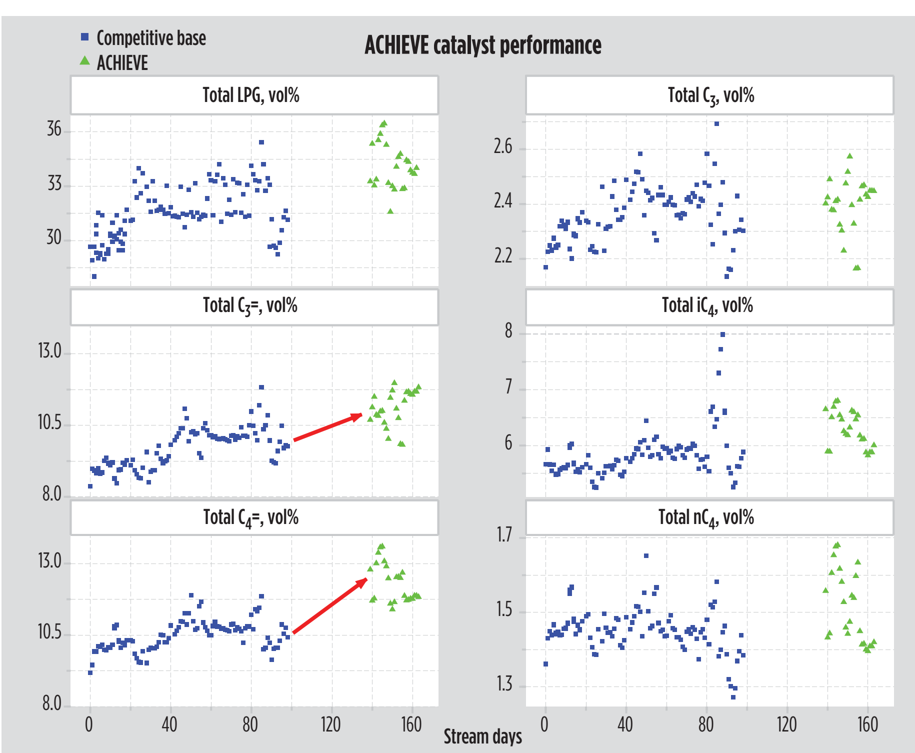

FIG. 3. The LPG yield breakdown suggests minimal increase in saturate production.

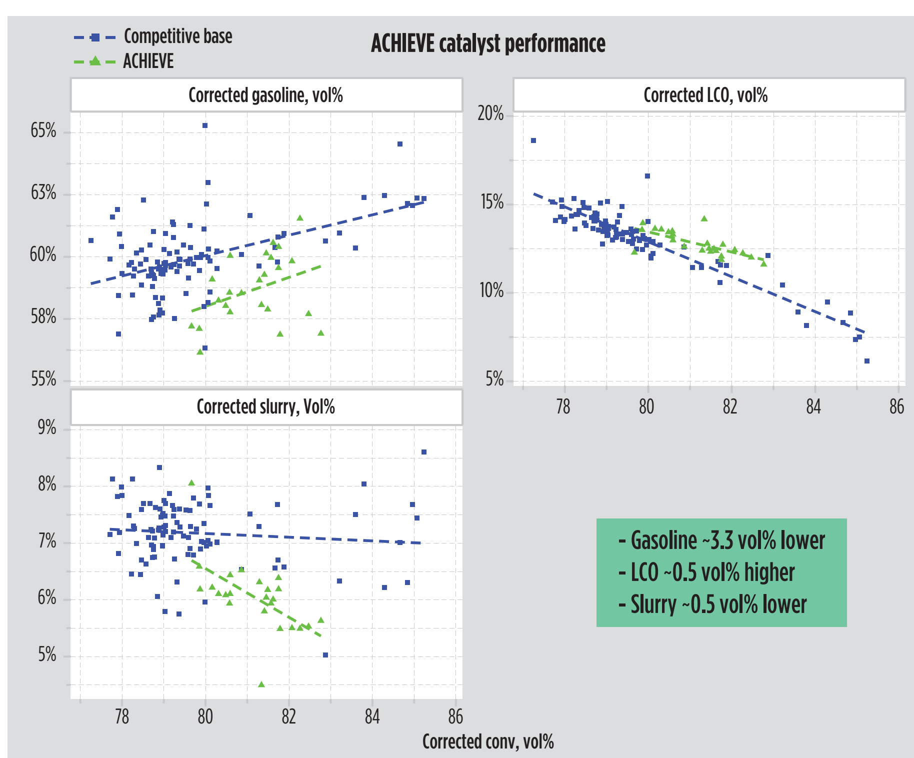

FIG. 4. Liquid yield shifts were consistent with refinery trial objectives.

Optimizing catalyst selection

KEN BRUNO and **HIROSHI TOSHIMA,** Albemarle

Refining companies apply different approaches to selecting catalysts for their units with the objective of improving performance and increasing their economic margins. To that end, refiners need higher-performing catalysts, as well as the data and modeling required to make an informed decision for their particular refining objectives.

Both in the lab and through decades of commercial applications, Albemarle can recommend optimal fluid catalytic cracking (FCC) and hydroprocessing catalyst (HPC) solutions. Albemarle features two "coke correction" methods to enhance FCC catalyst selection, demonstrated with an ACTION catalyst example, and STAX performance solutions for fixed-bed resid upgrading.

Maximizing value from laboratory data. Refiners often apply different approaches to selecting catalysts for their FCCUs. The most common approaches are based on laboratory testing or commercial side-by-side trials. **FIG. 1** shows that customers using testing to select catalysts generally choose high zeolite-to-matrix (Z/M) ratio catalysts for their units, whereas customers that conduct commercial trials choose low Z/M ratio catalysts. The catalyst with the optimum performance in a commercial FCCU is often not the catalyst that shows the best performance in standard laboratory testing.

Some customers have invested considerable time and effort in improving their catalyst testing methods and become more sophisticated in the process. Those improvements include exploring and optimizing different deactivation protocols or different performance testing methods. However, even the most sophisticated laboratory methods are not equivalent to the conditions in an FCCU.

The gap between laboratory and commercial performance is a testing artifact due to known and well-documented laboratory biases. Despite efforts to reduce the high coke artifact, and regardless of the continuous efforts to improve testing protocols, there are still important discrepancies that can artificially affect the outcome of the selection process. This is critical because commercial FCCU performance is the definitive benchmark for measuring the success of a catalyst. Consequently, considerable time and effort have been spent in applying the available commercial data to develop mathematical methods that close the gap between laboratory testing and reality.

The underlying concept. Looking at 19 commercial side-by-side comparisons has shown that: a) there is no difference in regenerator temperature between low and high Z/M ratio catalysts on average, i.e., there is no difference on average in coke selectivity when comparing at similar activities; and b) it follows that catalysts based on low Z/M ratio technology and high accessibility, such as Albemarle's UPGRADER, AFX, ACTION and AMBER families, would not result in excessive increases in delta coke or regenerator temperature, thus contradicting what is typically found during laboratory testing. In short, the coke selectivity difference between different Z/M ratio catalysts is exaggerated in testing, and the evidence clearly demonstrates the need to develop and apply a coke yield correction to laboratory data.

From a reaction mechanism point of view, it is important to remember that there are six contributors to the amount of coke an FCC catalyst produces:

1. Catalytic coke, a byproduct of catalytic cracking series reactions
2. Non-distillable coke resulting from incomplete feed vaporization
3. Contaminant (or metals) coke catalyzed by metals deposited on the catalyst
4. Feed (or Conradson carbon) coke, which is typically higher for resid feedstocks
5. Thermal coke from thermal cracking
6. Strippable coke, which has been found to be higher for catalysts with mass transfer limitations, i.e., low accessibility.

The catalytic and metal coke contributions are catalytically driven, whereas the non-distillable and Conradson carbon contributions are largely the result of high-molecular-weight material adsorbed on the catalyst, i.e., not vaporized. Coke can also be generated from thermal cracking of various large hydrocarbons, particularly aromatics. Strippable coke is the result of incomplete stripping as opposed to chemical reactions.

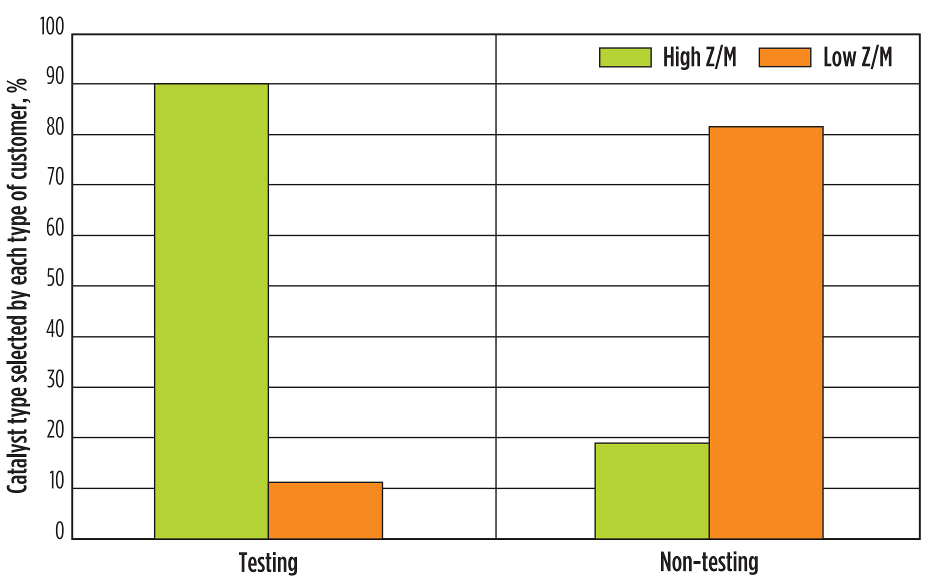

FIG. 1. Opposing catalyst choices are seen for refiners that test and those that do not.

Two models for maximizing value. In light of the above, Albemarle has developed and offers two coke correction models to adjust laboratory data to better reflect a catalyst's performance in an FCCU. Metal effects on laboratory-deactivated catalysts exaggerate both the hydrogen and the coke yield compared with those observed in an FCCU, so the metals coke correction model adjusts the laboratory coke using a stoichiometric relationship between coke and hydrogen yields. This model is very effective in accounting for metals-driven coke yield differences between catalysts in the laboratory and catalysts in the FCCU.

The second method is a lumped coke correction model, which accounts for all six contributions to coke make. The concept behind this correction model is for a refiner to develop a correction factor between laboratory coke and FCCU coke. To do this, a refiner needs to conduct commercial trials with different catalyst technologies, i.e., a low vs. high Z/M ratio catalyst, in the FCCU. If a refiner does not have such data, a robust estimate of correction factors based on 19 FCCU side-by-side comparisons is offered.

Some refiners have begun correcting their laboratory data to better reflect FCCU performance. A few have corrected for metals coke using laboratory hydrogen yields in a manner similar to that in the metals coke correction model. Others have taken a more holistic approach similar to that in the lumped coke correction model, and they have made a total coke (not just metals coke) adjustment based on differences in coke make between the laboratory and their FCCUs.

Coke correction models that are commercially validated, scientifically sound, simple and unbiased are offered, and they can be applied to any FCC catalyst manufacturing technology and to any dataset, regardless of the deactivation or testing protocol used.

Commercial ACTION case study. As an example, ACTION catalysts are routinely tested in the lab and the data routinely indicates at least a 40% increase in coke selectivity vs. higher Z/M catalysts. In a side-by-side FCCU trial, the coke selectivity for ACTION and a competitor's higher Z/M catalyst was equal (**FIG. 2**). If the lab coke selectivity for ACTION had been used to determine the fate of an ACTION FCCU trial, no trial would have occurred, and the benefits of lower bottoms, better liquefied petroleum gas (LPG) olefinicity and higher octane would have been lost to the refiner. This trial can also be used to develop coke correction factors between testing and the refiner's FCCU to gain confidence with future catalyst decisions.

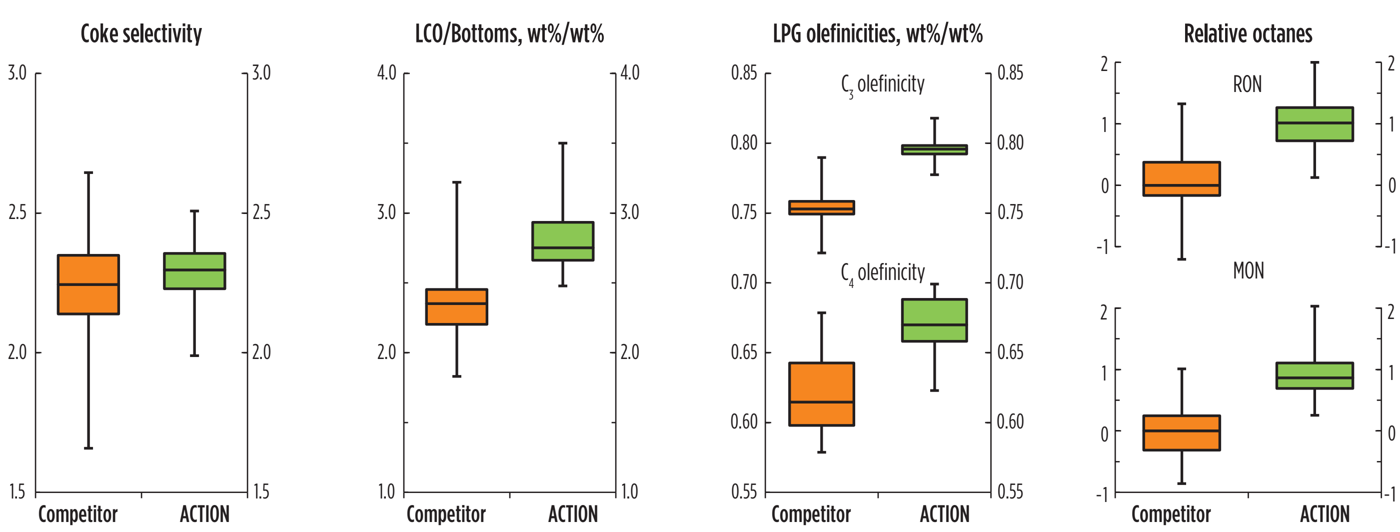

FIG. 2. Yield benefits for ACTION catalysts, including higher bottoms conversion and increases in RON and MON at lower riser temperature.

STAX solutions for FBR upgrading. Fixed-bed resid (FBR) catalysts used for "bottom-of-the-barrel" upgrading perform some of the most complex work in a refinery. The chemical reactions and related kinetics in a hydrotreater change with the nature of the feedstock, the operating conditions, the degree of conversion and the time onstream. FBR operating objectives typically involve the

▶ See ALBEMARLE, page 12

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removal of sulfur, nickel (Ni) and vanadium (V) in the conventional operation, but refiners also frequently aim to remove Conradson carbon residue (CCR), nitrogen (N) and even asphaltene (Asp) to maximize the performance of the downstream residue FCCUs, while meeting the required cycle length. To meet such complex objectives within the heaviest molecules hydrotreating process, catalysts and their serial loading technologies—which can be some of the greatest challenges in the oil refining industry—have been designed.

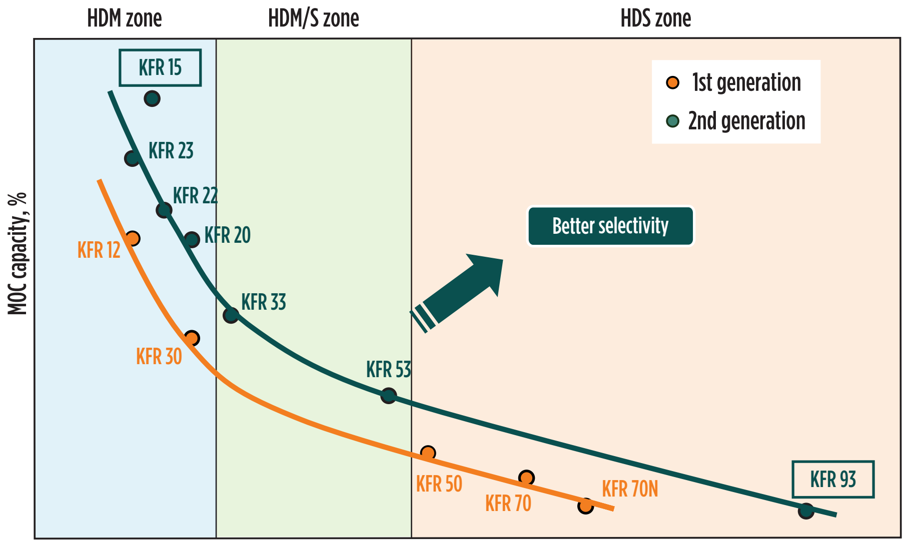

FIG. 3. Albemarle's KFR catalyst portfolio, as applied to the reactor zones, is helping refiners tackle catalytic loading complexity.

Albemarle's STAX performance loading optimizer can be used to design the right loading scheme using tailored catalyst portfolios of hydrodemetallation (HDM), transition and hydrodesulfurization (HDS) catalysts. This is accomplished by factoring in specific process objectives, economics and constraints, such as hydrogen availability or feed contaminants.

A robust KFR catalytic portfolio. To understand chemical structures, molecular association, diffusivity and reactivity, Albemarle has completed in-depth characterization of asphaltene and de-asphalted oil (DAO), continuously improving its catalytic portfolio of HDM, transition and HDS zones. More than 15 products have been commercialized over the last 30 years (**FIG. 3**). The latest development includes KFR 15, an improved asphaltene-cracking and higher metals-on-catalyst (MOC) capacity catalyst with high stability; and KFR 93, a step-out technology of very-high HDS activity to extensively lower the sulfur of product streams.

STAX zone concept and modeling. The FBR catalytic functionality and its serial loading take into account real, complex refining conditions to meet customers' objectives of contamination removals of Ni, V, sulfur, N, CCR and asphaltene. The cycle length must be well designed to meet the refinery operating plan. To meet these complex needs with optimal catalytic solutions, Albemarle has developed a unique STAX zone concept, kinetic modeling technology and loading diagram optimizer. Three main reactor zones for hydrotreating residue feedstocks have been identified, and an improved catalytic portfolio in each STAX zone is offered to optimize performance.

In Zone 1, the primary reactions are HDM and the overall conversion of asphaltenes, called hydro de-asphaltenization (HDAsp). Zone 2 is considered the transition zone, where there is higher HDM/HDAsp activity to trim refractory Ni/V/Asp. Zone 3 is the HDS zone, with high HDS (CCR, N) activity and selectivity for the de-asphalted molecules. The performance characteristics of each zone and the catalyst selection are highlighted in **FIG. 4.**

By utilizing STAX modeling, Albemarle can make accurate activity predictions for industry requirements of HDS, HDNi, HDV, HDCCR, HDN and HDAsp. STAX also enables reliable deactivation model and cycle-length forecasting capabilities much more accurately than before. The model gives refiners reactor performance design capabilities, leveraging the company's loading design optimizer (LDO) with its KFR-grade catalytic portfolio. ●

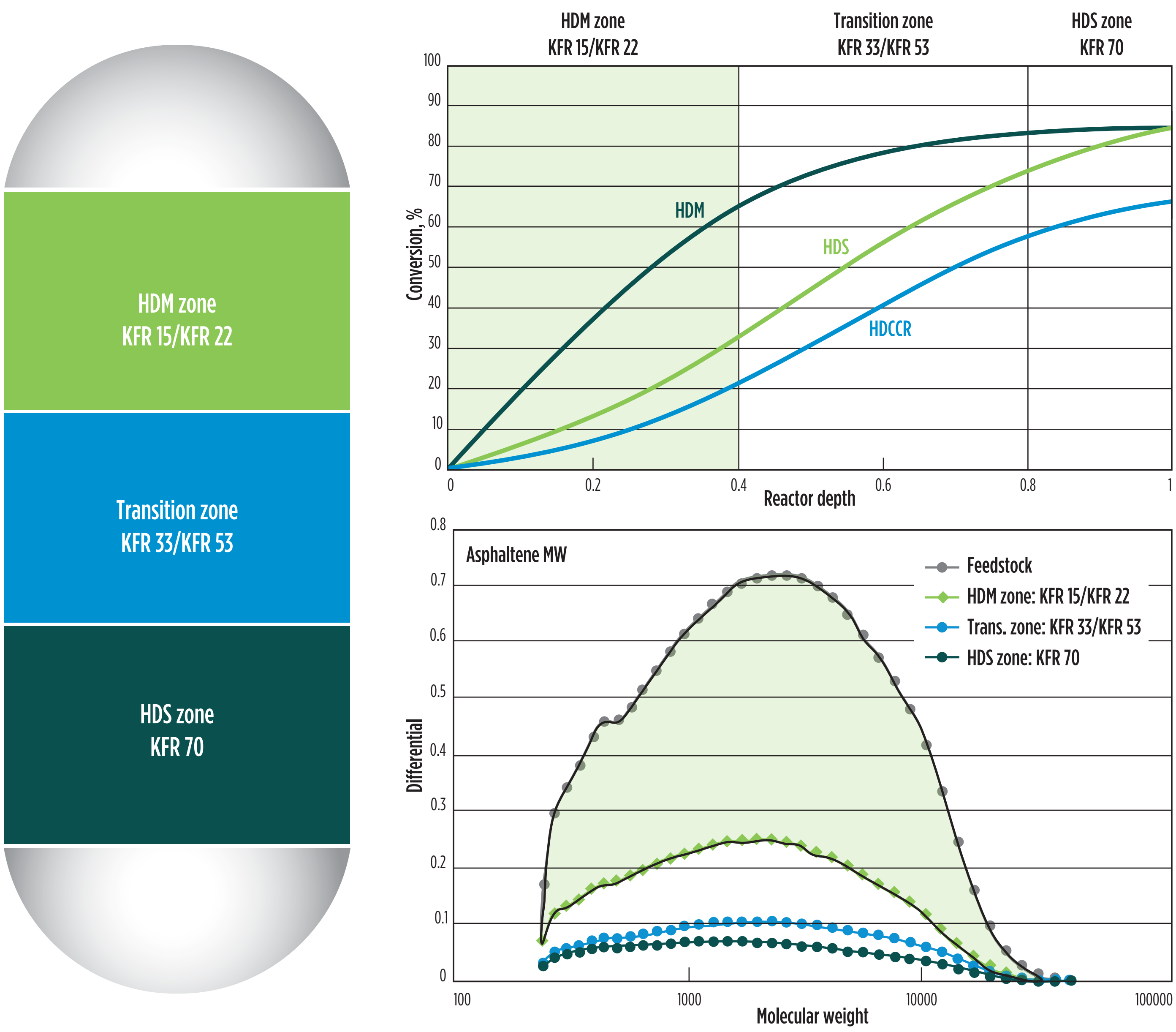

FIG. 4. Albemarle has identified three main reactor zones for hydrotreating residue feedstocks.

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The constrained downstream alkylation unit benefitted from the increased loading of C_4 olefins in the alkylation feed. Moreover, there were minimal increases in C_3 and C_4 saturates commensurate with these increases in olefin yield. This can be attributed to the tailored acidity and optimal H_2 transfer activity of the ACHIEVE catalyst system. LPG saturate yields are shown in **FIG. 3.**

Moving to a low Z/M, high-activity matrix catalyst also helped to improve slurry upgrading and increase LCO yield. Slurry yield dropped by ~0.5 vol%, while LCO yield increased by ~0.5 vol% at constant conversion. **FIG. 4** illustrates the plots of these shifts.

Additional benefits included reduced dry gas at comparable metals levels on Ecat, as well as improved overall conversion and volume swell.

Measurable outcomes. A review of the unit data shows that the US refiner was able to significantly improve profitability during the trial. The stated objectives were met, and the refiner obtained an additional benefit of lowering operational expenditures (OPEX) by reducing, and eventually stopping, the addition of ZSM-5 additive at full FCC charge rates. Due to the trial's success, the refiner is still using the Grace technology, which has generated an economic uplift of approximately $0.70/bbl.

As refinery needs continue to become more complex and diverse, FCC catalyst suppliers are continually challenged to respond with new flexible and adaptable technologies to meet these evolving needs and fulfill short-term refinery objectives. The ACHIEVE series (100, 200, 300, 400, 800) suite comprises catalysts technologies that are optimized to meet specific refinery opportunities without exceeding operating constraints. These catalysts have been applied in 30 commercial applications to date, and have delivered between $0.40/bbl and $0.95/bbl of incremental value. ●

WELCOME, continued from page 1

As entertaining as our guest speakers are, it is our breakout sessions that have made the AFPM Annual Meeting the premier downstream event. This year, 79 technical papers will be presented on the industry's most critical issues, including the Refinery Sector Rule, the new National Ambient Air Quality Standards for ozone, and 10 other regulations that take effect in 2016. All told, new federal regulations will burden US manufacturers with more than $100 B in regulatory compliance costs!

As you can see, we have our work cut out for us, but AFPM's commitment to creating a regulatory environment that is realistic and effective is stronger than ever. With my first year as president of AFPM drawing to a close, I am pleased to say that we are building upon the association's strong tradition of educating policymakers and the public about the benefits of fossil fuels and petrochemicals.

We hope the next several days afford an opportunity to gain valuable knowledge to take back to your team and community, to learn more about technological advances and the regulatory environment for the year ahead, and to make new connections. And, if we haven't already, our team looks forward to meeting you during the Annual Meeting.

Thank you for coming, and for your continued support of AFPM. ●

KBC, continued from page 4

great majority of heavy chemical plants and refineries have a large excess of heat between 150°C and 30°C that is rejected to air or cooling water. Finding a way to recover this energy would be very lucrative.

Examples of technologies that can convert this heat into a more useful form of energy are absorption refrigeration and the Organic Rankine/Kalina cycles. However, there are good reasons why these have not achieved wide industrial application:

- Distributed sources—In most chemical plants and refineries, heat sources that could be captured by these technologies are many in number and at a range of temperatures and heat content. As a consequence, it is not always possible to exploit economies of scale that would justify investment.
- Limited users—Absorption refrigeration is only worth considering if there is a suitable user for chilling. This may be to replace mechanical chillers or to capture additional light products. Whatever the case, the amount that can be utilized is limited.
- Relative efficiency—As shown in FIG. 1, the most efficient use of low-grade heat is through process heat recovery—i.e., a standard technology. Assuming that an appropriate user can be identified, 100% of the waste heat can be recovered, so this will always be the preferred option. The more heat that is recovered, the lower the temperature of the remaining low-grade heat, and, consequently, the lower the efficiency of alternative means of capture. Ultimately, the low efficiency of the Organic Rankine cycle energy recovery makes it unattractive, in most cases.

Generally, emerging technologies manage to gain acceptance as a result of the combination of a number of factors:

- A particular industry sector finds a unique application
- Separate developments in other areas provide synergy
- Evaluation techniques are improving
- Market economics become supportive (changing fuel and power prices).

While there is a perception that new technologies are an untapped means of radically improving energy performance, experience shows that the greatest financial benefits are realized by applying standard technologies. Typically, energy performance improvement programs yield savings of 10%–15% of base energy costs. Of this, approximately 80% of benefits are realized through operational changes and standard technologies. Emerging technologies do play a part with ~10% of total benefits, and it is worth noting that each individual application typically offers larger-than-average savings. ●

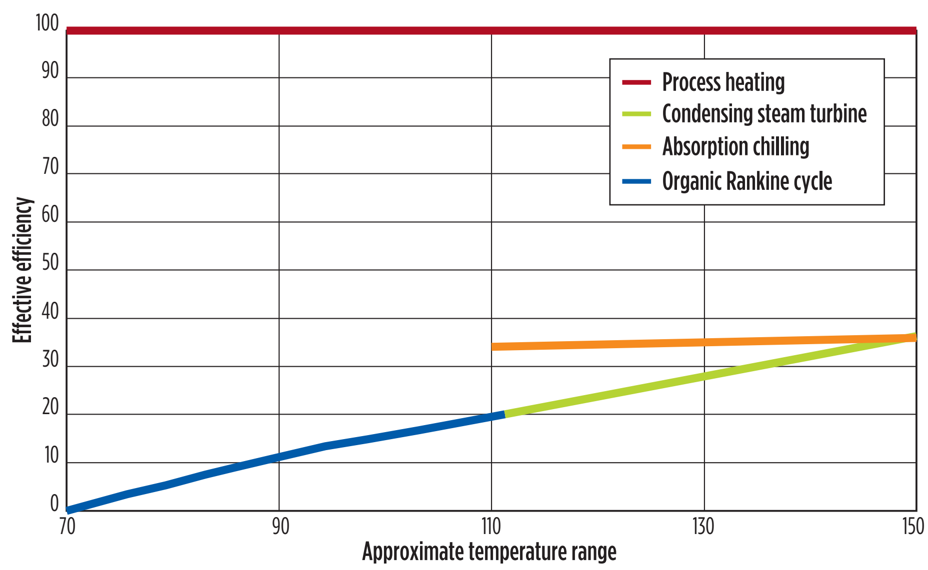


FIG. 1. The relative efficiencies of low-grade heat recovery methods.

Asset integrity management lowers plant ownership costs

NAVÈ ORGAD and **VINAYAK SUBRAMANYAM,** Pentair Valves & Controls

Tracking valves and controls that are in service for an extended period, and monitoring their performance over this time frame, are critical for improving uptime and minimizing maintenance costs and the risk of failure in chemical and petrochemical plants. This is particularly true for aging plants where the needs for improved efficiency and risk management are especially great.

Managers of large chemical and petrochemical plants are finding that asset tracking and asset integrity management provide them with a better understanding of their total assets and enable the "right-sizing" of inspection and repair intervals to improve their total cost of ownership (TCO). The Pentair Valves & Controls service team is addressing an increasing number of customer requests with regard to their valves and controls assets (**FIG. 1**). These range from outlining requirements associated with installed assets to providing recommendations for maintaining, repairing and replacing customer-owned parts and equipment. This trend has led manufacturers of safety and security-related valve solutions to rethink their service offerings toward a more holistic and reliability-driven asset management approach.

FIG. 1. To achieve optimal performance improvements, chemical and petrochemical plant owners-operators are focusing on standardization, knowledge of their asset base, the efficiency of maintenance operations and risk management. Source: Pentair Valves & Controls.

FIG. 2. Pentair Valves & Controls' asset integrity management cycle is based on several modules that can be tailored to customer needs. Source: Pentair Valves & Controls.

To achieve optimal performance improvements, chemical and petrochemical plant owners and operators are focusing primarily on:

- **Standardization.** Customers try to standardize their assets to rationalize the supplier base, and reduce and manage complexity, thus lowering costs while simplifying product-related safety and security procedures.
- **Knowledge of the asset base.** Customers need to have visibility of their asset inventory, including condition history and status. Equipped with this information and knowledge, they can focus on their critical assets from both an operational and safety standpoint.
- **Efficiency of maintenance operations.** In aging petrochemical plants, customers need to ensure the reliability of their equipment and drive costs down. By using a reliability-centric maintenance approach, owner-operators are able to increase uptime and safety while reducing costs.
- **Risk management.** Avoiding critical accidents is extremely important. Knowing and approaching critical assets with advanced maintenance methods will help reduce risk of catastrophic events.

An asset integrity management offering for recording and maintaining records of assets installed at customer plants has been developed (**FIG. 2**). Customers can access the underlying system 24/7 at a global scale through a Web portal, allowing them easy access to all asset records and fostering faster and more educated decision-making.

Pentair's asset integrity management addresses all the points above and allows chemical and petrochemical plant managers to use an integrated maintenance solution that includes:

- A robust asset tracking database to collect and keep records of repair workflows and historic information of valves and actuators
- An integrated risk-based inspection (RBI) module that supports preventive and predictive inspection, maintenance planning, and can be adapted to specific customer needs
- Root cause failure analysis (RCFA) documentation and reporting for use by operations and maintenance management
- Compliance management for easy access to records
- Inventory management that provides record keeping of spares, parts and swap spares
- Outage planning, including optimal parts and replacements planning by knowing asset repair intervals and history.

The main advantages of using asset integrity management solutions include:

- Asset data-based repair/replace recommendations before failure
- Shorter outages and repairs attributed to optimized parts and replacements planning.

In a real-case situation where the asset integrity management approach was implemented (**FIG. 3**), tangible benefits included:

- Asset repair cycle extended from 23 to 42 months, an increase of 83% of maintenance interval
- Repairs per year reduced by 18%
- Cost per repair reduced by 22%
- Overall maintenance costs of the assets under asset integrity management reduced by 35%
- Asset standardization moved from 60% to 90%.

Asset integrity management provides plant managers with a 360° view of their facility, equipping them with a full understanding of their current asset base and optimizing maintenance schedules. ●

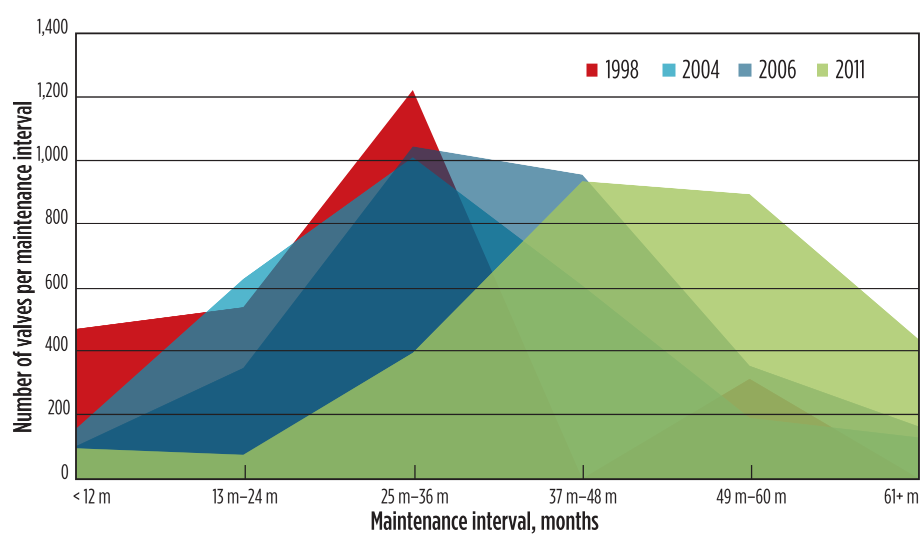


FIG. 3. A real case example of maintenance interval improvements obtained through asset integrity management implementation. Source: Pentair Valves & Controls.

APC implements optimization

JOSEPH MCMULLEN and **SAMANTHA WEAVER,**
Schneider Electric

Advanced process control (APC) software has been successfully implemented in the refining, petrochemical, chemical and other industries for years. APC uses rigorous and robust calculations, process modeling and controller design to provide robust control and optimization for operations, minimizing the typical process fluctuations from normal controller operation. Reducing these fluctuations allows for the controller set points to be set much closer to the operating limit, thus adding value with minimal danger of exceeding that limit (**FIG. 1**).

At a US 60-Mbpd refinery that produces naphtha, kerosene, diesel, automotive gasoil (AGO), light vacuum gasoil (LVGO) and heavy vacuum gasoil (HVGO), the operators had difficulty in keeping the unit stable with products on spec due to crude switches, especially with the addition of various slop oils as charge every few days. In May 2015, the refinery commissioned an APC from Schneider Electric, which ran constantly for five months without issue, even during turnaround at low rates. Implementation of the APC was positively accepted by operators and resulted in yield improvements that increased profitability by $875,000/yr. The payback period is typically less than a year.

The main challenge in implementing APC software has been the learning curve required to adequately develop and maintain an APC model. Recent advances in APC software, like SimSci APC, have significantly reduced that learning curve by improving the user interface to match the quality interface that users expect. When combined with an intuitive workflow, APC software is not only a value-generating software, but is easier to use with an improved interface, enhanced trending, advanced controller functionality and innovative customization.

Intuitive interface and streamlined workflow. The redesigned interface workflow allows the user to follow the natural progression of the APC project—from connecting to data, designing process tests, identifying the model, building and eventually commissioning the designed controller—with little need for the instruction manual.

Powerful trending and advanced functionalities. SimSci APC provides control engineers with the data they crave in the form of trends that can easily be created, managed, compared and manipulated for analysis. Each trend display can be individually customized, and all trends are synchronized automatically. Past, current and predicted future values for process variables can be plotted together with past, current and future moves for a controller to evaluate the controller performance.

The APC software also has multi-controller and subcontroller functionality. The multi-controller functionality allows it to design, commission and manage multiple APC controllers within a single APC server. The subcontroller functionality allows SimSci APC to turn segments of a controller on and off. Model migration is another key feature. Most engineers are not interested in rebuilding models, so the software allows the user to easily migrate models and controllers from Connoisseur, as well as from competitor APC software.

A powerful director code. Perhaps the most important feature of any APC software is customization. Director in SimSci provides re-useable, customizable, user-defined functions to augment the controller capabilities or add custom supporting functions to cope with changing process conditions or states. The result is that the SimSci APC can achieve a higher service factor when compared to traditional APC applications.

The future of APC is here. If APC on a 60-Mbpd refinery can increase profitability by $875,000/yr, why aren't all owner-operators considering it? SimSci can implement the same value from previous iterations of APC software with an easier-to-use, simpler and more intuitive program. •

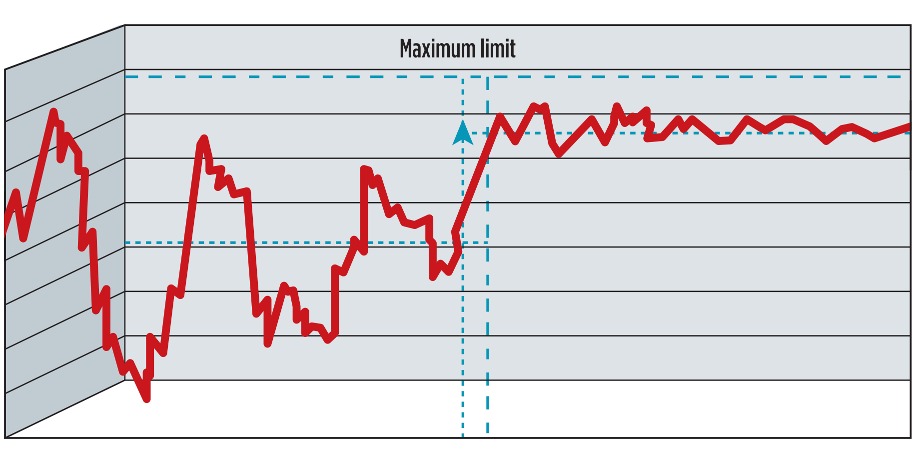


FIG. 1. APC reduces the typical process fluctuations, resulting in set points being closer to operational limits.

Paving the way to safer, more productive plants with the IIoT

BRUCE CALDER, Honeywell Process Solutions

The next generation of manufacturing will be driven by connectivity. It is happening today in modern plants: the Industrial Internet of Things (IIoT) is enabling manufacturers to embed physical objects with the capacity to both communicate with and sense the world around them. This is opening up new possibilities for safety, productivity, organizational responsiveness and, ultimately, profitability.

Make no mistake, the IIoT is not so much about the amount of data that is being generated—there is already an enormous amount of data available to manufacturers. Rather, the true value of the IIoT is its ability to deliver meaningful information where and when it is needed most. The network is the delivery mechanism, channelled by an army of sensors and mobile devices that combine to offer control room operators new perspectives on the way a plant is run, improving safety and efficiency, and sometimes uncovering new revenue streams.

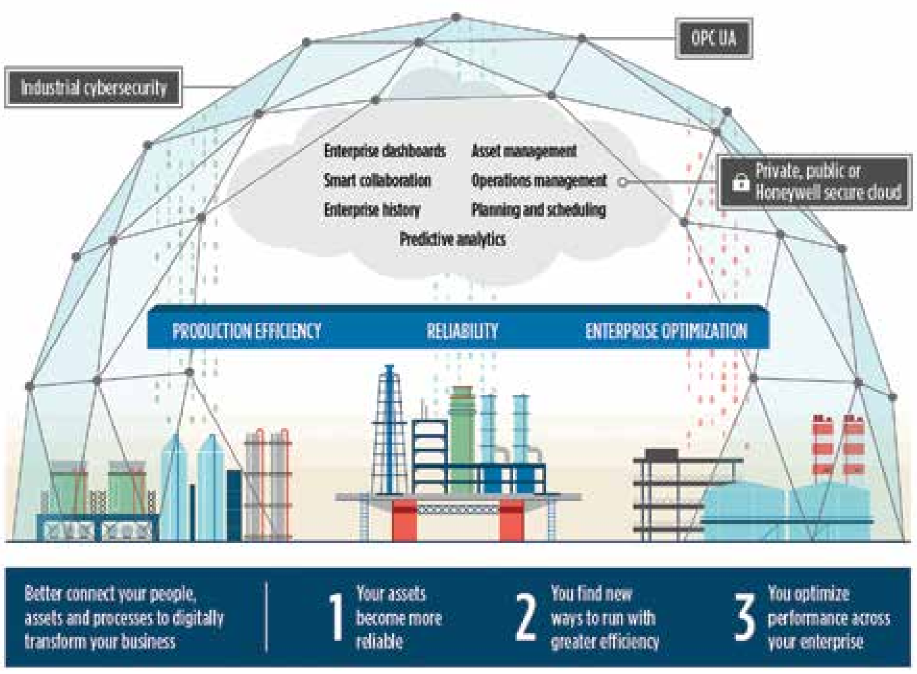


FIG. 1. The true value of the IIoT is its ability to deliver meaningful information where and when it is needed most.

The promise of greater output. The keystone of the IIoT is productivity. In the world of oil and gas, where plant owners have one eye on capital expenditures (CAPEX) and another on falling oil prices, the biggest driver of IIoT technology is the promise of greater output. As every control room manager knows, a plant is only effective when it is running.

The availability of timely, meaningful information can help prevent unplanned downtime, which is not only good news for production, it is also good news for the plant's safety record. Some of the largest big-data projects are about abnormal event detection, crunching terabytes of historical information, together with real-time data, to predict and control events and breakdowns before they develop into life-threatening incidents. For example, real-time data from sensors embedded in pipes combined with data from other networked plants can warn of hidden corrosion before it causes a threat to plant safety.

The IIoT can bring all this critical information to bear where and when it is needed most, but it would be a mistake to view the IIoT simply as a matter of sensors and connected devices. For the IIoT to be fully effective, plants must invest in a confluence of different technologies, from the cloud to predictive analytics, and wearables to augmented reality.

Integrating data across multiple plants. Let's begin with the cloud. Running applications on premise may offer information technology (IT) teams the illusion of control, but, in reality, the task of deploying and maintaining applications locally is becoming increasingly complex and costly. Cloud applications are quicker, cheaper and easier to deploy, but the greatest value comes from integrating data across a portfolio of plants. In a distributed organization, business leaders want to see unadulterated, clean data taken from across the entire business before they make big decisions. Cloud-hosted applications eliminate the politics of local reporting, self-serving key performance indicators (KPIs) and incomplete data sets, producing a meaningful, global view of what is happening and allowing big decisions to be taken at a lower risk to the business.

Of course, an effective IIoT also depends on enhanced mobility. Connected devices are already having an impact on employee safety. In gas plants, field technicians wear belt sensors that not only detect the presence of harmful gas, but triangulate an employee's position so that, in the event of a leak, the location of the problem can be established as quickly as the locations of at-risk employees.

More advanced applications are enabling connected devices to amplify employee skill sets, giving new recruits instant access to the knowledge and expertise of a more experienced colleague. Imagine carrying out a maintenance check on an unfamiliar system. What does a blinking red LED mean? What does this code signify? Armed with a smartphone fitted with augmented reality software, any engineer can instantly hold up the device for an enriched and accurate interpretation of what is in front of them.

Breaking down outdated perceptions. The prevailing view used to be that a closed system offered a greater chance of protection from cyberattack. This provided legacy technology with an undeserved advantage over newer connected technology, under the assumption that a connected environment simply provided attackers with more points of vulnerability. This theory has been proven false. Manufacturers are now waking up to the fact that many older products were designed largely without any cybersecurity measures at all. As hackers become more sophisticated, the safest systems are now connected ones.

There is no doubt that the IIoT is bringing real value to the process industries. Honeywell is working with customers to help them identify how the IIoT can benefit their operations (**FIG. 1**).

The emergence of the IIoT represents a digital transformation of manufacturing that shifts the source of competitive advantage away from physical machinery and towards information. The way in which data moves between people, and between devices, is increasingly creating the most value. A productive plant relies on employees receiving the best available information in a way that is meaningful to them. The more relevant and timely the information, the more empowering it is, enabling employees at every level to make instant decisions that directly impact productivity. Therein lies the power of IIoT. ●

Bruce Calder is the Vice President and Chief Technology Officer (CTO) of Honeywell Process Solutions. In this role, Bruce leads a global product development organization that delivers leading-edge process automation technology to Honeywell's customers in the process industries. The technologies for which Mr. Calder is responsible control and improve the productivity of some of the world's largest oil and gas, chemical, paper, mining and pharmaceutical manufacturers.

Managing gasoline sulfur Tier 3 standards

BART DE GRAAF and **EMERSON DOMINGO,** Johnson Matthey Process Technologies

Beginning January 2017, Tier 3 motor vehicle emissions and fuel standards will apply. These standards lower gasoline sulfur levels from 30 ppm to 10 ppm. The 10 ppm gasoline sulfur is an average, as current caps of 80 ppm at the refinery gate and 95 ppm downstream are maintained. The effects might not be felt immediately, as standards include an averaging, banking and trading (ABT) program. In this program, refiners can use credits obtained under Tier 2, and there is a one-year deficit carry-forward provision. This provision allows an individual refinery that does not meet the 10 ppm standard in a given year to carry a deficit forward, as long as the deficit is made up in the next year. For 30 small refiners and small volume refineries, the start date will be delayed until 2020. However, whether in the immediate or near future, allowable gasoline sulfur levels will decrease.

Reducing gasoline sulfur by two thirds is considerable. In the US, 25% to 40% of the gasoline pool comes from cracked naphtha from the fluid catalytic cracking unit (FCCU), but the FCC naphtha provides the majority of gasoline sulfur, typically 85% to 99%. Therefore, gasoline sulfur control will be heavily focused on FCC gasoline.

The effect on gasoline octanes. There are three control strategies: reduce the sulfur input of the FCCU, change the operating conditions of the FCCU, and apply posttreatment. Each strategy has an effect on gasoline octanes.

Gasoline sulfur is heavily dependent on the sulfur content in the feed. Depending on the nature of the feed sulfur species, between 2% and 10% ends up in FCC gasoline, less when the majority of sulfur species is paraffinic, and more if the majority is aromatic. Low-sulfur paraffinic feeds help effectively to reduce gasoline sulfur. These feeds trade at a premium and are not always readily available. Hydrotreating FCC feeds is a very effective, albeit expensive, option. The main benefits of hydrotreating are substantial yield improvements and lower fuel sulfur in gasoline and light cycle oil (LCO) fractions. This requires considerable investment in hardware and operating expenses. Feed hydrotreatment increases hydrogen in the feed, and this reduces gasoline octanes. FCC catalysts for hydrotreated feeds are typically high-rare earth catalysts, due to the high activity requirements to manage delta coke, and this reduces gasoline octanes even further.

Changes in operating conditions of the FCCU can help to control gasoline sulfur. As gasoline sulfur species exhibit a nearly exponential distribution, increasing with boiling point, decreasing gasoline endpoints helps to reduce gasoline sulfur. This comes at the expense of gasoline volume.

The effect on gasoline octane is less straightforward, as it depends on gasoline cutpoint. For gasolines with low final cutpoint (310°F or below), reducing gasoline cutpoint may improve gasoline octanes, as medium-cracked naphtha has a relatively low octane value. For gasolines with a high cutpoint, a decrease in octanes when the cutpoint is lowered is more common. Separately, gasoline sulfur content depends strongly on the quality of distillation. A heavy tail in the gasoline fraction increases sulfur content disproportionally. Heavy naphtha contains the highest sulfur levels. The recycling of heavy naphtha in the FCCU increases the catalyst-to-oil ratio and hydrogen transfer, and helps to crack sulfur species out of this fraction. This comes at some expense of volume and throughput. Gasoline sulfur additives can help to reduce gasoline sulfur, depending on the nature of sulfur species, typically by 15% to 35%. Effects on other yields and their qualities (such as octanes) are typically negligible.

Strategies and investments. Investments for gasoline post-treatment are substantially lower than those for feed pretreatment, as volumes and sulfur levels are lower, and the sulfur species are much more benign than those in feed. However, hydrogenation of FCC gasoline comes at octane loss. The octane loss can be minimized when this strategy is combined with other strategies to reduce gasoline sulfur (FIG. 1).

Gasoline sulfur control strategies may require additional considerations to mitigate their side effects—e.g., how to deal with octane loss. The optimal strategy to meet the more stringent sulfur specs without loss of gasoline octanes will be refinery dependent. Whether there is room in Reid vapor pressure; whether there is a surplus in reformate or isomerate; and whether or not high octane alkylate or oxygenates are available will all determine how much loss a refinery can afford in FCC gasoline octane. Next to controlling gasoline sulfur, gasoline octanes need to be managed. FCC catalyst formulation, additives to reduce sulfur in gasoline and ZSM-5 additives are key to maintaining gasoline octanes, while decreasing gasoline sulfur. ●

Johnson Matthey **INTERCAT** FCC additives. A superhero approach to meet Tier 3 standards includes reducing gasoline sulfur, maintaining and improving octane, and responding quickly to changing feeds.

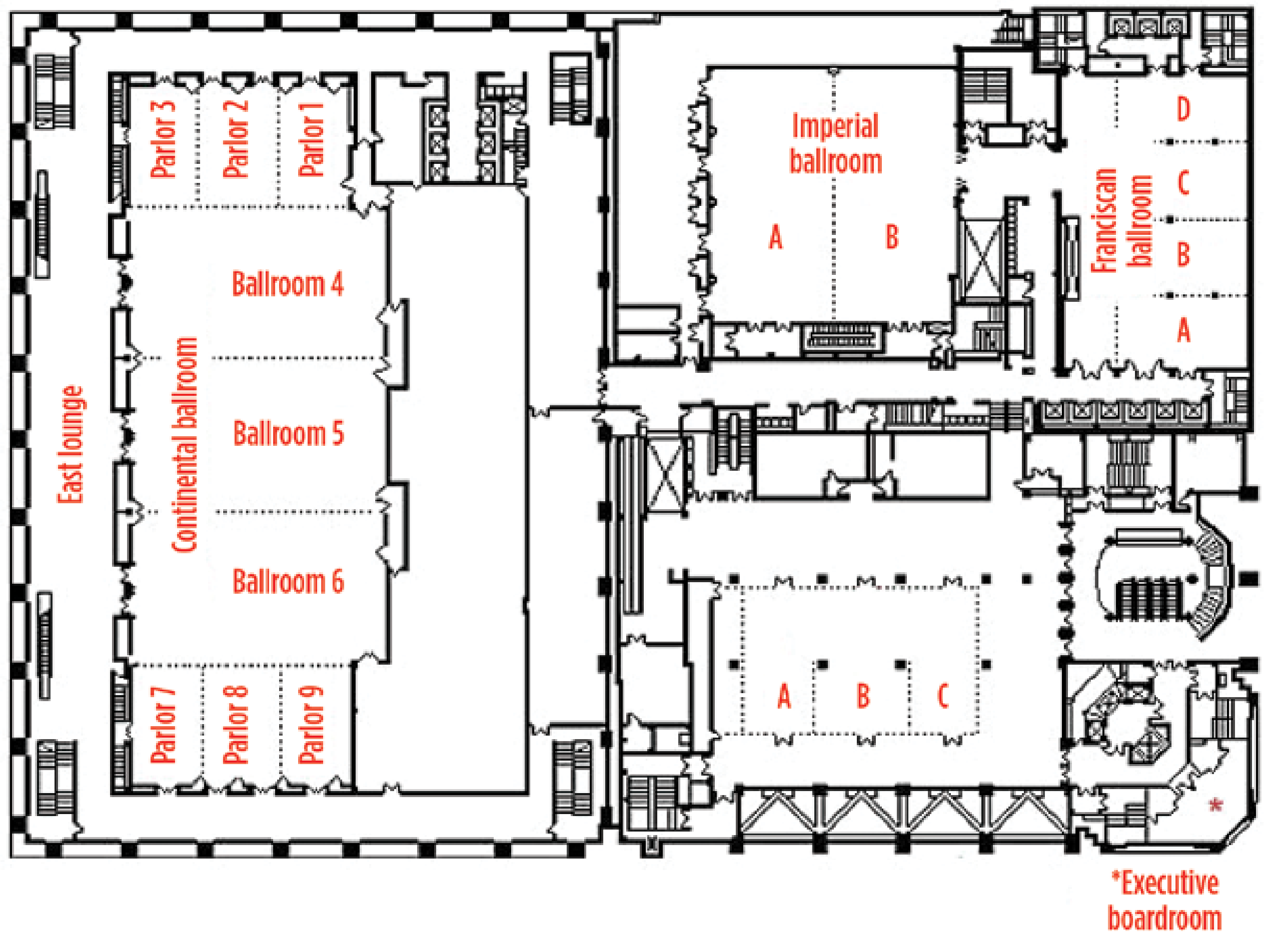
LINDE TO EXPAND PRESENCE IN HOUSTON ENERGY CORRIDOR

To better serve its customers in the Houston, Texas area, Linde Engineering North American Inc. (LENA) and Linde Americas, members of the Linde Group, have signed an agreement for new office space. Approximately 150 employees are expected to move into the new facility in early April.

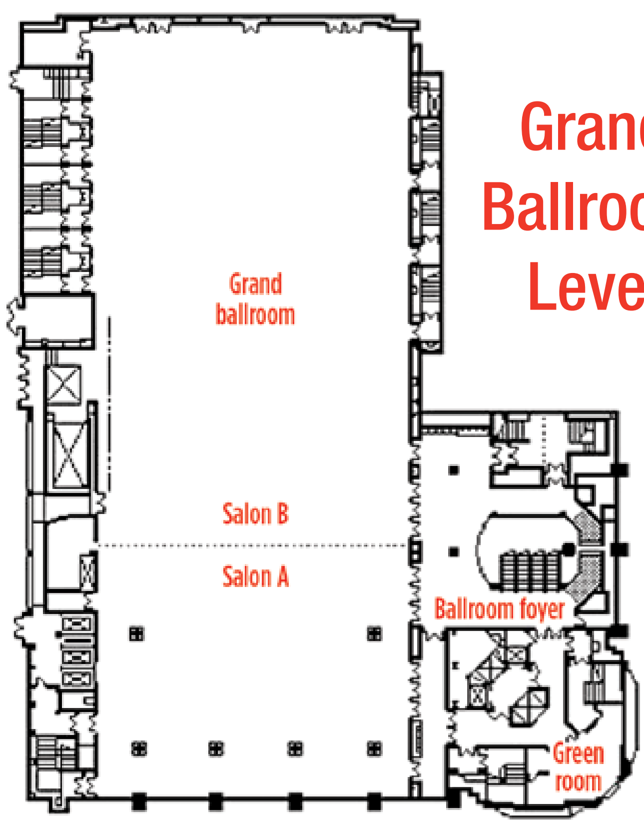
Linde has invested more than $250 MM in a large air separation unit (ASU), a new gasification train and supporting equipment and facilities in La Porte, Texas. LENA engineered, procured and constructed these plants for Linde Gases North America to own and operate. With the new plants, Linde has a fully integrated presence in the Houston area that covers air gases and synthesis gas products. ●

HILTON SAN FRANCISCO FLOOR PLAN

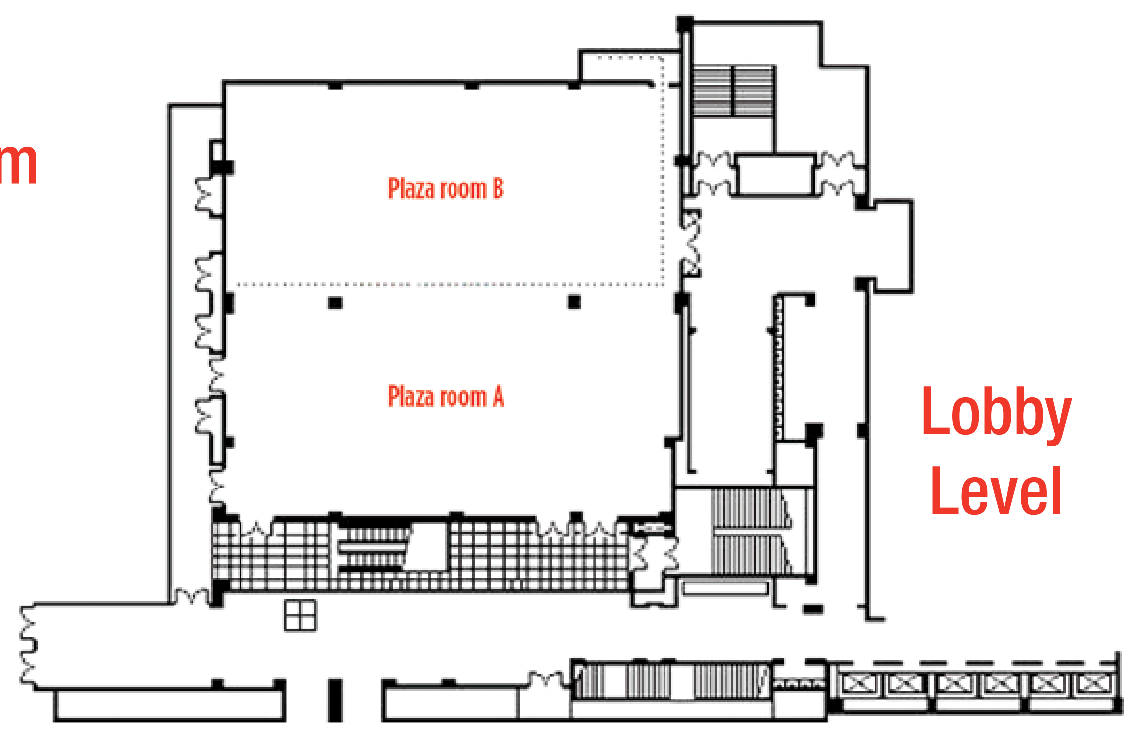
Ballroom Level



Grand Ballroom Level



Lobby Level



HOSPITALITY SUITES

To find the exact room number of a hospitality suite, please refer to the daily event board in the lobby of the hotel or the information wall located in the AFPM registration area in the Hilton Union Square Yosemite Foyer. To contact the hotel desk, dial 415-771-1400.

Advanced Refining Technologies—Sun., Mon. .... TBA
Air Liquide Large Industries—Mon. .... TBA
Albemarle—Mon. .... Union Square 21
Ambitech Engineering Corporation—Mon. .... TBA
Athlon Solutions—Mon. .... Union Square 15 and 16
Axens North America Inc.—Mon. .... Golden Gate 2
BASF Corporation—Sun. .... Union Square 21
CB&I—Mon. .... Continental 4
ChemTreat—Mon. .... Union Square 11
Chevron Lummus Global—Sun., Mon. .... Penthouse Suite TBA
Colonial Pipeline—Sun., Mon. .... Union Square 13
Criterion Catalysts & Technologies/
Shell Global Solutions—Mon. .... Golden Gate 4 and 5
Dorf Ketal Chemicals and Solenis—Sun., Mon. .... TBA
DuPont Clean Technologies—Mon. .... Union Square 25
Emerson Process Management—Sun. .... TBA
Grace Catalysts Technologies—Sun., Mon. .... TBA
Haldor Topsoe Inc.—Sun., Mon. .... Golden Gate 8
HCpect—Mon. .... Union Square 5
Honeywell UOP—Mon. .... Presidential Suite TBA
KBC Advanced Technologies Inc.—Sun., Mon. .... Union Square 14
KBR—Mon. .... TBA
Linde Engineering North America—Mon. .... Union Square 19 and 20
Merichem Company—Mon. .... Golden Gate 7
Platts—Mon. .... Union Square 17 and 18
Schneider Electric—Mon. .... Golden Gate 6
Technip Stone/Webster Process
Technology—Sun., Mon. .... Union Square 22
Wood Mackenzie—Mon. .... Union Square 1

BY INVITATION ONLY

Buckeye Partners L.P. .... Union Square 4
Honeywell Process Solutions .... TBA
Kinder Morgan Terminals .... Union Square 8
Vopak .... TBA
Zachry Group .... TBA