2017 American Fuel & Petrochemical Manufacturers
OPERATIONS AND PROCESS TECHNOLOGY SUMMIT
AFPM
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Weathering the storms and promoting innovation

CHET THOMPSON, President, American Fuel & Petrochemical Manufacturers

Welcome to the AFPM Operations & Process Technology Summit, and thank you for joining us this year in Austin, Texas. The past five weeks have been difficult and challenging for our Gulf Coast associates, employees and facilities, and for the millions of people impacted by Hurricanes Harvey and Irma. AFPM remains committed to continue its efforts to help in the recovery.

Hurricane Harvey ripped through the epicenter of US fuels and petrochemical production, knocking offline 25% of US refining capacity and approximately 80% of ethylene production. Yet, in a matter of only a few weeks, our industries were well on their way to being fully operational. That is a testament to the preparedness and resilience of our industries, as well as to our dedicated and skilled workforce. This did not happen by accident—we were prepared and enacted critical safety procedures, while working closely with first responders and the federal government to ensure that any disruptions to the fuel supply would be minimized.

Not only have we improved lives around the globe through our products, but we continue to innovate, advancing our industries through modern technology and efficiencies. By investing billions of dollars in research and development, and utilizing our collective ingenuity and industriousness, we have developed new processes that have reduced emissions and made the air cleaner now than it has been in 50 years.

Fuels and petrochemicals are largely responsible for many of humankind's major advancements over the last 100 years, and our industries will continue to be at the center of future innovations for generations to follow. The work that we do is instrumental in advancing our industries, which is why this conference is so important. I assure you that AFPM will take every opportunity to advocate for, and give voice to, the essential role that fuels and petrochemicals play in improving modern life.

This year marks the 70th anniversary of the Summit, and we want to extend our sincerest thanks to the many people that have made this event possible over the years, and for developing another program that you are sure to find informative and beneficial.

Again, welcome, and thank you for attending and showing your support for our industries and the great state of Texas. ●

INSIDE THIS ISSUE

Commemorating 70 years of industry advocacy

For 70 years, AFPM's Q&A and Technology Forum—now the Operations & Process Technology Summit—has played an important role in leading the discussion of issues, trends and challenges facing the refining and petrochemical industries, as well as addressing specific operating issues and problems within the industry.

The 2017 Summit represents 70 years of providing an open forum for industry professionals to network, collaborate and share technical information and best practices among peers.

Since the first Q&A in 1947, the refining industry has grown by leaps and bounds. The report of the committee on petroleum refining capacity to the National Petroleum Council on July 8, 1947, reported a total US refining capacity of 5.65 MMbpd (with an operating rate of 91%). Of the 141 refineries operating in 2017, 82 were built prior to 1947, and the total number of refineries in 2017 is about a quarter of the number in 1947. Refineries are now much larger and have a total 2017 capacity of 18.62 MMbpd (with an operating rate of 96.6%), according to a report from the Energy Information Association (EIA).

With the innovation of fluid catalytic cracking, improved catalyst technology in the 1940s and the expansion of US automobile demand post-WW2, demand for fuels grew rapidly, and refineries had to add capacity and become more reliable and efficient.

While technologies and our industries have changed over the past 70 years, the attendees' and presenters' willingness to educate and collaborate with one another has remained a key reason for the conference's long-term success. Source: AFPM.

The first mention of a "panel of authorities" discussion at an AFPM meeting was in 1947. This panel discussed catalytic cracking at the 1947 AFPM Annual Meeting in San Antonio, Texas. Note: AFPM was called the Western Petroleum Refiners Association (WPRA) at that time. Until 1961, the Q&A was held in El Dorado, Kansas—legend has it that the location was chosen because there were few, if any, distractions to prevent attendees from the sessions.

After 1961, the Q&A began moving to different locations around the country and attendance grew accordingly, reaching the 1,200–1,300 range in the 1970s. The Q&A panels expanded over the years to more than 20 panelists, who sat on the stage for two and a half days and answered submitted and floor questions. Today, four disciplines are broken up into four separate panels.

One thing that has not changed since 1947 is that the strength of the Q&A lies in the diverse exchange of ideas from competitors, operating companies, suppliers and customers, and the networking among the attendees. The first woman, Christina "Chris" McDowell, appeared on the panel in 1978, and has continued to participate in Summit planning and other activities for almost 40 years! Only Warren Letzsch, with more than 42 years of participation, has a longer tenure on the committee.

Aside from small adjustments to the panels for Q&A and more specific Q&A sessions for plant managers, the forum did not make many changes until the Principles and Practices (P&P) sessions were added in 2004 to complement the Q&A sessions. The P&P sessions were implemented to reinforce fundamental principles and proven operating practices of refinery and petrochemical processes for a target audience of mid-career and junior process engineers and operations staff.

In 2005, the Plant Automation and Decision Support Conference was colocated with the Q&A, and the "Technology Forum" was formed. Attendees whose responsibilities overlap between process engineering, unit operations, process control and planning were now able to use their conference time more effectively. For the last few years, we have added a Young Leaders segment, where we offer a three-hour session and a special networking

► See 70 YEARS, page 3

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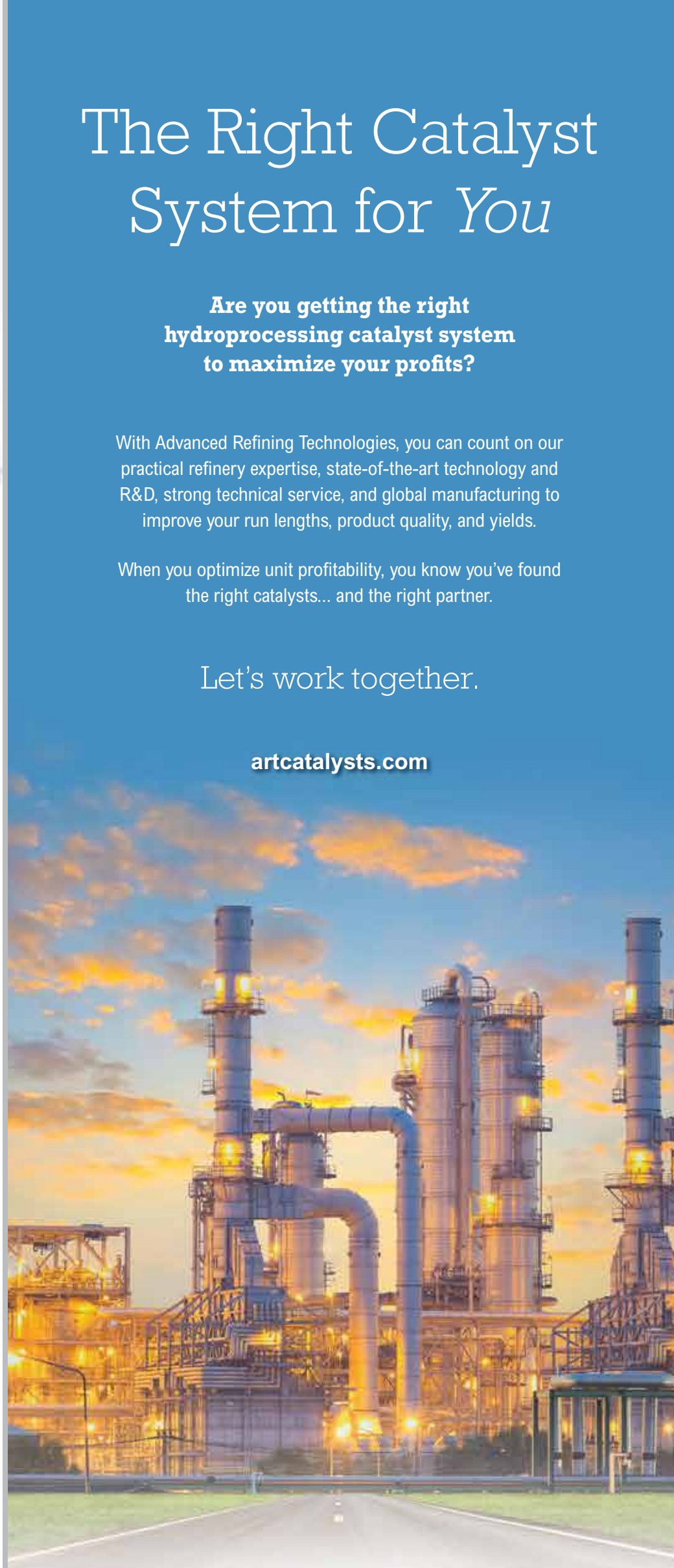

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70 YEARS, continued from page 1

ALLAN MUSE, Chairman of the NPRA Manufacturing Committee in 1972, opens that year's NPRA Q&A session on refining technology. Source: AFPM.

event for less experienced industry professionals to attract and bring them back to the Q&A and, more importantly, retain them in our industry.

The industry has changed greatly over the last 70 years (e.g., intense competitive pressures have resulted in numerous small refinery closures and a reduction in the number of independents in the business). Those same pressures have led to mergers and acquisitions that have changed the shape of the industry. The growth of some independent refiners through acquisition, and the recent emergence of "super majors," have concentrated refinery capacity in fewer companies, leaving small refiners to survive in regional markets. Adding to the pressures of the marketplace have been environmental rules for gasoline, diesel fuel and refinery emissions that have required capital expenditures that reduce the amount of capital available for profit-improving projects.

The more things change, the more they remain the same. The topics of discussion at the Q&A over the last 70 years have been very similar. Discussions about fluid catalytic cracking, crude quality, coking, alkylation, catalysts, reforming and hydroprocessing—among other long-time subjects—have dominated the decades. As technologies have developed and the industry has become more efficient, asset reliability and plant availability have improved through better materials, enhanced maintenance methods and improved equipment.

For 70 years, this conference has been—and remains—the leading technical venue for the exchange of information, ideas and best practices in the petrochemical and refining industries. The Summit would not have lasted and remained strong without the buy-in of the professionals in our industry, and the attendees' and presenters' willingness to educate and collaborate with one another. ●

AFPM

2017 OPERATIONS AND PROCESS TECHNOLOGY SUMMIT

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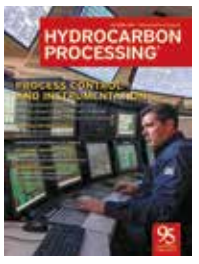


SCHEDULE OF SESSIONS AND SPECIAL EVENTS

SUNDAY, OCTOBER 1, 2017

3–6:30 p.m.	**Registration and badge pickup**
5–6:30 p.m.	**The Summit Kickoff Networking Event**

MONDAY, OCTOBER 2, 2017

7 a.m.–6:30 p.m.	**Registration**
7–8 a.m.	**New Manager Morning Mixer**
8–8:55 a.m.	**General session**
9–10 a.m.	**Concurrent Sessions:** • Cybersecurity • Operational Planning, Control and Automation Technologies • Principles & Practices—Emerging Leaders Town Hall • Q&A and Discussion Session—Gasoline Processes
10–10:15 a.m.	**Coffee Break**
10:15 a.m.–12 p.m.	**Concurrent Sessions cont.**
12–2 p.m.	**Lunch in Exhibit Hall**
2–3:30 p.m.	**Concurrent Sessions:** • Cybersecurity • Operational Planning, Control and Automation Technologies • Principles & Practices—Gasoline Processes • Q&A and Discussion Session—Hydroprocessing
3:30–3:45 p.m.	**Refreshment Break**
3:45–5:15 p.m.	**Concurrent Sessions cont.**
5:15–6:30 p.m.	**Reception in Exhibit Hall**

TUESDAY, OCTOBER 3, 2017

7 a.m.–5 p.m.	**Registration**
8–10 a.m.	**Concurrent Sessions:** • Cybersecurity • Operational Planning, Control and Automation Technologies • Principles & Practices—Hydroprocessing • Q&A and Discussion Session—Crude/Vacuum Distillation and Coking
10–10:15 a.m.	**Coffee Break**
10:15 a.m.–12 p.m.	**Concurrent Sessions cont.**
12–2 p.m.	**Lunch in Exhibit Hall**
2–3:30 p.m.	**Concurrent Sessions:** • Cybersecurity • Operational Planning, Control and Automation Technologies • Principles & Practices—Crude/Vacuum Distillation and Coking • Q&A Session—FCC
3:30–3:45 p.m.	**Refreshment Break**
3:45–5:15 p.m.	**Concurrent Sessions cont.**
5:30–6:30 p.m.	**Women in Refining Networking Event** Reception open to registered women only.

WEDNESDAY, OCTOBER 4, 2017

7:30–10 a.m.	**Registration**
8–9:30 am	**Concurrent Sessions:** • Cybersecurity • Principles & Practices—FCC • Principles & Practices—Fostering Profitability
9:30–9:45 a.m.	**Coffee Break**
9:45–11 a.m.	**Concurrent Sessions cont.**

2017 SUMMIT PANELIST BIOS

Brant Aggus, Becht Engineering

Noaman Al-Fudhail, Aramco, began his career with Saudi Aramco in the Ras Tanura Refinery as a hydrocracker Process Engineer and grew to hold a number of leading positions. As part of Saudi Aramco's training program, Mr. Al-Fudhail spent a year and a half working with UOP, performing design and technical support for hydrocrackers and diesel hydrotreaters. He has recently served as the Senior Operations Representative for the hydrocracker and diesel hydrotreater at Saudi Aramco's Jazan Refinery, working with the project management team and the EPC contractor during the units' detailed design phase. He is now the Superintendent of refinery engineering at Saudi Aramco's Riyadh Refinery, overseeing and leading all engineering resources and activities for the refinery. Mr. Al-Fudhail graduated from the University of Washington with a BS degree in chemical engineering.

Sanjay Bhargava, KBC, is a Principal Consultant/Senior Advisor working in the downstream operations/solutions group and in business development for large multi-refinery and petrochemical profit improvement and energy reduction projects. He has more than 28 years of experience in the oil and gas industry, and has performed consulting work in more than 50 refining and petrochemical complexes worldwide. Recently, he led plant-wide, best practices-based operational excellence programs—spanning organizational alignment, business work processes and procedures, workforce capability development, sustained margin improvement, refinery modernization feasibility studies, crude optimization and safety reliability improvement projects—in Latin America and India. Prior to that, he served as Operations Manager for KBC's North Asia hub in Beijing, China, and has managed several refinery and petrochemical profit improvement, integration (RPI) and implementation projects (PIP), energy reduction programs (SER), and reliability and operational planning improvement programs in the US, China, India, Brazil, Japan and Thailand. Mr. Bhargava has spent more than 15 years working as an FCC and alkylation specialist in several refineries worldwide. He earned dual MS degrees in the US: an MS degree in chemical engineering and an MBA degree in finance.

Bryan Dinkel, Marathon Petroleum, is an FCC Technologist for Marathon Petroleum Co. (MPC) in Texas City, Texas, and provides operational and technical support to the seven FCCUs within the MPC system. Mr. Dinkel has 14 years of refining experience, and has been in this role at Marathon for more than 4 years. His previous roles with BP included various process and project engineer roles, FCC/alky site Consultant and Technical Services Supervisor. He earned a BS degree in chemical engineering from Texas A&M University.

Geoff Dubin, Axens North America, is a Technology Manager at Axens North America covering olefins and light oil hydroprocessing technologies. Mr. Dubin has been with Axens for 14 years and has held several positions within the company, with experience covering process engineering, energy optimization, project management and business development. In his present role as Technology Manager, he is responsible for technology positioning and licensing for the fields he covers, as well as providing technical guidance to other departments in the organization. Mr. Dubin earned a BS degree in chemical engineering from the University of Delaware.

Hector Gamboa-Arizpe, CITGO Petroleum Corp., works as a Strategic Planning Engineer at the CITGO Corpus Christi Refinery (CCR), developing and designing process solutions for mid-to-large capital projects across the facility. He has 15 years of industry experience in petroleum refining, and has worked as a process engineer for several key refinery processes, including delayed coker, sulfur plant and amine treating systems; a crude/vacuum unit; several MEROX units; and several hydrotreaters. He has held various subject matter expert (SME) roles in corporate technology teams that aim to synergize the sharing of process knowledge across CITGO's operating facilities. He was part of a team that recently improved the sulfur removal capacity of CCR to satisfy more stringent Tier 3 gasoline emissions standards. As part of that effort, three of CCR's MEROX units were expanded and CCR's gasoline hydrotreater was revamped to accommodate 25% more charge. Mr. Gamboa-Arizpe holds a BS degree in chemical engineering from the Massachusetts Institute of Technology.

Michael Federspiel, W. R. Grace & Co., is a Chief FCC Technologist in Grace's global customer technology group. Based outside of Chicago, Illinois, Mr. Federspiel provides support for Grace customers in the Americas, Asia and the Middle East. He has more than 19 years of experience in FCC design, development, commissioning, technical service, operations management, and catalyst sales and service. He earned a BS degree in chemical engineering from the University of Wisconsin–Madison.

Darin Foote, CHS, is an Operations Superintendent at the CHS Inc. refinery in Laurel, Montana. In addition to his role in operations, he has held roles in refinery LP modeling and process engineering, and managed a 2-MM-hour, site-wide turnaround. Mr. Foote has spent 17 years working in the areas of crude/vacuum, FCCU, solvent extraction and fired heaters. Prior to joining CHS, he worked for Flint Hills Resources and John Zink Co. in various roles. He earned a BS degree in chemical engineering from Brigham Young University in Provo, Utah.

Errol Johnson, Motiva, is the process engineering Team Lead for Motiva Enterprises in Port Arthur, Texas. His responsibilities include supervising process engineers who provide technical support to all hydrocracking, hydroprocessing, reforming and base oil units for the site. Previously, he worked for Valero Energy as a Process Engineer covering a wide range of petroleum refining areas. Mr. Johnson earned a BS degree in chemical engineering from the University of Texas A&M–College Station and an MBA degree from the University of Texas A&M–Corpus Christi. He has more than 12 years of experience in the petroleum refining industry.

Bryan Kinderman, Clariant, has served as Clariant's Sales Director for the refining business, responsible for North and South America, since 2015. Previously, he worked for UOP for 15 years. Mr. Kinderman has been working in the refining industry for 28 years across multiple businesses in the oil and gas industry, from upstream drilling, midstream and refining. He graduated from the Colorado School of Mines in 1989 with a BS degree in chemical engineering, and earned an MBA degree from DePaul University in 2000.

Eric Légaré, Andeavor, is Process Development Manager at the Andeavor Martinez Refinery in Martinez, California. He is responsible for the development of refinery capital projects that support turnarounds, regulatory, income and sustaining projects, as well as developing new project management tools to improve the efficiency of the FEL process while promoting stakeholder engagement in the project development process. Prior roles during his 12 years with Andeavor include supervision of the refinery's operations engineers and management positions in process engineering and operations. Mr. Légaré has 24 years of industry experience, and holds a BEng degree in chemical engineering from McGill University in Montreal, Canada.

Darwin Logerot, Prosys Inc., is a Senior Consulting Engineer at ProSys Inc., a global process control software and engineering consulting firm located in Baton Rouge, Louisiana. Since joining ProSys in 2006, he has become one of the company's leaders in the areas of state-based control, alarm management and model predictive control. Prior to joining ProSys' consulting team, Mr. Logerot had more than 30 years of experience in the process chemical industry in a variety of chemical engineering roles, including process design, operations and project management. He has had successful tenures at companies such as Exxon Chemical, Ethyl Corp. and ENGlobal Corp. Mr. Logerot graduated from Louisiana State University in Baton Rouge with a BS degree in chemical engineering in 1973. He earned his Professional Engineer (P.E.) designation from the Louisiana Professional Engineering and Land Surveying Board in 1981.

Sarah Long, Navajo Refinery, is a process engineer for HollyFrontier Navajo in Artesia, New Mexico. She holds a BS degree in chemical engineering, with an emphasis in biological engineering and mathematics, from Texas Tech University.

Alex Maller, Technip

William Ross McDaniel, KP Engineering LP, is a Senior Process Engineer at KP Engineering LP. He has 14 years of professional experience focused on consulting refineries on crude, vacuum and hydrotreating revamp projects. His experience involves all levels of front-end design, including conceptual/feasibility studies, refinery optimization studies and feed studies leading to EPC projects. Additionally, his experience includes assisting clients directly with turnarounds, new startups and small projects onsite. Mr. McDaniel received a BS degree in chemical engineering from the University of Lamar, and is a registered Professional Engineer in the state of Texas.

David Pappal, Valero, began his career in the refining industry, joining Mobil Research and Development Corporation in 1974, where he worked for 27 years in a variety of research, development and technical support assignments. Prior to Mobil's merger with Exxon, Mr. Paooal lead the R&D, equity technical support, and technical and marketing support

for hydroprocessing licensing activities at Mobil. After leaving Mobil, he joined Akzo-Nobel Catalysts as Worldwide Development Director for hydrocrackng catalysts, where many new hydrotreating and hydrocracking catalysts were successfully deployed in the industry. Upon joining Valero in September 2003, Mr. Pappal was promoted to Refinery Technology Director in the strategic development and technology section in San Antonio, Texas. His responsibilities included technical support for Valero's hydrotreating and hydrocracking assets, with a particular focus on the implementation of technology from idea inception through commercial unit startup. Tier 2 and Tier 3 gasoline compliance projects, ULSD implementation and strategic projects commercializing hydrocracking technology were successfully completed. A major accomplishment was the design, construction and startup of two world-scale, two-stage distillate selective hydrocrackers.

Ramamoorthy Ramachandran, Bharat Petroleum, is Director (refineries)—and a member of the board—of Bharat Petroleum Corp. Ltd. (BPCL), a Fortune Global 500 company and one of India's leading oil companies, with a significant presence across the entire petroleum value chain. Prior to his present role, Mr. Ramachandran was the Managing Director of Bharat Oman Refineries Ltd. a JV company with Oman Oil. He has more than 35 years of experience in refinery operations, projects, technical services, corporate affairs and ERP. As Director, he is also responsible for overseeing the JV and subsidiary companies of BPCL in the refining business, as well as its R&D, international trade, pipelines, central procurement organization and group refineries information services.

Alexander Sabitov, Phillips 66, is the Senior Reforming and Isomerization Engineer for Phillips 66's refining business improvement group. He provides day-to-day technical support for the reforming, isomerization, aromatic extraction and S Zorb process units, and leads the development of short- and long-term opportunities to maximize returns by improving naphtha processing assets. He began his career with UOP in 1996 as an R&D Development Engineer, and worked in various functions with UOP technical services and naphtha technology business development departments until joining Phillips 66 in 2015. Mr. Sabitov graduated with an MS degree in chemical engineering from Ufa Oil Technological University in Russia.

Lyle Schoellkopf, Advanced Refining Technologies

Kyle Sharon, Valero Energy

Kevin Solomon, Athlon

Patrick Sugg, UOP, has 23 years of service at UOP, and serves as a Services Manager for multiple US sites. He has made contributions across the project lifecycle, from technology development and engineering to commissioning and ongoing service support. Mr. Sugg's technical focus has been on petrochemicals and reforming units that utilize continuous catalyst regeneration systems.

JEREMY THEISS, MARATHON PETROLEUM, has been a Technical Service Manager for Marathon Petroleum Corp.'s Detroit, Michigan refinery for two years. He has 15 years of experience in the refining industry working in various roles for Marathon Petroleum. His previous roles include Process Engineer, Operations Supervisor, Economics and Planning Engineer, and Product Control Manager. Mr. Theiss earned a BS degree in chemical engineering from the University of Cincinnati.

Steve Tragesser, KBR, has 33 years of industry experience, 26 of which have been with KBR. In his role as Chief Technology Engineer, he is responsible for the implementation of technology on FCC and alkylation projects, including grassroots and revamps. His other roles at KBR have included FCC Technology Manager, supporting marketing efforts for FCC grassroots and revamp projects. He also worked in FCC technical service, providing troubleshooting and startup support on grassroots and revamp projects. Mr. Tragesser has participated in more than 23 FCC grassroots and revamp startups, and has worked in FCC process design for many grassroots and revamp projects, as well as studies. He previously worked at Stone and Webster as Technology Manager, and for Akzo Nobel (Albemarle) early in his career. He earned a BS degree in chemical engineering from the University of Texas in 1984.

Process engineers, discrete entities and the nature of reality

RAVI AGLAVE, Siemens PLM

Some of the most significant discoveries in the 19th and 20th centuries pointed to very similar observations in numerous fields: every quantity that appeared to be continuous was discovered to be discrete. Light consists of photons; matter is comprised of atomic and sub-atomic particles; the energy levels of electrons consists of quantas; digital information flows in bits; and even hereditary information is transferred in smaller discrete units called genes. Most scientific efforts revolved around building the nature of reality from such discrete elements and their transport. Developing fundamental models for discrete behavior provided the necessary understanding and tools to recreate the apparent continuity in the observable phenomenon.

Particulate materials—consisting of such discrete units or elements—are very common in the chemical and process industry. While designing or troubleshooting equipment, an understanding of the bulk behavior of particles is needed. Such reality can be built by using models based on the fundamental behavior of particles. Joseph-Louis Lagrange gave us the framework of looking at flow from a different frame of reference, which was essential in the development of solutions of such discrete flows (**FIG. 1**).

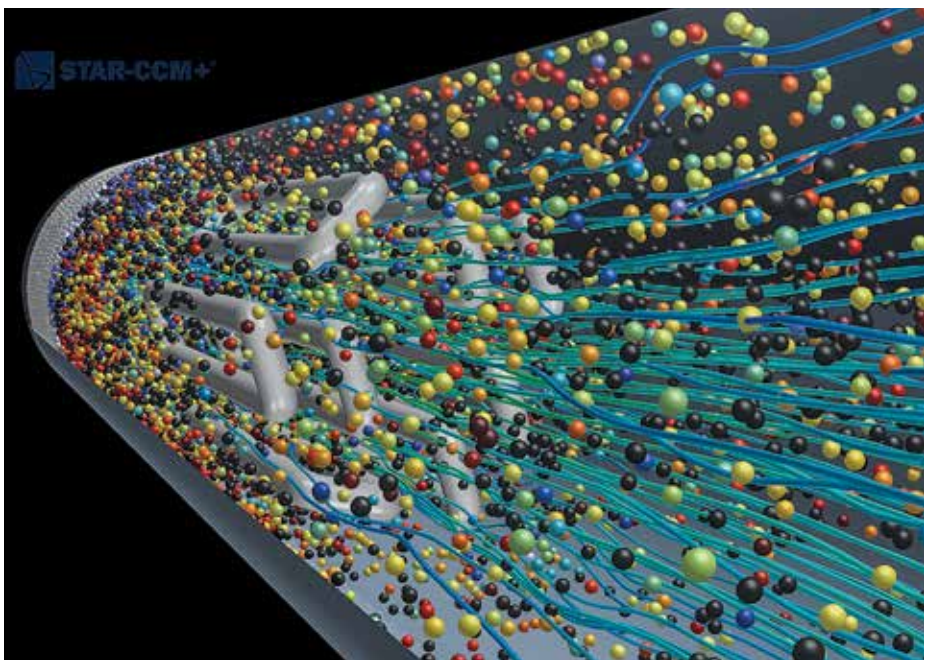


FIG. 1. Designing or troubleshooting equipment can be improved by using models based on the fundamental behavior of particles.

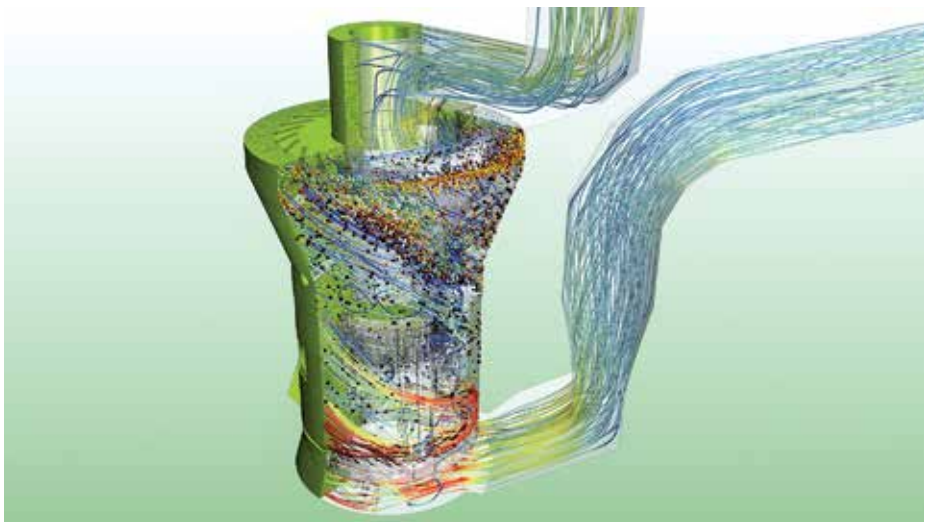


FIG. 2. Particle flow simulation in a coal mill classifier with STAR-CCM+. (Image courtesy of Aerotherm)

Of course, numerous other scientists contributed by including complex physical behaviors such as momentum, mass and energy transfer with surrounding fluid, friction, collision, drag, wetting and cohesion with other particles as well as erosion, and abrasion or boundaries. Deriving from the basis of molecular dynamics, the discrete element method (DEM) has made several advances in recent years to emerge as a prominent numerical analysis method of industrial equipment.

An integrated environment. Traditionally, designing particulate processes involved thumb rules and expensive experimentation, leading to processes that were not fully optimized for maximum life, distribution and efficiency at a low-energy usage and cost.

A solution has been developed that is the first to have full integration of flow and particulate modeling from within a single integrated environment. For lean particle flows, Lagrangian modeling methods are available in STAR-CCM+® software from Siemens PLM Software, while the Discrete Element Model (DEM) handles denser flows. Process engineers can now use a single tool to simulate realistic, non-spherical particle shapes of varying sizes, accurately model particle motion and contact, utilize compatibility with other advanced physics models and reduce expensive testing, all with a single license and from a single graphic user interface (GUI).

The Lagrangian particle model (LMP) solves discrete phase trajectories through a continua for low-particle volume fractions predicting the turbulence effect on dispersion where contact mechanics are not important. The DEM, on the other hand, accounts for collisions, cohesion, adhesion, custom contacts, particle shapes, granular flow properties and particle-particle interactions. Depending on application and modeling needs, a one-stop tool is now available to better understand particulate flows.

Many companies are deploying this unique capability and reaping the rewards, including:

- Coal Milling Projects (CMP): In partnership with Aerotherm, CMP recently maximized the throughput of pulverized coal to their burners while reducing pressure drop using simulation. The lower operating cost of the resulting fan design and the reduced wear from the particles (**FIG. 2**) resulted in a 21% average throughput improvement and an increase in maximum throughput from 22 tph to 30 tph. With this, CMP improved the existing design, resulting in improved mill product output, lowered fan resistances, reduced internal wear and air heater leakages, and lower power consumption.
- ArcelorMittal: In partnership with Aerotherm, ArcelorMittal reduced erosion by 30% in particle separators in its steel plant. By using the DEM technology to create a digital twin of the ash extraction unit in a steel plant, the location and severity of erosion were accurately predicted and the design was modified.

These examples show the benefits of a coupled DEM-CFD and/or the Lagrangian approach to designing particulate flow processes. Taking this one step further, the in-built Design Manager in STAR-CCM+ and design exploration tool HEEDSTM software help engineers use intelligent search algorithms to automatically explore the design space and determine better process designs and solutions more quickly. With such tools available, there has never been a better time to be a process engineer. ●

Monday morning's New Manager Morning Mixer is both a breakfast and informal networking event for those who are in, or will be assuming, new managerial and supervisory roles.

AFPM FEATURED EVENT: NEW MANAGER MORNING MIXER

AFPM is excited to introduce a new event this year: the New Manager Morning Mixer, held Monday morning from 7–8 a.m.

This is a new event for those who are about to or have just entered into a formal supervisory or managing role. Whether you are comfortable and well-trained or nervous and have lots of questions, come meet like-positioned peers who can share with you their experience and help you boost your team's performance.

This new manager networking session is a breakfast with both informal networking and a "speed networking" event that centers around an activity called, "How would you handle…?" In that event, attendees will be paired off and given some prepared questions and perhaps answers to those questions. The questions should be some that a new manager/supervisor is likely to face, and for which they may not have been well prepared.

For example, "How would you handle an employee that chronically calls in sick?" The answers can be serious—such as, "Have a discussion with the employee expressing your concern over their health"—or they can be not-so-serious—such as, "Buy the employee a case of chicken noodle soup and give it to them during their next performance review." Or, they can be both. While interesting, answering the questions is not the goal of the session: the most important part of this event is to get people talking to each other and building their networks. As new managers, they probably don't have the answers!

The new event is open to those who have been managers/supervisors for 5 years or less and those who will become managers/supervisors in the next year. We look forward to seeing you Monday morning! ●

Five unique ways to improve revamp projects

MAUREEN PRICE, Fluor

As refiners and petrochemical companies are challenged to deliver improved results with reduced budgets, the industry is becoming more open to innovation and ideas that improve productivity and predictability.

While state-of-the-art technology is important, harnessing the knowledge of industry subject matter experts (SMEs) to examine challenges with a fresh perspective is just as vital. A minor investment in time can result in major cost and schedule savings, as evidenced in these five case studies:

1. **Support scope modifications.** On a recent revamp project, using Fluor's distillation expert, Henry Kister, for oversight and guidance, Fluor made simple but effective improvements to improperly configured hot vapor bypass controls for tower pressure in two separate columns (a depentanizer and a debutanizer). These relatively modest scope modifications resulted in significant operational benefits, including improved stability and product quality.
2. **Remove existing system constraints.** Revamps are often constrained by existing overpressure protection and relief systems. Fluor leveraged Jesus Cabrera's expertise in relief system design and dynamic simulation modeling to evaluate and eventually validate the performance of an existing relief valve for future conditions, saving potentially $1 MM in costly flare system retrofits and avoiding new permitting requirements (**FIG. 1**).
3. **Maximize utility of existing equipment.** Revamps require ingenuity and innovation to get the most utility out of existing equipment with the least capital investment. Stan Lum, a hydrotreating technology expert, helped configure a revamp of the preheat system upstream of a naphtha light hydrotreater. This approach allowed heavier boiling-range feedstock to be processed without needing to retrofit the fired heater or expand the heater permitted duty, reducing the cost and schedule.
4. **Take advantage of industry standards.** Developing custom designs can create unnecessary delays in fabrication and cost. On a recent project, mechanical SMEs performed a detailed elastic/plastic finite element analysis. This analysis confirmed that the vendor-fabricated injection compressor with a wall thickness below the design minimum was acceptable for full design pressure and full corrosion allowance. This approach avoided a seven-month project delay.
5. **Take a hard look at "requirements."** On a recent project, a contractor needed to demolish 30 tanks and stated that the cracks in the tanks needed to be repaired prior to lifting and demolishing the tanks. Fluor SMEs were engaged and proved that the tanks could be lifted and demolished without repairing the cracks, resulting in a cost savings of $100 MM.

These are just five of the countless examples of SMEs delivering value for this industry. This conference provides a valuable opportunity for the industry to come together and share best practices and improvements. Harnessing the knowledge of the industry's SMEs will position the refining and petrochemical industry for success in years to come. ●

FIG. 1. Validating the performance of an existing relief valve system saved $1 MM in flare system retrofits.

New revenue stream for refineries will come from excess fuel gas

by Jens Michael Poulsen, jemp@topsoe.com, Haldor Topsoe

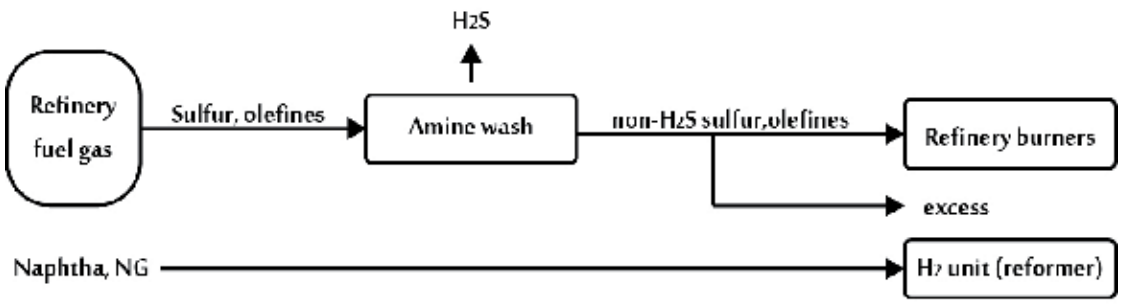


Fig. 1 Conventional fuel gas system

Sour Refinery fuel gasses (RFG) are considered low-value gases composed of off-gases from a variety of sources within the refinery. They are problematic due to their composition containing high levels of sulfur species and olefins which makes them an environmental liability.

In a conventional RFG system, see fig. 1, an amine wash will remove H_2S, but does not extract the 100's ppm of other sulfur species. Also, a hydrogen reformer cannot accept several % olefins.

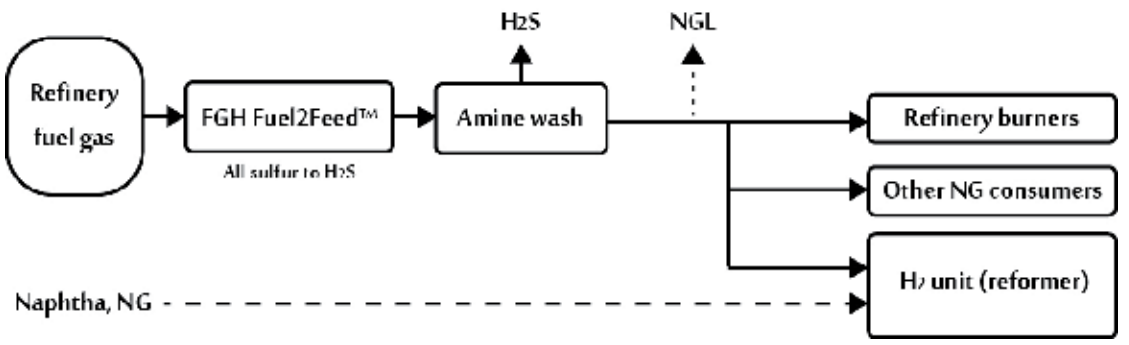


Fig. 2 Hydrotreating concept for desulfurization of sour fuel gases

Refinery industry trends such as:

- regulations for low sulfur gasoline and diesel,
- reduced sulfur bunker fuel,
- more heavy and sour crude regulations,

clearly indicate that RFG are growing in volume.

The fuel gas system can however easily be modified to purify the gasses, resulting in low sulfur emissions and value-adding hydrogen feedstock.
A hydrotreating (HDT) concept for desulfurizing extremely sour fuel will turn your refinery fuel gas, not only into clean fuel, but also bring it to a level where it can be used as valuable feedstock for catalytic production of hydrogen, methanol, support fuel for Claus sulfur units or other consumers of sulfur-free alkanes ◘

SPONSORED CONTENT

Improve visibility, increase profitability with planning and scheduling

PATRICK GARRETT, AspenTech

Planners and schedulers must navigate unpredictable and risky environments. The ongoing period of crude oil price volatility is an example of the new normal, accompanied by fluctuating feedstock pricing, hyperactive commodities trading, extensive currency movements, and acute shifts in demand and supply patterns. To ensure optimal performance, companies must focus on operational excellence and build flexibility into their operating plans. One way to do this is through planning and scheduling technology.

Global shale plays have increased the range of options for refiners. According to Rystad Energy, the US is now home to more oil reserves than Saudi Arabia or Russia. Depending on the source, new feedstocks can be lighter or heavier than crudes that are traditionally used, requiring changes in refinery configurations. Fortunately, planners and schedulers now have access to technology that optimizes existing assets. Advanced software helps navigate complex decisions, and accurate planning and advanced scheduling tools ensure that margins can be maintained despite numerous changes and challenges.

Understanding the plan. Most refineries (FIG. 1) operate within relatively thin margins, meaning that any error can be detrimental to profitability. Decisions must be made with a mathematical optimizer as the only way to adequately represent a very complex reality. By adopting the following best practices, planners can achieve optimal results:

Planning with sustained profitability in mind. This includes selecting the correct parameters from the hundreds of plant and market variables to create a model that takes into consideration factors such as prices, yield, energy consumption and other economic drivers. Typically, this map would be a linear program model to represent the complexity of real refinery and/or olefins operations.

Solving the optimization problem reliably. Once the model is built to the right level of accuracy, including non-linear relationships, the tool must be tested. New features in some advanced optimization programs allow planners to detect false positives (local optima) by solving cases from a number of starting conditions. This greatly increases confidence in the results and prevents lost profits by avoiding local optima.

Analyzing the solution for robustness. The largest barrier to implementing contingency planning lies in running the vast number of cases it requires. The best companies in the industry are investigating the use of cloud computing to test more cases in less time. For example, a leading refining company in the Asia-Pacific region was able to solve 800 cases in 90 min. with advanced optimization and multi-core processing. This resulted in a major advantage over the competition, as this process would previously take up to 36 hr.

Building the schedule. The refining industry is relatively unpredictable by nature, and schedulers are faced with stricter product specifications, market and regulatory requirements that can impact profit margins. Having a comprehensive, refinery-wide schedule can lead to significantly more stable operations and reliability. One US refining company reported that it reduced operational target changes by 70% in its refineries that used scheduling technology.

The first step to achieving this is through a collaborative environment. By bringing all schedulers and their activities onto a single platform, refiners can streamline their workflow and achieve a greater view of the entire petroleum supply chain. Scheduling automation software enables crude and product schedulers to work from the same schedule. This enhances communication between functions and improves visibility into the refinery's activities, which can ultimately increase profitability.

Organizations that implement best-in-class scheduling technology often find their teams empowered to make decisions faster and have more time for improvement projects. With the planning and scheduling software, refiners can run different scenarios, which allows them to make the best decisions on how to run the refinery during disruption, and provides them with the tools to return to ideal operations quickly. Schedulers can also compare plan and schedule results vs. actuals to better understand where production gaps exist.

Finally, schedulers should have an advanced blending solution available to maximize margins and reduce product quality giveaway. The purpose of any refinery is to refine crude into different blendstocks that are eventually blended into saleable products, such as distillates, gasoline or fuel oils. As blend complexity increases and additional constraints are introduced, having the right tools is crucial for schedulers to create an optimal blend recipe.

A tall order, but not impossible to fulfill. With change as a constant, the shortage of experienced workers in the refining and petrochemical industries is a growing concern. A crucial need for leaders with diverse business experience drives many companies to rotate new engineers and managers through planning and scheduling roles. Proficiency with best-in-class planning and scheduling technologies are mandatory for refiners to be competitive. With the right innovation, refiners can now improve visibility across the entire petroleum supply chain and increase profitability. ●

FIG. 1. Best-in-class planning and scheduling technologies improve visibility across the entire petroleum supply chain and increase profitability.

EIA: Changing quality affects decisions

According to a recent report by the US Energy Information Association (EIA), growth in global liquid fuels supply since March 2017 has been driven by increases in the production of historically higher-priced light crude oils. This growth has more than offset recent declines in the production of medium and heavy crude oils. As these production trends continue, price differences between certain crude oils are narrowing, and refinery operation decisions are changing.

When comparing the qualities of different crude oils, two of the most important attributes are sulfur content and density (**FIG. 1**). EIA defines crude oil with less than 1% sulfur as sweet and crude oil with greater than 1% sulfur as sour. Density is measured in API gravity, an inverse of the petroleum liquid's density relative to water. API gravity ranges from heavy, or high, density (less than 25° API) to light, or low, density (greater than 35° API). On the US Gulf Coast (USGC), the premium for Louisiana Light Sweet (LLS) crude oil over heavy Maya crude oil from Mexico narrowed from $9/bbl in March to $5/bbl in August. In the Midwest, the premium for light crude West Texas Intermediate (WTI) over heavy Western Canada Select (WCS) also narrowed from $13/bbl in March to $10/bbl in August.

Differences in sulfur content also affect the price of crude oil and where it can be processed. Sour crude oil requires more complex refinery processing to meet low-sulfur fuel specifications and to avoid damage to refinery units.

Processing heavy-sour crude oil requires additional refinery units—including crackers, cokers and hydrotreaters—to yield light products. These additional units increase refinery complexity, but also allow the refiner more flexibility to select types of crude oils to purchase and run through their refineries.

Because the price of crude oil and refinery complexity are major factors that affect profitability, a wider price differential between heavy and medium crude oils and light crude oils benefits more complex refineries. In 2017, the price differential between medium and heavy crude oil and light crude oil has gotten smaller, reducing the competitive advantage of some more complex refineries, the EIA report says.

Voluntary production cuts from OPEC members since November 2016 have reduced the global supply of medium- and heavy-quality crude oil. In addition, crude oil production outages in Canada and declines in production from Mexico and Venezuela are further reducing the total amount of medium and heavy crude oil available to refiners.

Much of the increase in US crude oil production has come from shale formations in the Lower 48 states, which contain primarily light-density crude oil.

As the relative availability of light and heavy crude oils has changed, price spreads between light and heavy crude oils have narrowed. Relatively light crude oils are typically priced higher than heavier crude oils, because light crude oils require less refinery processing to produce high-value products, such as gasoline and diesel. Lighter crude oils are also considered more valuable because not all refiners have the equipment necessary to process heavier, denser crude oils. ●

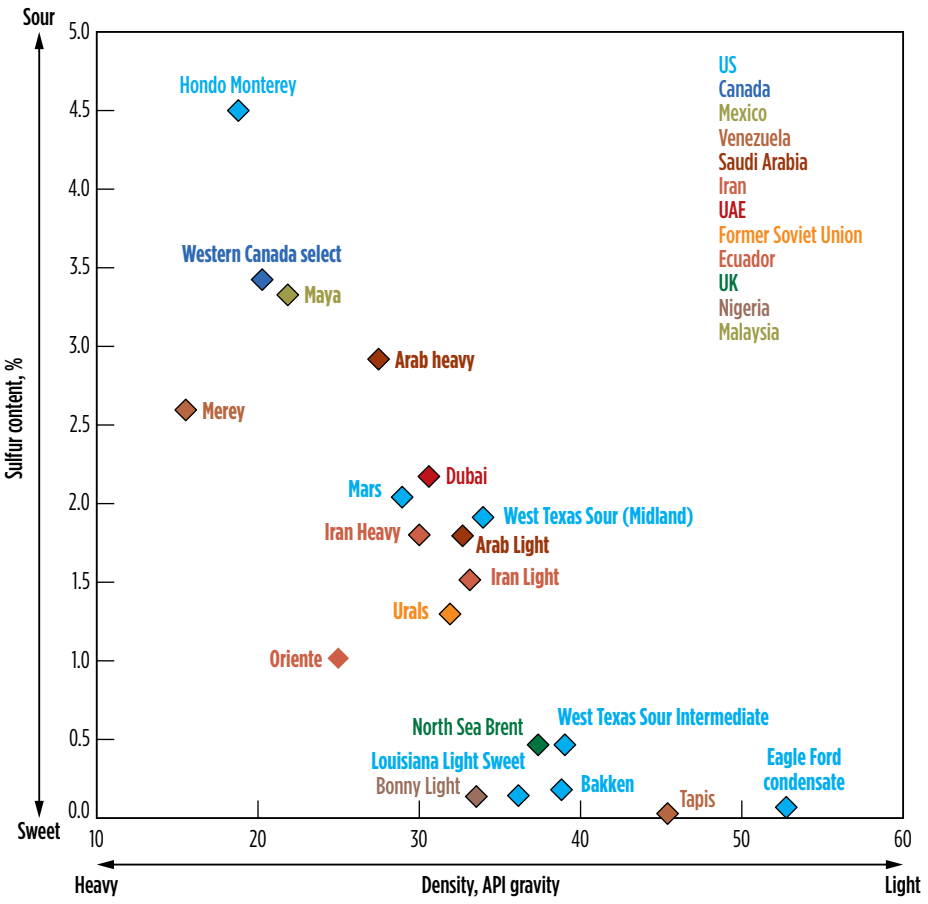


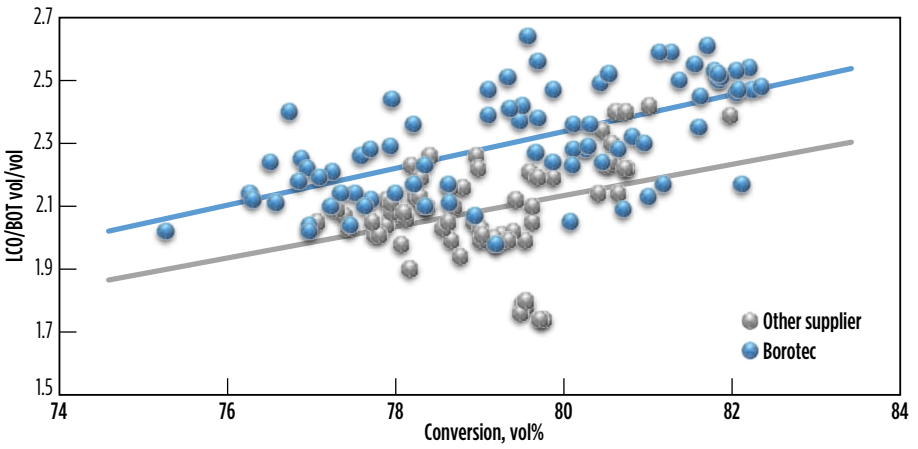
FIG. 1. Density and sulfur content of selected crude oils, %.

Improve FCC yields from contaminated feeds using boron-based nickel passivation

KITTY CHA, BASF Corporation

The drive to improve refinery margins leads to the processing of heavier, more contaminated crude. Consequently, the presence of contaminants in fluid catalytic cracking (FCC) feedstock is also increasing. One of the contaminants, nickel (Ni), deposits on the FCC catalyst and catalyzes dehydrogenation reactions, producing unwanted hydrogen (H_2) and contaminant coke. These effects typically diminish the profitability and operability of the FCCU. So, strong demand exists for improved Ni passivation technology. Nickel passivation is especially beneficial when the FCCU operates at the wet gas compressor (WGC), the regenerator temperature limit, or the air limit. By alleviating these constraints, a substantial increase in profitability is immediately possible by increasing either the FCCU throughput or the severity. Ni's effect can be reduced using passivators (such as antimony or specialty alumina) or, more recently, boron-based technology.

FCC Ni passivation technologies. Nickel passivation using antimony (Sb) compounds has been in use for more than 40 years. It has been shown that Sb injection alone can reduce the dehydrogenation effect of Ni by 20%–40%. After injection, an immediate, sharp reduction in dry gas production and delta coke is typical. Apart from passivating Ni, Sb can also poison carbon monoxide (CO) combustion promoters and increase nitrogen oxide (NO_x) emissions. The Sb pickup by the FCC catalyst can vary depending on several factors, impacting its effectiveness on Ni passivation. Furthermore, the use of Sb is not permitted in some FCCUs due to environmental and safe handling concerns. For most FCCUs that can use Sb, further passivation of Ni is still needed.



	Base/Another supplier	Borotec	Delta
Conversion, wt%	80	80.5	0.5
LPG, wt%	16.9	17	0.1
Gasoline, wt%	54	54.5	0.5
LCO, wt%	14.2	13.9	-0.3
Slurry, wt%	5.9	5.6	-0.3
LCO/slurry, wt/wt	2.4	2.5	0.1

FIG. 1. Borotec FCC catalyst delivered significantly improved bottom conversion and liquid yields.

Specialty aluminas are a commonly used option in residual FCC catalysts for trapping Ni by keeping it in a higher oxidation state, reducing overall H_2 and contaminant coke production. The efficacy of this route is limited by the very low mobility of Ni and the immobile nature of the alumina trap. It is known that Ni deposition on residual FCC catalysts typically follows a gradient, where higher amounts of Ni accumulate on the outer stages of the catalyst particle. Since Ni tends to be concentrated on the peripheral surfaces of a residual FCC catalyst, it can be trapped by alumina only within sufficient proximity. Therefore, the lack of mobility for both alumina trap and contaminant Ni within the catalyst particle limits alumina's ability to passivate Ni. BASF set out to develop the next generation of Ni passivation technology.

Boron-based technology. A unique solution to passivate Ni using boron chemistry is the heart of BASF's Boron Based Technology (BBT) platform. Multiple spectroscopic studies have shown that by using boron-based technology, Ni can be kept in a more electron deficient (i.e., less reducible) state, inhibiting its potential to participate in dehydrogenation reactions and lowering the formation of H_2 and contaminant coke. BBT also presents additional benefits. Unlike Sb, boron does not increase NO_x emissions in the FCCU. As boron is mobile under FCC conditions, its efficacy in Ni passivation is greater than that of specialty alumina, as it migrates within the catalyst to passivate Ni.

In 2016, BASF introduced BoroCat™, the first FCC catalyst based on the BBT platform. Since then, BoroCat has been successfully implemented in refineries all over the world. Results have shown that refineries using BoroCat can process heavier, more contaminated feedstocks and improve their profitability. Building on the success of BoroCat, Borotec™ was launched in 2017 and caters to refiners processing variable-quality or mild- to moderate-resid feedstocks.

At a refinery that processes mild-resid feedstock, Borotec was compared against another supplier's premium bottoms upgrading technology. In this commercial trial, Borotec enabled the refinery to:

- Decrease contaminant delta coke
- Improve activity retention, at similar vanadium and sodium levels
- Significantly improve bottoms upgrading and liquid yields (**FIG. 1** and **TABLE 1**)
- Improve propylene and butylene yields, after catalyst optimization.

While the initial Borotec performance exceeded that of the competitive catalyst, BASF was able to further optimize the catalyst to give higher C_3= and C_4=, resulting in a $0.23/bbl profit improvement over the competitive catalyst. This successful commercial trial verified Borotec's ability to improve performance, leading to higher yields of valuable products and lower bottom-of-the-barrel yields compared to competitive technologies. The improved metals tolerance provided by Borotec allows improved crude flexibility for refiners that engage in crude spot buying to maximize profits.

To date, the ability of BASF's BBT to effectively passivate Ni and improve profitability has been demonstrated in more than a dozen refineries. Borotec, the latest innovation from the BBT platform, provides mild- and moderate-resid feed FCCUs more flexibility in crude selection and increased yields of high-value products.

For more information, and to meet the BASF team, join them at Tables 1 and 2 in the exhibition hall. ●

DRIVE PROFITABILITY THROUGH DATA ANALYSIS

As industry becomes more digitalized, companies have greater amounts of data at their disposal. The challenge is to make this data meaningful and get it to the right people to enable impactful business decision-making. ABB has introduced Collaborative Operations, the newest part of the ABB Ability™ service offering. Using the ABB Ability capability and Cloud infrastructure, Collaborative Operations offers true data-driven solutions by providing remote connectivity, secure access to process performance information and technical support, enabling companies to collect data, apply predictive analytics, and generate insights that can help drive profitability.

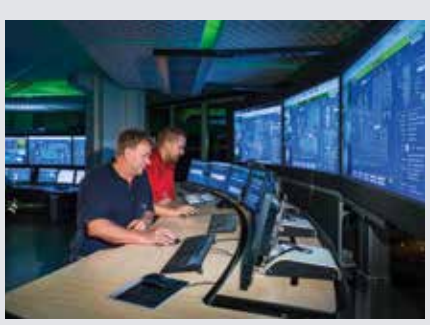


FIG. 1. ABB experts and customers collaborate to make data-driven decisions in real time.

Field devices are installed to gather data, and analytics are applied to quickly identify, categorize and prioritize issues. Common communications protocols are established between customer sites, ABB technical centers and customer headquarters for further financial analysis and for use in decision-making processes.

Collaborative Operations brings together people, products, solutions and services to provide analytic intelligence that can improve efficiencies and reduce risk, enabling a digital business transformation.

It also enables users to securely integrate and aggregate data from multiple sites. This data is automatically analyzed and continuously monitored by both customers and ABB experts in connected Collaborative Operations centers (**FIG. 1**).

ABB gives personnel and asset safety and reliability the highest priority. Data connections must be safe, but the value of that data should also be protected. Rather than forfeit safety, value or control to realize the benefits of digitization, ABB Ability meets these needs with an innovative, multi-layered approach to security. ABB pursues digital security innovation via its Group Cyber Security Council, and participates in standardization efforts such as Plattform Industrie 4.0 and Industrial Internet Consortium.

In addition to monitoring, the platform provides immediate access to high-level technical experts to quickly resolve issues. ABB experts and customers work in close collaboration, making data-driven decisions in real time to increase operational performance and business profitability.

Processes to avoid repeating the same problems can be developed and replicated, enabling the financial impact to be realized across the entire enterprise. ●

AFPM is "keeping Austin weird"

The slogan, "Keep Austin Weird," has grown from an urban catchphrase into an underlying, unspoken attitude that has been adopted by the city's vibrant and welcoming community. Austin is different from the rest of Texas (and the rest of the country), from its place as the self-proclaimed "live music capital of the world" and world-class restaurants, to its diverse population of cultures, political leanings and lifestyles.

The capital of Texas is one of the fastest-growing cities in the country, as new residents and visitors flock to the hill country for some of the best entrepreneurial conditions outside of Silicon Valley, great weather and an outdoor lifestyle. The hiking, biking, swimming, boating, running, triathlon and beer-drinking, river-floating communities are especially strong. Austin also features a collection of breweries and BBQ joints that rival any in the country.

Settlers founded the village of Waterloo on the banks of the Colorado River in 1837, following the establishment of the Republic of Texas. Two years later, it was renamed Austin after Stephen F. Austin, the "father of Texas," and became the capital. President Lamar's decision to place the capital in such a remote location—and vulnerable to attack by Mexican troops and Native American tribes—was unpopular throughout the new Republic, but he felt that it was a prime location that intersected the roads to San Antonio and Santa Fe. Throughout its early history, the path to statehood, the Civil War, the Great Depression and into the new century, Austin has remained a center of Texas political, cultural and economic turmoil and prosperity.

Austin offers so many things to do, see and experience. The city's arts scene is known for its creativity and is home to world-class museums like the Blanton, with the nation's largest University-owned collection on exhibit; and the Harry Ransom Center, featuring the first photograph and the Gutenberg Bible. Explore the work of designers, painters, sculptors, writers, photographers, filmmakers, dancers and musicians at a variety of venues. Learn about President Lyndon Johnson and Lady Bird Johnson at the interactive LBJ Presidential Library.

The city also features numerous activities for the adventurous visitor: The Escape Game Austin, the IFLY Austin indoor skydiving facility, bike tours, city-wide scavenger hunt adventures, and (in keeping with the "weird" theme) Bat Fest, a celebration of the world's largest urban bat colony. Each year, two million Mexican Free Tail bats assume seasonal residence beneath the Congress Avenue Bridge and take to the skies for their nightly flight. Austin's packed yearly events calendar includes: The Austin Marathon, which draws 20,000 runners from around the world; the Austin Food + Wine Festival, showcasing the city's innovative cuisine; and countless music festivals, including the Austin City Limits Music Festival, which welcomes 70,000 fans per day to Zilker Park for performances by more than 100 bands.

The city is proudly eclectic, and it doesn't take long for that spirit to spread to its visitors. Austin welcomes AFPM with open arms, and we invite you to get out and soak up the sights, sounds and smells of one of the most interesting places in the country. ●

FIG. 1. Bands like Ben Harper and the Innocent Criminals make Austin the "live music capital of the world." Image courtesy of Austin Music Source.

FIG. 2. The Austin skyline at night.

Increasing amine system H_2S and CO_2 recovery efficiency

MASSIMO CAPRA, Aggreko Process Services, Europe

A common and critical operation at all refineries is hydrogen sulfide (H_2S) removal from hydrogen (H_2)-rich streams. This operation is performed as part of hydrotreating processes seen with hydrocrackers (HDC) or hydrodesulfurization (HDS) units, as well as with natural gas sweetening units. The liquid-gas effluent mixture from the fixed bed catalytic reactors is characterized by a gas phase containing H_2S, the product of the desulfurization reaction. The H_2-rich gas can be recycled to the reactor only after removal of the H_2S. This operation is performed in a scrubber, where the gas is contacted with an H_2S sequestrating solvent, generally a water solution of monoethanolamine (MEA), methyldiethanolamine (MDEA), diethanolamine (DEA) or diisopropylamine (DIPA).

The solvent is then processed in a reboiled regenerator, where solvent and H_2S are separated to reuse the lean amine in the scrubbing operation, as shown in **FIG.1.**

The H_2S scrubbing efficiency of the sour gas is critical for the desulfurization reaction yield, as well as for limiting the corrosion of the compressor downstream from the scrubber.

It is critical to maintain a low H_2S concentration in natural gas operations due to its toxicity and environmentally polluting combustion products. Also, carbon dioxide (CO_2) removal is very important to increase combustion heat per scf (standard cubic feet) of natural gas. Natural gas can also supply feedstock for gas-to-liquids (GTL) plants, and achieving low H_2S concentration allows the production of super-clean liquid fuels.

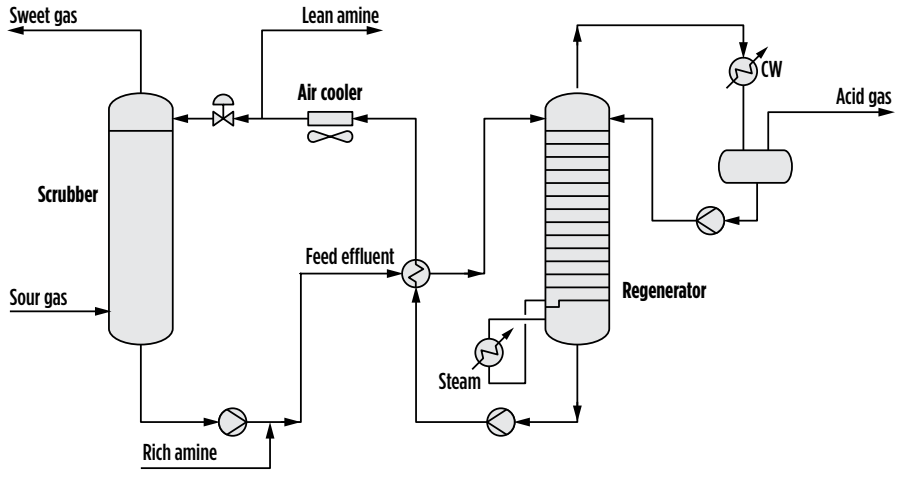


FIG. 1. In a reboiled regenerator, solvent and H_2S are separated to reuse the lean amine in the scrubbing operation.

MEA solutions are the most efficient for H_2S and CO_2 removal, but they are also the most corrosive. The corrosion rate increases when MEA solutions are combined with an H_2S-rich atmosphere, or with amine's oxidation products generated by exposure to atmospheric oxygen.

The resulting iron sulfide (FeS) corrosion product imparts poor passivation qualities to the steel surface exposed to corrosion due to its weak adhesion characteristics, compounded by the abrasive nature of the amine flow. The final result is an accumulation of solid FeS in the liquid stream, making the stream even more abrasive and detectable by a rapid change in amine solution color, which is also an indicator of its status.

Furthermore, considering that H_2S in the recycled gas inhibits the desulfurization reaction, particular attention should be paid to fouling of the lean amine coolers, the regenerator feed-effluent exchanger and the lean amine air cooler. As the concentration of the suspended solids in the lean amine increases, the cooling efficiency deteriorates, resulting in higher-temperature lean amine fed to the scrubber. The cooling efficiency is even worse during hot summer ambient conditions. Foaming, fouling and hot weather conditions amplify one another's effects.

Many factors work against having enough cooling at the top of the amine unit regenerator, including warmer air and warmer cooling water temperatures. The most common overhead cooling arrangement is either a combination of a fin-fan and cooling water exchanger, or just a cooling water exchanger. Either of these exchanger configurations can become limited. When this is detected, additional exchangers can circulate more cooling water through a closed loop mechanical refrigeration system, allowing unit operators to maintain lower tower pressure while fully regenerating the lean amine.

Engineered temporary cooling solutions provide ideal process conditions during critical periods of the year when temperatures average higher, with no production interruption. Additionally, the immediate added marginal value reduces the need for non-productive capital assets acquired to minimize the risk of interrupting production. ●

Protecting automation technology from EMP

FIG. 1. Bedrock Automation has recently been certified for compliance with US MIL-STD-461F, demonstrating that its intrinsically cyber secure industrial control system and stand-alone power supplies can also withstand repeated EMP blasts. The Bedrock UPS.500, shown here, provides an EMP-protected power backup for any control system.

The possibility of an electromagnetic pulse (EMP) knocking out critical infrastructure is of growing concern to global security experts. To ensure that defense technology remains functional in the event of such an attack, the US has established Military Standard 461 (MIL-STD-461F) and International Electrical Commission 61000 (IEC 61000) for EMP resistance. While these standards have been used primarily by defense technology, Bedrock Automation has recently demonstrated compliance for its cyber-secure Bedrock control system and its power and UPS subsystems for use across multiple applications (**FIG. 1**).

When most existing control systems were designed, EMP was of minimal concern. However, it is gaining more attention today, as is concern about lower-level electromagnetic interference (EMI). While some industrial control systems do protect against EMI, Bedrock Automation has designed in EMP protection resistance as well.

The Bedrock control system sought MIL-STD-461F to complement the intrinsic cyber security built into its open, secure automation system. Dayton Brown, an independent military and industrial testing firm, conducted test RS105 for EMP radiated susceptibility on a fully operational Bedrock system. The test involved repeated 50,000 V/m nanosecond EMP strikes to emulate the energy of a high-altitude electromagnetic pulse (HEMP). The Bedrock system performed without error and without consequential damage during and after the test, even after consecutive test runs.

Like its intrinsic cyber security, Bedrock Automation was able to build EMP resistance into its systems at the design phase because it started from a clean sheet of paper. Bedrock engineers achieved both cyber security and EMP protection through the incorporation of numerous detailed design elements. This included the creation and deployment of a pinless backplane, which eliminates the possibility of pins as antennae to absorb and disperse energy.

The Bedrock control system provides secure, high-performance DCS, PAC, PLC or SCADA RTU functionality. The power supplies were designed to provide secure, EMP-hardened power and power backup for the Bedrock system, but they can also be used with any control system. ●

Overcoming the "lost decade" of ICS security

GALINA ANTOVA, Claroty

The last decade in the world of IT network security has certainly presented more than its fair share of challenges and setbacks. Despite the collective failures in that space, major advances in security controls were clearly made. Countless innovations—significant investments in terms of people and money, the birth and evolution of an industry/sub-industries, a proven ability to respond to (although not foresee) emerging threats—indicate a tremendous amount of positives hidden behind the losses.

In the world of industrial control systems (ICS) security (operational technology), despite nearly two decades of discussion around nightmarish cyberattack scenarios and outcomes, the past 10 years can arguably be labeled, "The lost decade of information security in industrial control systems networks."

It can be said that we are no better off today in terms of cybersecurity readiness than we were 10 years ago. The theoretical is becoming reality and, unfortunately, we are not prepared to counter the threat that is just over the horizon (**FIG. 1**).

Encouragingly, in the past two years we have seen an accelerated pace of awareness and prioritization being given to ICS security. The emergence of new startups in the sector, the newly found focus of entrenched security companies, the level of discussion among chief information security officers (CISOs), board members, etc., shows some promise amid an otherwise gloomy analysis. However, all of this new prioritization and awareness have come as a result of an increasing amount of targeted and spillover attacks into this domain. Where did we go wrong?

Failing to "bridge the gap" between IT and ICS (engineering) staff. These teams have made strides in terms of working together, but a lack of solutions built specifically for ICS that do not jeopardize uptime and safety and offer a demonstrable value to both teams has resulted in a closed-door policy in most cases. "I own the shop floor. I need to keep production moving. I need to ensure that nothing fails that could cause safety concerns for our teams or the public. No, you are NOT putting that in my network."

Falling victim to the notion that prescriptive commands/standards can and will be implemented. ICS security focus and developing regulations such as NERC CIP to mandate security controls in this domain are a positive step. However, while standards such as IEC 62443 have done a very good job outlining controls that can be applied, anyone who has done hands-on work on these networks knows that they are not easy to apply. While theoretically the right thing to do, many of these recommendations are simply impractical when considering business requirements. As is the case with virtually all standards/compliance-type regimes, what is intended as a floor too often becomes a ceiling.

Trying to force the "square pegs" of IT security into the "round holes" of ICS networks. IT security tools were not designed for fragile ICS networks. When implemented, approaches like active scanning, active querying and other "standard IT tools" have crashed PLCs, interrupted uptime and caused significant problems. We know of one real-world, recent example where a widely utilized network scanning tool caused an electrical outage.

Delaying investment because these attacks are presently theoretical. Logically, cybersecurity budgets over the past decade have been dedicated to the areas where the bleeding was occurring. This makes sense and we cannot really fault companies for investing this way. However, this "whack-a-mole" approach to dealing with cyberthreats has resulted in woefully underfunded programs for ICS cybersecurity.

Believing that the concept of "air-gapped" networks was ever a reality, or would stand up against business and efficiency demands. Networks have been designed so they cannot be accessed from the outside and without interconnectivity to the IT network. This sounded good for a time, but business demands have eradicated the notion of an "air-gapped" ICS network. Maintenance requirements, connectivity to the supply chain, remote analytics, managing "top floor to shop floor" KPIs, and the desire to drive predictive analytics have seen "air gapping" become all but obsolete.

Maintaining cumbersome, difficult to implement, hard to consume, previous-generation ICS-specific solutions. A number of promising ICS-specific cybersecurity solutions have emerged and failed to gain mainstream traction over the years. Difficulty in implementation (installing a firewall in front of every PLC) and consumption (massive installation projects, significant upfront time to configure), and unwieldy/unrealistic maintenance requirements saw these promises fail. They simply did not understand the unique needs of the ICS consumer.

It can be said that a decade was lost and that the threats are now at our doorstep. Clearly, we cannot afford another 10 years to evolve through the same layered, defense-in-depth strategies that marked the last decade in IT security. We need a revolution.

First, we must stop "studying" the problem. We need immediate focus and investment from government, board rooms, CIOs, CISOs, ICS owner-operators, security vendors and ICS equipment manufacturers on the problems that confront our industry.

We need a reference architecture that delivers the "biggest bang for the buck" and the most rapid increase in security readiness. It should be an easily and rapidly (i.e., months, not years) implementable framework that focuses on risk assessment, real-time monitoring, high-risk vulnerability management, threat intelligence, advanced endpoint protection and rapid response. ●

Galina Antova is the Cofounder and Chief Business Development Officer of Claroty. Prior to that, she was the Global Head of Industrial Security Services at Siemens, overseeing development of its services that protect industrial customers against cyberattacks. Ms. Antova was also responsible for leading its Cybersecurity Practice and Cybersecurity Operations Center, which provided managed security services for industrial control systems operators. Previously, she was with IBM Canada, with roles in the Provisioning and Cloud Solutions business. Ms. Antova holds a BS degree in computer science from York University in Toronto, Canada, and an MBA degree from the International Institute of Management and Development (IMD) in Lausanne, Switzerland.

FIG. 1. With increasing cybersecurity threats on the horizon, the industry cannot afford another 10 years to evolve through the same layered, defense-in-depth strategies.

Pursuing reliability and improved profitability

Kevin Solomon, Athlon Solutions' Engineering & Technical Support Director, is one of this year's panelists for the Q&A Hydroprocessing Sessions. AFPM and *Hydrocarbon Processing* had our own Q&A discussion with Mr. Solomon prior to the Crude/Vacuum Distillation & Coking session to learn more about him, Athlon Solutions and where they see the industry going.

KEVIN SOLOMON is the Engineering & Technical Support Director for Athlon Solutions.

AFPM/*HP*: You are new to AFPM and Athlon Solutions. Tell us a little about yourself and what brought you to the company.

Solomon: Before I joined Athlon Solutions in January, I was an Expert Consultant at McKinsey & Co., where I worked with many organizations to improve their operations. Before that, I worked more directly with the industry: I was a Process Excellence Leader at Hess Corp., a Technical Advisor at GE Water & Process Technologies, and for 23 years I worked as an engineer and business leader for Chevron Texaco.

One of the big reasons I came to Athlon Solutions is because I wanted to have fun. It is not a rigid, process-focused organization. It is nimble, which lends itself to providing innovative solutions for customers.

Despite being a new name to the downstream industry, Athlon Solutions is full of talented people and industry know-how. Fewer boundaries than larger organizations allow for easy collaboration between groups and quick-to-market solutions. In my short time here, I have seen many examples of it and the potential for a lot more. That is exciting and fun.

AFPM/*HP*: Your experience is broad and includes domestic and international assignments. What are the major challenges you see for industrial water and process treatment?

Solomon: From my perspective, it is people, and I think that the challenge of finding the right people spans the entire oil and gas industry. We all know we are in an industry that has huge economic cycles, but we also face the challenge of attracting and retaining talent. The workforce is aging and we are competing with other industries for younger talent that perceive our industry to be not as high-tech, "hip" or glamourous as companies like Google. We must do a better job of showing how important our industry is and how clean it has become over the last 10–20 years.

AFPM/*HP*: What kind of questions will the Crude/Vacuum Distillation & Coking session be addressing this year?

Solomon: We have an excellent panel and great topics, including discussions on safety, coker units, desalting, fouling, corrosion control, vacuum towers and advanced process controls. If I had to pick one theme that ties them together, I think it would be reliability and improved profitability.

The industry is challenged by differing types of crude, and that is increasing with heavier crudes, shale oil and opportunity crudes that refiners are seeing. They need reliable technology to manage the differing physical characteristics, and this means new chemistries, applications and engineered solutions. The industry works with an ever-changing crude slate. Some refiners know how to deal with the changes, and many are just learning to adapt.

The Q&A and Discussion Session on Crude/Vacuum Distillation & Coking will be Tuesday morning from 8–10 a.m. Join the Athlon Solutions team at their hospitality suite Monday night in room 208. ●

UPCOMING AFPM GATHERINGS

AFPM Annual Meeting

March 11–13, 2018 / New Orleans, Louisiana

Don't miss the 2018 AFPM Annual Meeting in New Orleans. The world's premier refining meeting will once again assemble key executives and technical experts from refining and marketing organizations worldwide, as well as representatives from associated industries. Leading industry experts share valuable insights on major issues, including energy and environmental initiatives, and the latest technological developments impacting refining and petrochemical industry management and performance. A new topic has been added: Hurricane Harvey—the lessons learned, hurricane preparedness, crisis management, shutdowns and startup, best practices, and helping our employees and the community.

Turnkey sulfur treatment meets regulatory specs, boosts value

Sulfur removal remains an ongoing challenge for midstream and downstream operators, particularly as increasingly complex sulfur compounds—many that cannot be removed by traditional chemical scavengers—enter the processing stream. Adding to the challenge, the US Environmental Protection Agency (EPA) recently implemented its Tier 3 gasoline sulfur reduction standards, requiring operators to reduce the average sulfur content in gasoline from 30 ppm to 10 ppm.

While the installation of a hydrotreater provides a long-term solution, it also requires years of development lead time and a major capital investment. Other alternatives include purchasing sulfur credits to meet Tier 3 compliance or choosing to process more expensive streams, which avoids more complex sulfur compounds altogether.

Baker Hughes, a GE company (BHGE), has developed a more efficient and economical solution with its EXALT™ sulfur extraction services. Designed to help operators achieve their required sulfur removal metrics and improve product value, the services provide a turnkey, cost-efficient and flexible solution that incorporates a proprietary combination of chemical treatment and mechanical processing.

Collaboration drives success. BHGE representatives first work with an operator's personnel to develop a site-specific extraction solution. This begins with an upfront survey so the team can better understand the system and compositions of the different streams being processed. The analysis results help determine the optimal treatment to meet program objectives.

The services' sulfur extraction chemical technologies are industry proven for removing heavier, complex sulfur compounds more effectively than traditional chemical programs. When it becomes necessary to drive the reaction further and boost extraction efficiency, BHGE partners with Vapor Point to implement patent-pending mechanical solutions in conjunction with the chemical treatment. The mechanical equipment is mobile for easy installation and is leased rather than purchased, which eases CAPEX constraints. This turnkey solution allows for temporary, contingency-based sulfur extraction when existing equipment is down for maintenance or when product volumes fluctuate.

In addition to successfully removing sulfur compounds from light hydrocarbon streams, the services avoid having to sacrifice product value or octane levels simply to reach the required sulfur spec. The solution also frees up existing hydrotreater capacity for more complex production streams, while avoiding the capital and operating expenses associated with installing additional hydrotreater systems.

Proving its potential. Refiners have used the sulfur extraction services to bring their complex process streams into spec, while realizing significant revenue gains. In one example, a US Gulf Coast refinery faced several challenges in producing on-spec naphtha and propane as a result of reactive sulfur contamination. The propane had to be sold at a discount because it failed the D-1838 copper corrosion specification due to the presence of reactive sulfur. In addition, valuable naphtha was being lost into the propane stream, causing the light naphtha to be downgraded.

Reviewing the various solutions to remove sulfur contaminants and bring streams on-spec, the refiner considered installing a hydrotreater. However, the $50-MM capital investment, coupled with ongoing operating expenses, prompted the operator to contact BHGE for an alternative solution that required less lead time and investment.

Following a system survey, BHGE recommended EXALT sulfur extraction services, a combination of sulfur removal chemistries and mechanical equipment designed to improve sulfur-chemical contact efficiency in the propane stream. This comprehensive treatment separated the light naphthas and heavier sulfur compounds, resulting in a new light liquid naphtha stream.

After treatment, results showed more than 98% removal of the total sulfur compounds, including reduced levels of methyl mercaptan, carbonyl sulfide and carbon disulfide—compounds that could not be removed by caustic treatment alone (FIG. 1). This treatment did not affect the characteristics of the product, such as color or volatility, and the propane successfully passed the copper corrosion tests. This solution helped reduce other extraneous contamination, which limited future catalyst and corrosion issues. The refiner was able to increase the overhead rates in an already limited system, thus meeting the Reid vapor pressure (RVP) requirements for the heavier naphtha streams.

EXALT sulfur extraction services delivered a turnkey solution that enabled the refiner to bring the propane stream back on-spec and recover revenue of more than $1.5 MM/month. In addition, the new liquid naphtha stream generated an incremental profit of $3 MM/month. By separating these streams, the refiner debottlenecked the tower capacity, which enhanced overall process efficiency by 20%. Satisfied with these results, the refiner decided not to move forward with long-term plans to install a hydrotreater, thus avoiding a substantial CAPEX investment. ●

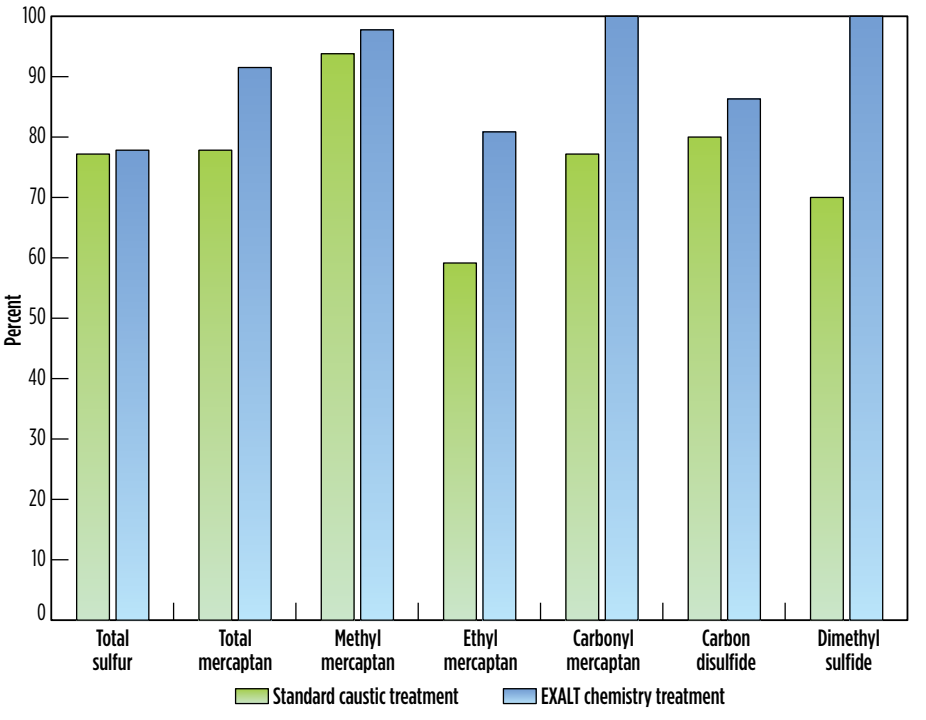


FIG. 1. Sulfur extraction performance.

AFPM CONTINUES TO SUPPORT THE INDUSTRY IN HARVEY'S WAKE

Hurricane Harvey has affected operations at 21 Gulf Coast refineries (representing 25% of US capacity), squeezing supplies and putting upward pressure on fuel prices. While the temporary, lower refinery output reduced shipments, substantial US inventories of refined products have aided in the recovery. The US crude and fuel supply and distribution system is dynamic and resilient, and AFPM commends the industry for its tireless efforts and leadership during these difficult times. We will continue to advocate for the industry that we are proud to represent. ●

What is APC 2.0?

ALLAN KERN, APC Performance LLC

Large-matrix, model-based multivariable control (call it MPC or APC 1.0) has been the dominant advanced process control (APC) technology in industries, such as oil refining, chemicals and petrochemicals, for close to three decades.

The virtues and successes of MPC aside, it has also earned a reputation as an ownership challenge in many areas, including cost, maintenance, support and performance. While MPC may always be the preferred solution in select applications, many end-users have been moving away from MPC as an everyday tool, even if the technology to backfill that gap (call it APC 2.0) has yet to fully emerge.

Experience makes it increasingly clear that industry needs a multivariable control tool that is much more *agile*—more operation-friendly in every respect—to catalyze renewed progress in advanced process automation. Thirty years of the APC 1.0 paradigm have left many companies thinking that large-matrix, model-based, multivariable control and optimization must all go together, and that you cannot have one part without the others. However, experience now shows that alternative solutions are actually quite possible and even readily available within existing modern control system capabilities.

Going forward, the emerging APC 2.0 paradigm will differ from APC 1.0 in key aspects:

- APC 2.0 will feature a matrix, but not necessarily models
- Focus will shift to control-layer automation and business-layer optimization
- Operational performance will become the new norm (after 75 years of Zeigler-Nichols).

Behold the matrix! Probably the most important and enduring contribution of the model-based era to process automation will prove to be the matrix (not models). The matrix has emerged as the natural way to define essential aspects of the multivariable nature of almost any process. It captures available handles, important constraints, useful interactions and optimization potentials in an intuitive format, and serves as a guide to operations and as a specification for automation. The matrix (**FIG. 1**) puts all parts of an operating team (control engineers, process engineers and operations personnel) on the same page to align their efforts for more effective operations. Industry owes a large debt of gratitude to APC 1.0 for bringing the concept of the matrix to the forefront of process operation and automation technology.

Meanwhile, models have proven to be very unreliable, and as much a vulnerability as a strength. Building an APC solution based on model-based control theory front-loads the solution with many ownership challenges. It remains to be seen, after 30 years, whether that burden is sustainable or ultimately outweighs the benefits of using models in the first place. Fortunately, experience and emerging technologies also suggest that models may actually be dispensable to the job of reliable closed-loop control.

Automation rules! In most industrial process operations, the optimization solution (i.e., the target operating point), just like the matrix (i.e., the operating window), is well-known *a priori* by the operating team. Process engineers are likely to make process economics and process interactions the first thing they learn, and operators are unlikely to move up to the console or supervision without learning these operational aspects. This is *common knowledge* among operating teams, so building an optimizer into the APC solution to produce it on a real-time basis is largely superfluous, adding substantially to APC complexity and ownership burdens without adding commensurate new value.

A better paradigm is to let optimization results flow down from the business layer to the control layer, whether via the computer system or the chain of command (this is common, in any case). The business layer has much more of a global optimization horizon (more complete information) and results do not normally change in real time.

The essential role of APC is to honor these optimization results in the live process environment where the related process values (not the optimization targets themselves) are subject to change in real time. This optimization paradigm is more streamlined, eliminates redundancy and enables each layer to focus on its essential role (**FIG. 2**).

Operational control performance. While virtually every aspect of modern process control technology is rooted in the concept of models, it turns out that control performance is one area where industry does not want a model-based solution. Industry wants *operational* performance. This has been another long, slow lesson of APC 1.0, and an even longer one for single-loop PID control!

Operational performance, in a nutshell, means having preset process "speed limits;" approaching targets and constraints in a steady first-order manner; avoiding overshoot and oscillation; and taking extra precautions, where appropriate, to preserve and ensure process stability at all times. This is quite a different statement from, and ultimately directly conflicts with, traditional error-minimization control performance criteria, which is based on process models.

Experience has shown that operators are perfectly willing to sacrifice automatic control—place loops in manual and circumvent (degrade or switch off) APCs—where operational performance is not met. To achieve greater success, APC 2.0, both single-loop and multivariable, must come to grips with *operational* process control performance criteria (**FIG. 3**).

Agility is the word. All of this information suggests a more agile APC 2.0 solution and paradigm:

- Costs that fall within normal operating budgets
- Schedules that meet modern manufacturing precepts—days or weeks rather than months or years
- Support requirements that fall within the scope of existing in-house control engineers
- Performance that meets with operations' expectations and approval
- Technology that falls within existing control system capabilities (think function blocks).

To the extent that this paradigm has yet to fully emerge, industry would do well to make this its target. ●

	Constraints	51AI110	51AI115	51AI116	51AI125	51PC105	51PDI104
Handles		NAP90	KER090	KEROFLSH	DSL90	PRESSURE	TOP DP
51TC102	Feed heater					+1	
51FC103	Bottom steam					+1	
51FC128	Pump-around					–1	–1 OPT
51TC106	Top temperture	+1 OPT	+1	+1	+1		
51FC112	Kerosine draw		+1 OPT		+1		
51FC122	Diesel draw				+1 OPT		
51HC128A	PA bypass					+1	+1

FIG. 1. Example matrix and its fundamental elements.

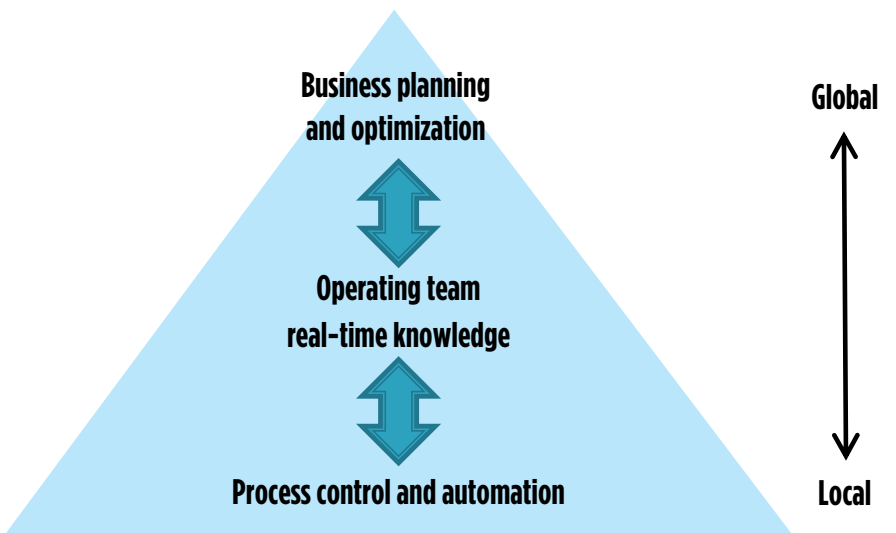


FIG. 2. The APC 2.0 paradigm eliminates redundancy and empowers each layer to focus on its core area of expertise and responsibility.

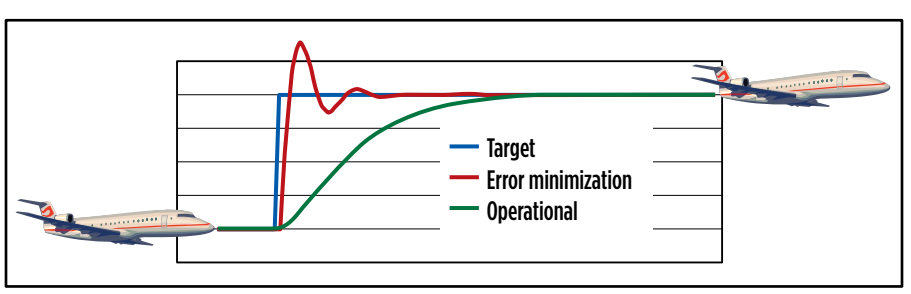


FIG. 3. The passenger plane changing altitude illustrates why "operational performance" criteria are more appropriate for industrial process operation than traditional model-based error minimization.

HARVEY'S EFFECTS FELT FAR FROM THE FLOOD ZONES

The aftermath of Hurricane Harvey is disrupting plans for crucial maintenance at refineries thousands of miles away. Demand usually slows at this time of year, enabling repairs and the installation of new equipment at plants normally in continuous operation. At least 13 refineries from Louisiana to Montana with a combined 3.27 MMbpd have delayed maintenance for weeks or months to take advantage of strong margins, while others lack the personnel who were dispatched to help repair and restart storm-hit facilities along the Gulf Coast. ●

Advantages of sulfuric acid alkylation technology confirmed

ARVIDS JUDZIS JR., ROMAIN LEMOINE and **JACKIE MEDINA,** CB&I

Maintenance inspections were conducted at two commercial CD*Alky*® units, licensed by CB&I. Findings confirmed significant advantages of this sulfuric acid (H_2SO_4) alkylation technology over conventional technology. In particular, corrosion rates and fouling propensity are greatly reduced with CD*Alky* technology. Its innovative reactor design enables the refiner to "break the low temperature barrier" compared to conventional sulfuric acid technologies, provides for an easy separation of the acid and hydrocarbon phases, eliminates the need for post treatment of the alkylate product, and produces a dry reactor effluent for the downstream fractionation system.

CB&I's CD*Alky* technology has been in commercial operation since March 2013, when the first unit, with a capacity of 5 Mbpd (thousands of barrels per day) of alkylate, started at Shandong Sincier Chemical Co. Ltd. in China. The second CD*Alky* unit to be inspected, in operation since July 2014, is also located in China at Ningbo Haiyue. This unit has a capacity of 15 Mbpd of alkylate.

CB&I has now licensed 13 CD*Alky* units, with three in operation, two more to start up shortly, and eight awarded in the last 14 months. These recent awards are from major refiners, including one in North America.

Shandong Sincier shut down its FCCU for a planned turnaround. Since the FCCU was the source of olefin feed for the CD*Alky* unit, the refinery took the opportunity to also inspect the alkylation unit that was a year and a half into its run. No signs of corrosion, damage, pitting or hydrogen (H_2) grooving were found. The DIB column was not opened due to time constraints.

Ningbo Haiyue shut down its CD*Alky* unit in July 2017 due to local safety regulations that require an inspection of newly commissioned units after three years of service. Absent the regulation, the unit was running very well and would not have required a shutdown. The inspection revealed no visible signs of corrosion or fouling in the reactor section, coalescers or fractionation system. Furthermore, no issues were found with any pump seals, and all proprietary equipment was in good condition and required no replacement. **FIG. 1** shows the reboiler bundle for the DIB column. After three years of operation, underlying or fundamental fouling and corrosion issues would certainly have been evident.

The reduced corrosion rates and absence of fouling observed at both Sincier and Haiyue are attributable to the innovative design of the CD*Alky* reactors, which not only allows the refiner to cost-effectively break the low temperature barrier for enhanced product quality, but also to eliminate the alkylate product post-treatment section. With conventional sulfuric acid alkylation technology, this section can cause downstream corrosion and fouling problems. Without post-treatment, the need to handle large waste streams is also eliminated, thereby reducing its environmental footprint.

The amount of acid leaving the reactor is limited by the reactor's novel design, which increases acid utilization while operating at low temperatures. The acid droplet size is controlled by the use of an optimized proprietary packing system rather than a rotating impeller, providing for an efficient and easy separation of the acid-hydrocarbon phases, which eliminates acid carryover entirely. The unit operates in an acid-to-olefin regime that minimizes the formation of stable, hydrocarbon-soluble sulfates.

This strategy ensures that the reactor effluent is dry, greatly reducing corrosion rates and associated maintenance costs and safety risks. It also provides for an alkylate product that has an extremely low sulfur content, clearly an advantage in a Tier 3 world. The advantages of operating at colder reactor temperatures on corrosion rate, alkylate quality and acid consumption rate have been well documented.

To meet the CB&I team and learn more about the advanced CD*Alky* sulfuric acid alkylation technology, visit the company's hospitality suite Monday night in room 406. ●

FIG. 1. The inspection revealed no visible signs of corrosion or fouling in the reactor section, coalescers, fractionation system or the reboiler bundle for the DIB column, shown here.

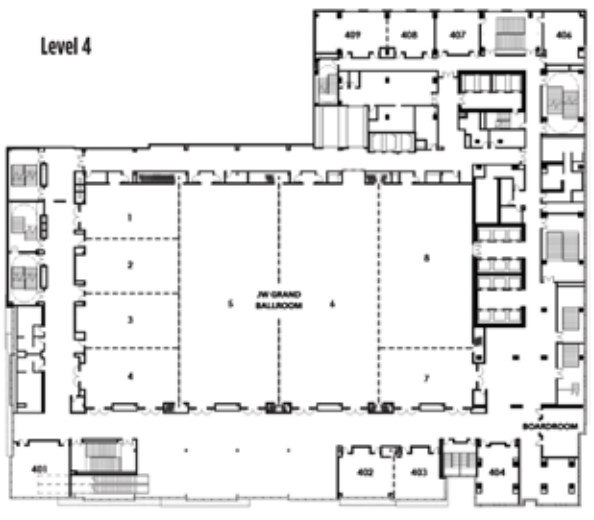
HOSPITALITY SUITES

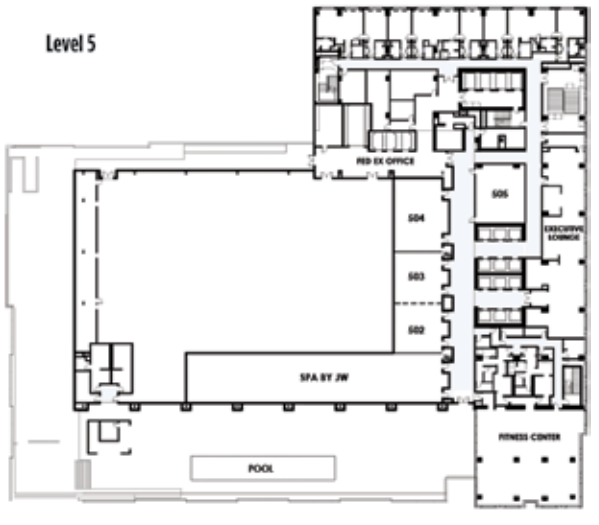
This is a directory of the companies that host hospitality functions at the Operations and Process Technology Summit. Open hours are determined by the individual host in compliance with AFPM's policy not to conflict with regularly scheduled association sessions and activities and to close by 1 a.m.

COMPANY	LOCATION	DAY
Advanced Refining Technologies	TBD	Mon., Tues.
Albemarle Corporation	Room 210	Mon.
Athlon Solutions	Room 208	Mon.
Axens North America	Room 504	Mon.
CB&I	Room 406	Mon.
CRI Catalysts/Criterion Catalysts/ Shell Global Solutions	Room 408/409	Mon., Tues.
Dorf Ketal Chemicals LLC	Room 208	Sun.
The Dow Chemical Company	TBD	Sun., Mon.
DuPont Clean Technologies	Room 404	Sun., Mon.
Haldor Topsoe Inc.	Room 211/212	Mon., Tues.
Honeywell UOP	Room 213	Sun., Mon., Tues.
Johnson Matthey/Tracerco	Room 502/503	Sun., Mon., Tues.
Reactor Resources LLC	Room 407	Mon.
TechnipFMC Process Technology	Room 209	Sun., Mon.
W. R. Grace & Co.	TBD	Mon., Tues.

Functions held in rooms are on the 2nd, 4th and 5th floors as indicated by the first digit in the room number. Suites are held on the sleeping room floors and numbers can be found on the AFPM Mobile App or the Hospitality Notice Board in the AFPM Registration area.

MEETING ROOMS MAP

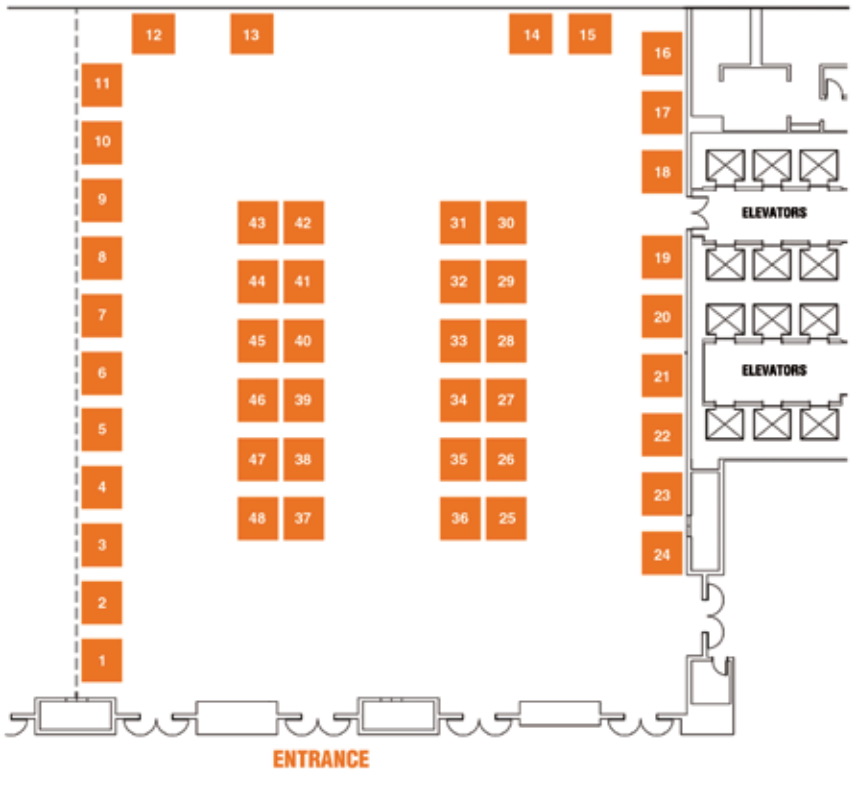




LIST OF EXHIBITORS

Exhibitor information is provided solely for the use of attendees to search for products and services offered by exhibiting companies. Use of this information for solicitation purposes of any kind, by anyone other than a registered attendee, is strictly prohibited.

MAP OF EXHIBITION
JW GRAND BALLROOM SALONS 6-8



POWERING AHEAD IN 2018

AFPM 2018 Meetings

Annual Meeting
March 11 – 13
New Orleans Hilton
New Orleans, LA

International Petrochemical Conference
March 25 – 27
Grand Hyatt
San Antonio, TX

International Base Oils and Waxes Conference
March 25 – 27
Grand Hyatt
San Antonio, TX

Security Conference
April 23 – 25
Omni Royal Orleans
New Orleans, LA

Labor Relations/ Human Resources Conference
April 26, 27
Omni Royal Orleans
New Orleans, LA

National Occupational & Process Safety Conference
May 15, 16
Grand Hyatt
San Antonio, TX

Reliability & Maintenance Conference
May 22 – 25
Henry B. Gonzalez Convention Center
San Antonio, TX

Cat Cracker Seminar
August 21, 22
Royal Sonesta
Houston, TX

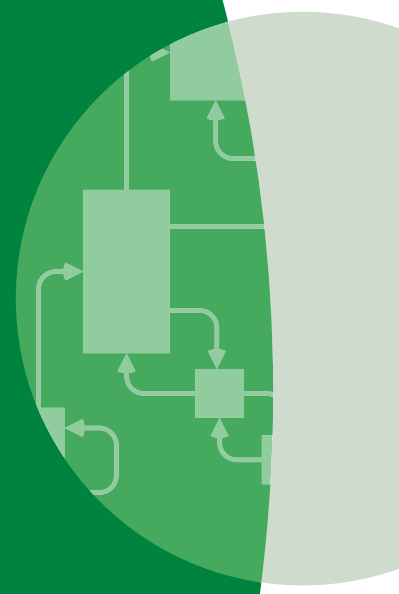
Operations & Process Technology Summit
October 1 – 3
Atlanta Marriott Marquis
Atlanta, GA

Environmental Conference
October 14 – 16
Marriott Rivercenter
San Antonio, TX

www.afpm.org/conferences

AFPM

breakthrough catalyst technology



Johnson Matthey's breakthrough catalyst technology, **CATACEL SSR**, a high performance structured catalyst for steam reforming, delivers greater capacity and longer catalyst life than traditional pelleted catalysts.

Our **CATACEL SSR** technology is proven to ease operating limits on the reformer and increase throughput through reduced tube wall temperature, lower pressure drop, decreased energy consumption, and improved carbon resistance.

Our technical support team will work with you to assess your needs and determine if **CATACEL SSR** technology is a good fit for your operation.

JM Johnson Matthey
Inspiring science, enhancing life

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