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# Refiners to see enhanced competition from IMO 2020

**ADRIENNE BLUME,** *Hydrocarbon Processing*

During a Tuesday morning session on Priority Regulatory Issues, Gary Devenish of independent energy consultancy Baker & O'Brien talked about "what is keeping refiners up at night," despite 2017 being a good year for refiners.

"We are not back to the Golden Age yet, but we saw sustained performance," Devenish said. Margins were healthy in 2017 due to good fundamentals; an abundant supply of crude oil; access to export markets, particularly in Latin America; a well-developed infrastructure; and now, a favorable tax structure.

**GARY DEVENISH** of independent energy consultancy Baker & O'Brien forecasts that significant challenges on the horizon will impact US refinery margins and competitiveness.

However, Devenish noted that significant challenges on the horizon will impact margins and competitiveness. International Maritime Organization (IMO) 2020 regulations will limit sulfur in marine fuels to 0.5% from 3.5%, which is likely to result in a large discount in the futures curve for high-sulfur fuel oil (HSFO) beginning in 2019.

The IMO regulations will significantly impact European refiners, as they produce large volumes of HSFO for marine bunker use. US refiners produce around 200,000 bpd of HSFO, accounting for just 6.7% of the global total of 300 million bpd. However, refiners of heavy sour crude worldwide are preparing for increased crude feedstock costs as a result of IMO 2020.

**Facing the new challenge.** A few strategies for US refiners to take advantage of stranded fuel oil include making investments in hydrotreating and upgrading capacity. However, Devenish cautioned that refiners that have not yet started on upgrading may be too late to do so. Another option is to make operational adjustments to the crude slate.

The overall US crude slate has become lighter over recent years, which has led refiners in some regions, such as PADD 3 (Gulf Coast), to have available capacity to upgrade HSFO. Devenish estimates up to 850,000 bpd of total spare coking and hydrocracking capacity in the US.

Devenish said that IMO 2020 could strengthen US refiner competitiveness, particularly those refineries with high crude flexibility and spare upgrading capacity.

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# Octane challenges and opportunities for refiners, automakers

**ADRIENNE BLUME,** *Hydrocarbon Processing*

A Tuesday morning panel session explored the policy and technical issues surrounding octane standards in the US. Tony Sementelli, Executive Vice President at Flint Hills Resources, noted that refiners have been studying the issues of octane improvement and fuel efficiency requirements for some time. "The industry is aware that consumers are seeking improved products. We have to be open to what society is asking for," Sementelli said.

However, today's dialogue on fuel economy is also debating the long-term usefulness of internal combustion engines (ICEs) and fossil fuels. Cities, states and countries are considering bans on hydrocarbon products. Sementelli called these discussions "disturbing to our industry," but added, "it is important to acknowledge that these debates are happening."

**Demand for greater efficiency.** In the US, rising demand for improved fuel efficiency means that automakers are facing challenges in meeting miles-per-gallon compliance. Sementelli noted that automakers' manufacturing processes are planned years in advance. "They know what processes and technologies they will use through 2022 to meet targets," he said. "CAFE [corporate average fuel economy] is a very expensive regulation to hit, and they [automakers] do not over-comply."

Automakers have a handful of choices to address ongoing carbon emissions and CAFE discussions post-2022, Sementelli said. They can add technologies for fuel efficiency, which will result in continual increases in the cost of ICE vehicles. They can also work with refiners to invest in higher-efficiency fuels.

A pressing question is how much a higher octane standard would be able to help automakers in meeting fuel standards for ICEs. Policymakers have expressed interest in this route, Sementelli said.

**Technical options for creating HOF.** Bob Anderson, Senior Policy Advisor for Chevron, said that carbon emissions mitigation, CAFE regulations

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The "Costs and Benefits of Various Octane Levels" panel was moderated by **GEOFF MOODY** (left) from AFPM. Panelists included (left to right) **TONY SEMENTELLI,** Flint Hills Resources; **BOB ANDERSON,** Chevron U.S.A. Inc.; **FRED WALAS,** Marathon Petroleum Corporation; and **JOANNE SHORE** from AFPM.


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# Women in Industry: NFL's Hudson champions diversity, career flexibility

**ADRIENNE BLUME,** *Hydrocarbon Processing*

At Monday afternoon's Women in Industry Luncheon, Dawn Hudson, Chief Marketing Officer for the US National Football League (NFL) and former President and CEO of PepsiCo North America, spoke to attendees about her career evolution and offered advice for women working in male-dominated industries.

Hudson started off her talk with an interesting statistic: Women who play sports in their youth will earn 7% more, on average, than women who do not. "It is because they [women who play sports] stand up for themselves," she said.

**Journey to the top.** Hudson took luncheon attendees through the route of her career, which began with Compton Advertising, where she was given one of the firm's largest accounts—Tide laundry detergent. She was the first woman to work on the account, which she found somewhat "bizarre" since laundry is often perceived as women's work.

She then received a call to move over to the client side, and became a brand manager for Clairol. After moving to the Midwest from New York and starting a family with her husband, she worked for Proctor & Gamble on the company's Head & Shoulders campaign. She then moved to advertising agency DDB, where she stayed for 10 years. She worked on Kraft and Frito-Lay, eventually serving as Frito-Lay's global representative.

After having her second daughter, Hudson and her family moved back to New York. "It was around this time that I began wondering why there were no women running advertising agencies," she said. Within a short time, she left DDB to become the Managing Director of advertising agency D'Arcy.

Before long, however, she received an offer from Frito-Lay to become the head of advertising and marketing for PepsiCo. She accepted, and eventually became President and CEO of PepsiCo North America. Hudson stayed with the company for 11 years and consolidated the Frito-Lay, Quaker and Pepsi brands.

She left Pepsi when the soft drink business began to decline due to public health perception. The 3%–5% per year downturn in the soft drink industry had forced her to work on downsizing and managing cost efficiencies. "I learned a lot, but my passion is in growing things," she said. Hudson then joined Parthenon, which was later sold to EY.

**Segue into the NFL.** Hudson's next big break came when she received a call in 2014 from Roger Goodell, who was serving as the NFL Commissioner, and with whom she had worked when the NFL switched its soft drink sponsorship from Coca-Cola to Pepsi. Goodell said he was seeking a senior woman on staff, and offered her a job with the NFL, which she accepted.

In the male-dominated world of sports, Hudson said, "I felt like I was walking 20 years back in time … They didn't even recognize that the fastest-growing segment of their business was women." She noted that women working in the energy industry would be able to relate.

"By virtue of being at a later stage in my career, I didn't worry," Hudson said. "I just spoke my mind." She added, "But I had to physically reject the culture" to be an effective leader in the NFL.

**How to stand out.** Hudson shared some tips with attendees for making a name for themselves, regardless of the industry in which they work. Most importantly, she said, "Define your brand. What do you want to be known for?" For Hudson, defining her brand means being a challenger of the status quo as well as an innovator. She is also results-oriented and a champion of diversity—"Not just because it is the right thing to do, but because there is so much diversity" in the NFL fanbase. "I think it is good business," she asserted.

She also advised open and honest conversations with colleagues, business partners and family, combined with smart work and life choices. "Family and personal always trumps work," Hudson said. "I've also learned that you are your best coach. Stand up for yourself—get that 7% more pay! And have fun. Who you work with matters."

Hudson also noted, "Flexibility is under-valued. The older you get in your career, if you don't watch it, you can get into the mindset of 'this is the way it's done.' So keep learning."

"With all the pace of change, do the best you can do and see where it takes you," Hudson advised, in closing. "And when you leave a job, it is really important to leave on good terms, because you never know where things are going to go." •

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**Long-term fuel demand trends show declines in gasoline, diesel.** Devenish also discussed the long-term demand trends for gasoline and diesel. As electric, fuel cell and alternative fuel vehicles gain popularity, very low growth is expected over the long term for petroleum demand worldwide, he said.

The long-term growth forecast for US gasoline and diesel demand growth is negative through 2040, although the country will see some growth in distillate demand through 2025. US gasoline demand is expected to be negative through 2025.

Over the near term, most additional refining capacity will be built in regions with increasing demand—i.e., Asia-Pacific and the Middle East. Through 2022, Devenish sees 7 million bpd–8 million bpd of new capacity construction in these two regions. The new Middle East facilities will target European markets.

European refiners are characterized by several disadvantages, such as higher operating costs, stagnating regional demand, litigation and high feedstock costs. US refiners, however, have structural advantages. "They are not the lowest cost, but they can be competitive with refineries worldwide," Devenish explained.

The Middle East, on the other hand, is the world's lowest-cost supplier, while Asian refiners will be buoyed by strong regional demand.

Although present conditions are good for most refiners, Devenish noted that long-term issues remain. These issues include IMO 2020, uncertain technology curves, and unknowns on the future of carbon taxation and litigation.

These new regulations and uncertain trends could lead to demand destruction. As a result, "we have a somewhat pessimistic forecast for oil-based liquids consumption," Devenish acknowledged. However, he added, "US refiners have shown amazing flexibility and adaptability over the last few years, and should retain their competitive status over the near term."

**RFS, carbon tax proposals keep pressure on US refiners.** Devenish next addressed the upcoming changes to the Renewable Fuel Standard (RFS) in the US, and the potential impacts of these changes on program participants.

He noted that no major relief is being seen in the RFS from the new presidential administration. The original RFS, as established in 2007, envisions 27 billion gallons of ethanol blended in 2018. The RFS will remain at around 10%, however, and refiners will be up against the blend wall. "There is a serious push to provide relief for refiners, but we will see if anything comes from it," Devenish said.

Carbon taxes to address climate change could also impact refining profits in the future. Oil majors ExxonMobil, BP and Shell back a proposed carbon tax of $40/metric ton to curb carbon emissions. In Canada, a federal carbon tax target of $50/metric ton is in place for 2022.

Increasingly, government and local citizen groups are using the courts to fight climate change, Devenish said. These groups are using "attribution science" and weather events to trace climate change back to approximately 90 energy companies.

"The single purpose of a carbon tax is to drive down demand for fossil fuels," Devenish said. The potential impacts of a $40/metric ton carbon tax are a $0.32/gallon increase in the price of gasoline and a $0.41/gallon price increase for diesel, as well as a 320,000-bpd decrease in gasoline demand and a 210,000-bpd decrease in diesel demand. •


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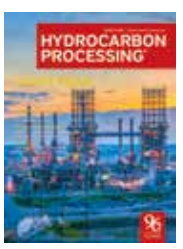


# Filling the gap—The US as a net exporter of petroleum products

**MIKE RHODES,** *Hydrocarbon Processing*

At Dupont Clean Technologies' pre-conference seminar on Sunday afternoon, the company presented an overview of the present state of supply and demand for both gasoline and distillates, as well as a look ahead at how regulations, NAFTA, political unrest and financial challenges will impact future trends.

Curt Hassler, North American Sales Leader for DuPont Clean Technologies, opened the program by explaining how the US is poised to fill three gaps that exist globally: the volume gap, the octane gap and the regulation gap. "The volume gap is simply an increased demand for refined products and crude products outside the US," Hassler said. "Globally, demand for gasoline is increasing at least for the foreseeable future. The demand is trending downward in North America, and there is a gap between what the US needs and what it can produce."

Increased capacity projects in the US are expected to increase that gap, enabling the country to export more gasoline and crude oil products. "It is interesting that crude oil has become an important US export since 2015, when the ban on its export was lifted. We have also seen significant growth in gas liquids," Hassler said. According to the US Energy Information Administration (EIA), US crude oil exports grew to 1.1 million bpd in 2017, or 527,000 bpd (89%) more than exports in 2016, in the second full year of unrestricted US crude oil exports.

The gasoline-based octane gap in the US is viewed as a supply and demand issue, Hassler said. "Supply-wise, there is an increased need for octane products. Some of the processing schemes for Tier 3 lower sulfur fuels cause the octane to fall off. A gap is increasing between the demand for regular fuel and for high-octane fuel." Some of the attendees in the audience suggested that this gap could be caused not only by the higher number of cars on the road, but also by the increasing use of high-performance, turbo-charged vehicles. "Vehicle emissions, CAFE (corporate average fuel economy) standards and other factors are all driving the demand for higher-octane fuels in the US," he said.

"We see opportunity in regions that do not fit in the 10 ppm–15 ppm range for lower sulfur diesel products. To achieve regulatory compliance, they are either going to have to make big investments, or they are going to have to import additional products. This gap is driven by regulations," Hassler said.

Hassler cited the impending IMO low-sulfur regulation for marine vessels as another important driver for increasing low-sulfur fuel demand. The US is uniquely positioned to benefit from these global scenarios due to low-priced feedstock and materials availability, the increased throughput US refineries are able to achieve through scale and technical support, and, most importantly, the extensive infrastructure that already exists.

**CURT HASSLER,** North American Sales Leader, DuPont Clean Technologies

**SAMANTHA PRESLEY,** Global Licensing Manager, DuPont Clean Technologies

**Gasoline.** Samantha Presley, Global Licensing Manager for DuPont Clean Technologies, took the podium to make a connection between the lifting of the 2015 crude export ban and the 2010 shale oil boom. "Since that time, production in the US has almost doubled, while the amount of light crude oil that is being imported has reduced. That was five years before the 2015 export ban was lifted," Presley said. At the same time, global fuel specifications have been getting progressively more strict, putting the US in a strong position as an exporter of petroleum products. "When the ban was lifted, it was a natural fit for the US to become an exporter of crude oil, as well."

The US has been an exporter of refined petroleum products for a number of years, and the shale oil boom caused a noticeable uptick. The US had access to inexpensive, domestically produced crude feedstocks. "We have the most complex refining network in the world," Presley stated, "so we were well-positioned to produce additional volume for export."

The majority of US production comes out of PADD 2 (Midwest) and PADD 3 (Gulf Coast). Because refineries in PADD 2 have ramped up their production in recent years, PADD 3 refineries are in a strong export position, particularly to Latin America, due to the transportation infrastructure that is in place.

"In 2017, the US produced more gasoline than demand required," Presley said. "We are one example of a country that is both an exporter and an importer of gasoline. The US exports a lot of gasoline from the Gulf Coast, but rather than transport that gasoline to the East Coast where refining assets have been shut down, it is actually less expensive for those East Coast refiners to import gasoline from Europe. So we are exporting through the Gulf Coast and importing from the Atlantic. Many countries in the world are both exporters and importers of gasoline." ●

**OCTANE,** continued from page 1

and high-octane fuel (HOF) production scenarios will be achievable with the existing E10 infrastructure.

A technical feasibility analysis from the AFPM technical committee focuses on octane measured as research octane number (RON), as RON was found to be more relevant to automakers than motor octane number (MON) or anti-knock index (AKI) for representing the requirements of modern engines. RON also results in fewer refining production constraints than does AKI.

Automakers have focused on a 95-RON fuel for future efficiency technology. Tradeoffs exist between vehicle contributions to efficiency and fuel contributions to efficiency, Anderson said. The AFPM committee examined combinations of fuel and vehicle technology at a constant fuel economy improvement, and found that CAFE regulations would be met in all cases.

However, refiner production costs increase as octane is increased, while automaker costs are reduced. The question remains: How can refiners and automakers work together to achieve a balance in meeting fuel efficiency requirements?

A combined, well-to-wheel cost analysis for refiners and automakers found an optimum RON level of 94–96 for reducing carbon emissions. However, California may be a limiting factor for RON levels greater than 95, particularly in the time frame needed to meet national 2022–2025 CAFE standards, Anderson said.

Challenges also remain with regard to stationary source permitting. Additional analysis will be required to understand the issues that lie outside of the refinery gate and through the retail system.

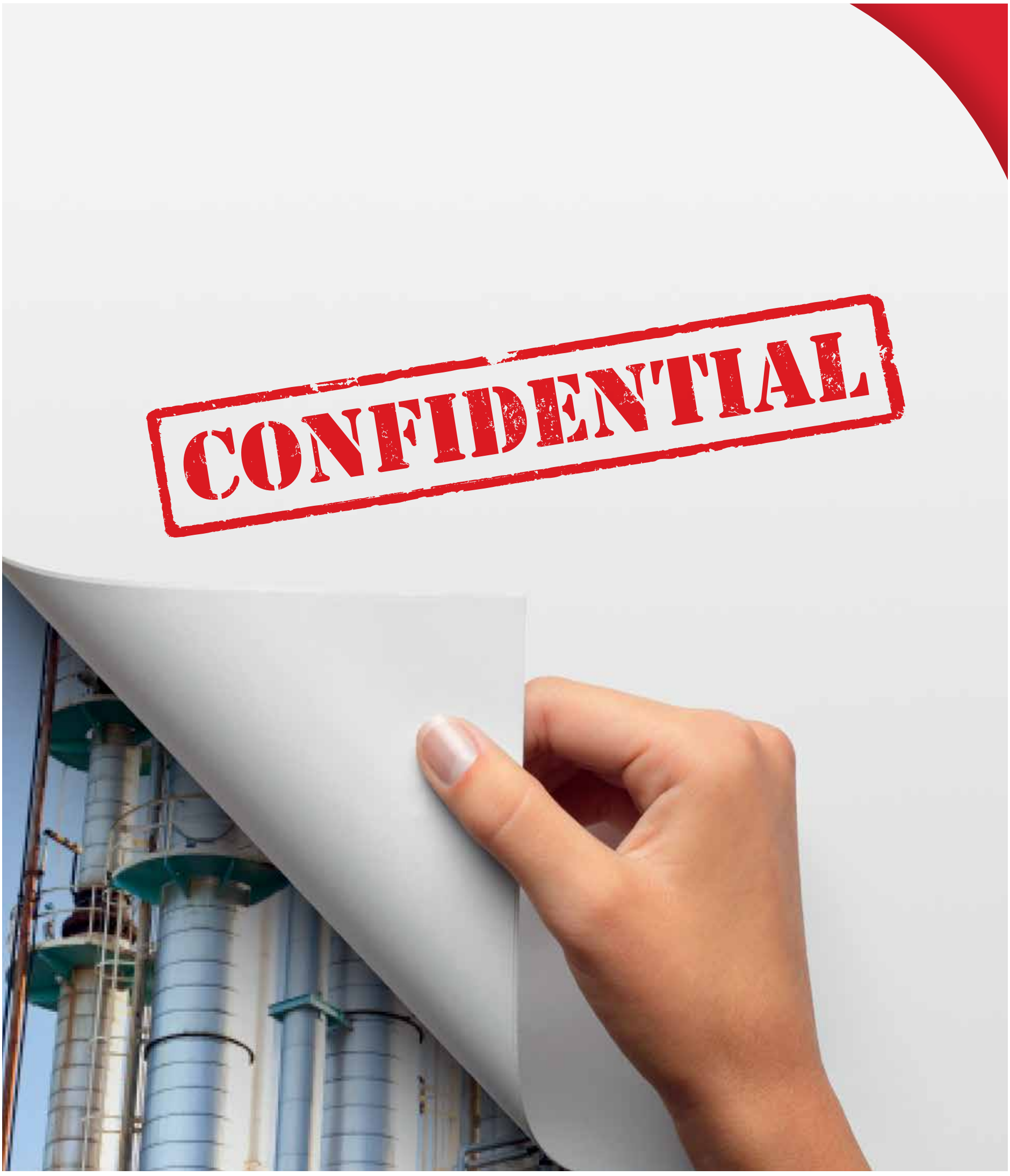
**Logistical and implementation issues.** Fred Walas, Fuels Technology Manager for Marathon Petroleum, discussed issues the industry must consider with a 95-RON standard, including potential impacts to terminals, retail stations, pipelines, etc.

Walas noted that 150,000–155,000 fueling stations will need to become compliant with the octane standard, with around 60% of those stations being owned by independent businesses. The standard could be phased in to align with the introduction of new vehicles, which would allow flexibility in the timing of refinery investments. However, this investment must be front-loaded so that the fuel is available immediately. "You cannot spread it out over 20 years," Walas warned.

The technical committee is focusing on three scenarios to solve the issue, listed in order of increasing difficulty to implement: (1) Replace the existing premium fuel with the new HOF, (2) add a new HOF to the fuel supply and retain the existing three grades, and (3) replace the existing premium fuel with E15 HOF. Five key topics involved in the scenario discussions include vehicle needs, distribution system transition, retail misfueling prevention, retail dispenser labeling and fuel certification, and retail technical issues.

New vehicles would be purposely built to operate on the new HOF. However, either these vehicles would also need to be able to operate on existing fuels, or a method would need to be established to ensure that consumers use only the HOF in their new cars. "How do you get 150,000 gas stations in compliance?" Walas said.

Making the system "idiot-proof" would require that a misfueling system be in place when the first new HOF vehicle comes off the line, he added. Otherwise, vehicle engines could be damaged or broken by the use of lower-grade fuel in new cars. ●

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# IMO 2020 0.5% sulfur regulation: The debate over scrubbers

**ARA BARSAMIAN** and **LEE CURCIO,** Refinery Automation Institute LLC

The new IMO 2020 sulfur (0.5 wt%) regulation is creating concern and uncertainty worldwide. Everyone is afraid of the impossibility of making new bunker blend recipes that satisfy the regulation, and are "sleepwalking into gasoil." Of course, this fear is unfounded, as Refinery Automation Institute (RAI) showed in its internal research on making IMO 2020 compliant fuels in the US Gulf Coast.

What about alternatives, such as using scrubbers? Is it really cheaper than buying ultra-low sulfur fuel oil (ULSFO) or marine gasoil (MGO)? The answer is, "Yes." Scrubbers allow vessels to continue burning cheap IFO 3.5 wt% S, and they pay for themselves in a year or less.

The results of two calculations to determine scrubber payback are discussed here: simple return on investment (ROI) and discounted cash flow (DCF) return. The payback varies with ship size (different fuel consumption rates), from a couple of months for Container Post Panamax-es to more than a year for smaller ferries and small Panamax Bulkers. Individual parameters can be used for calculations depending on the specific case situation. The difference between the two calculators is that the first (ROI) is a quick ballpark estimator, while the second (DCF) calculates the internal rate of return and net present value using CAPEX, OPEX, life of equipment, interest rates and depreciation.

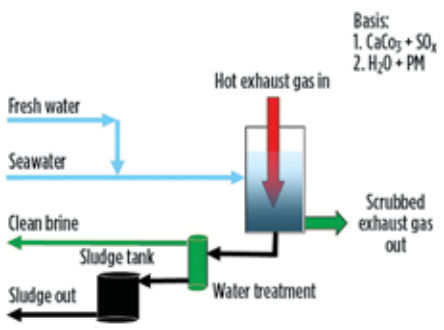


**FIG. 1.** Exhaust gas $SO_x$ scrubber principle.

**What is a scrubber?** A scrubber is a fairly large electromechanical-chemical device that is attached to the vessel's exhaust chimney to clean the bunker-burning engine exhaust gas sulfur to a globally acceptable level, i.e., below 0.5 wt% S.

The scrubber chemically converts the sulfur dioxide ($SO_2$) and sulfur trioxide ($SO_3$) in the exhaust gas into rather benign calcium sulfate ($CaSO_4$).

The most frequently used scrubbers are either an open-loop or closed-loop type (**FIG. 1**). In an open-loop scrubber, the water with $CaSO_4$ is simply placed into the ocean; obviously, this is a cheap solution, but it does affect the alkalinity of the seawater. In a closed-loop scrubber, the $CaSO_4$ is filtered out as "sludge" and disposed of properly in a port equipped for sludge disposal. Consequently, this option is more expensive.

Other considerations impact scrubber costs:

- They consume a lot of space and weigh many tons, so there must be space to install them and support their weight.
- They must be equipped with performance-monitoring electronics (sensors and computers) to prove that the cleaned exhaust meets the IMO 2020 specs.
- They create "back-pressure" on the engine, which affects energy efficiency.
- The engine exhaust and sludge are highly corrosive, which limits the life of the scrubber, even with the use of corrosion-resistant materials.
- The cost of sludge disposal is not negligible, as is the scrubber's periodic maintenance cost.

**Payback and ROI scenarios.** The money-saving capability of a scrubber relies on the price differential between today's IFO380 3.5% S and LS MGO, which ranges from $150 metric t–$200 metric t. The price differential has been relatively constant for the last decade, and is due to two factors:

- The "bottom-of-the-barrel" residue is much cheaper than any other distillation fraction cut from a barrel of crude oil, such as gasoils (kerosine, jet, diesel, LAGO/HAGO).
- The high cost of desulfurization, which traditionally uses hydrogen ($H_2$), catalyst and energy to "bind" sulfur species to $H_2$ in the form of hydrogen sulfide ($H_2S$). This costs a significant amount of money.

To estimate payback time, two cases were analyzed spanning min/max vessel fuel consumption ranges, from 40 tpd–300 tpd. The payback varied between 0.3 years and 1 year.

The main assumptions used were:

- Life of scrubber: 10 years
- Price of scrubber, installed: $5 MM
- Annual maintenance cost: $1 MM/year in sludge disposal, scrubber inspections and minor repairs, and checking performance monitoring instrumentation
- Prices of fuels and maintenance costs are in 2017 USD using Singapore prices, and were assumed constant over the next 10 years.

Exceptions do exist: for smaller vessels like those in a fishing fleet, the payback is still favorable. The big problem is the lack of space, the ability to carry the extra weight on a smaller vessel, and the impact of back pressure on engine efficiency and fuel consumption.

For all cases where daily fuel consumptions are greater than 40 tpd, scrubbers will pay for themselves in significantly less than one year, providing a real alternative to "sleepwalking into gasoil." ●

# Three lessons learned from industrial cyberattacks

**KATHERINE BROCKLEHURST,** Claroty

The increasing digitization and modernization of technology in the oil and gas industry has many business benefits, including increased efficiency, better utilization of existing technology and human resources, improved reliability and lower costs for global oil and gas supply chains from wellhead to distribution point. However, these benefits carry the unintended consequence of increased cyber risk through interconnected technology and web-based communications.

Real-time monitoring for cyber threats within industrial networks, communications, protocols and processes is definitely one of many important layers of protective defense necessary to catch industrial cyber threats early in the attack cycle. In 2016 and 2017, important malware threats to industrial networks and even safety systems showed that additional lessons can be learned.

> "The attacks that we once spoke of as theoretical, and that we thought represented a 'red-line' that was too solid for anyone to cross, are becoming a reality. Industrial networks are now a target of our adversaries, and not just nation-state actors. We are already seeing cyber criminals attack these networks with ransomware. What we must understand is that industrial networks are everywhere: in oil and gas, chemical, transportation, manufacturing, and even building and data center management systems. These networks power our industries and underpin our global financial system."
>
> **Dave DeWalt, Chairman of the Board, Claroty**
> **Former Executive Chairman and CEO of FireEye**

**Lesson 1: Real-time monitoring is important, but it is not enough.** Widespread power outages occurred in the two separate 2015 and 2016 Ukraine power grid cyberattacks. The 2016 incident has been attributed to well-funded nation-state threat actors targeting industrial systems. Their methods found the easiest digital pathways into industrial environments to create the biggest cyber-physical impact. What is the big, "So what?" Not only should real-time monitoring be used to detect industrial threat activity earlier in the attack cycle, but an industrial solution should help secure some of the easiest pathways into industrial organizations—remote access, stolen credentials/privilege escalation and compromised remote users accessing ICS assets through VPNs.

**Lesson 2: Protection for known and unknown industrial threats is needed.** The spate of 2016 and 2017 Petya/NotPetya and Wannacry malware with ransomware-style capabilities showed that even if an industrial organization is not specifically targeted, it can still face disruption, downtime and millions of dollars in business losses. These malware types had a heavy impact within corporate networks, but also caused business impact through production and factory system shutdowns. The impact also hit the bottom line as losses were reported publicly in corporate filings. New attacks or malware types not seen before (zero-days) cannot be protected against with classic IT solutions, such as signatures-based intrusion detection systems or anti-virus. These systems must build a signature after the attack surfaces to detect and protect. However, detection for unknown threats within industrial networks is required to avert unplanned downtime.

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# A cost-effective, out-of-pit sulfur degassing technology for revamps

**BRIAN JUNG** and **THOMAS CHOW,** Fluor

With global regulatory efforts to reduce sulfur in transportation fuels, many refineries are undergoing revamps to recover more sulfur from crude oil. This recovery process leads to higher acid gas feed rates to the downstream sulfur recovery unit (SRU) and tail gas treating unit (TGTU). Expanding the processing capacity of the SRU/TGTU while reusing much of the existing equipment can typically be achieved by utilizing oxygen enrichment. Debottlenecking the sulfur product rundown and degassing system, on the other hand, can be a challenge.

**FIG. 1.** The modularized D'GAASS sulfur degassing unit can successfully enhance the degassing capacity of the refinery without modifications to the existing sulfur pit.

Typical "in-pit" degassing technologies require a 24-hr liquid sulfur residence time, which warrants an increase in size or changes to the existing sulfur pit to accommodate the additional sulfur production. The plot space and turnaround time requirements associated with sulfur pit modifications can pose significant economic and logistical obstacles to the revamp. In such situations, the modularized Goar, Allison & Associates' (GAA) D'GAASS sulfur degassing unit (**FIG. 1**) can be installed to successfully enhance the degassing capacity of the refinery without modifications to the existing sulfur pit.

The D'GAASS sulfur degassing process is an out-of-pit degassing technology that is commercially proven with more than 110 installations of capacities ranging from as low as 9 metric tpd to 2,600 metric tpd. The D'GAASS process removes hydrogen sulfide ($H_2S$) and polysulfides ($H_2S_X$) from the product sulfur in a pressurized vertical vessel outside the sulfur pit. The un-degassed product sulfur is pumped from the sulfur pit to the vessel, where it is counter-currently contacted with pressurized process air.

The vessel has special fixed internals that ensure that the process air is adequately distributed to achieve effective oxidation and stripping of $H_2S$ and $H_2S_X$ from the product sulfur. Typically the $H_2S$ + $H_2S_X$ content is reduced to less than 10 ppmw without any addition of chemical catalysts. A shell-and-tube exchanger upstream of the vessel controls the sulfur temperature to ensure optimal degassing occurs. Since the vessel operates under pressure, the degassed sulfur can be routed to sulfur storage, forming or loading without additional pumping. Similarly, the overhead vapor, which consists of process air with traces of $H_2S$, sulfur dioxide ($SO_2$) and sulfur vapor, can be routed to the incinerator without the need of an ejector. If higher sulfur recovery is desired, the overhead can be recycled to the inlet of the SRU thermal stage, tail gas unit burner or selective oxidation reactor without additional equipment.

The modularized D'GAASS unit contains the vertical vessel, shell-and-tube exchanger, interconnecting piping, process instrumentation and controls, and electrical conduits in one compact package. The module can be installed at a convenient location during normal operation, and tie-ins can be made during the plant shutdown.

The major advantages of the modular D'GAASS process are listed here and focus particularly on cost-effectiveness, reliability and flexibility.

- Cost-effectiveness
  - No modifications to the existing sulfur pit
  - No continuous catalyst or chemical consumption
  - Smaller equipment sizes due to pressurized operation
  - Low residence time for achieving less than 10 ppmw $H_2S$
  - Much lower degassing air requirements compared to competing in-pit sulfur technology
  - Minimal production downtime, since the degassing unit is independent from the existing sulfur pit
  - Reduced installation cost and field work due to modularization
- Reliability
  - Fixed, low-maintenance vessel internals
  - The only additional maintenance item is an air compressor if existing process air pressure is insufficient
- Flexibility
  - Pressurized operation allows sulfur product and overhead vapor to be routed to any destination without additional equipment
  - Pressurized operation allows degassing unit to be installed at a convenient location with less concern towards hydraulics
  - Small footprint due to modularization
  - Ability to degas to less than 10 ppmw $H_2S$.

With today's oil and gas industry as competitive as ever, it is crucial that refineries utilize commercially proven, cost-effective solutions to maximize profits. The modular D'GAASS unit is one such solution that can provide great value, especially during retrofits, as it minimizes production downtime during initial installation and provides added flexibility in comparison to in-pit degassing designs. ●

## CB&I CD*ALKY* TECHNOLOGY CHOSEN FOR VALERO REFINERY IN LOUISIANA

CB&I's CD*Alky*® technology has been selected by Valero Refining–New Orleans LLC for its St. Charles Alkylation Project located in Norco, Louisiana. CB&I's overall scope of supply on the project includes CD*Alky* technology license, basic engineering and proprietary equipment. When it becomes operational in 2020, the new CD*Alky* unit will produce 25,000 bpd of alkylate from FCC-derived olefin feedstocks.

CB&I's CD*Alky* technology is an advanced, low-temperature sulfuric acid alkylation process that produces a high-octane, premium gasoline blending component with less environmental impact, while also reducing overall maintenance and chemicals costs for refineries. ●

## CYBERATTACKS, continued from page 6

**Lesson 3: Safety instrumented systems (SISs) are already under attack.** Many operations and process control engineering teams tend to believe that threats to industrial systems are overhyped or inaccurately reported by the press: in many cases, this is true. However, oil and gas, water, utilities, manufacturing, chemical and many other critical infrastructure sectors should take notice when targeted attacks like Industroyer and Triton (also called Trisis) successfully breached SISs. Industrial sites independently monitor critical systems using multiple SISs to ensure acceptable operating safety thresholds and, when exceeded, the SIS will automatically shut the systems down to ensure equipment, personnel and public safety.

Triconex is a safety system that has been manufactured and deployed globally for decades within industrial settings. Schneider Electric manufactures Triconex and recently discovered a targeted attack on one of its customers that leveraged a vulnerability in the Triconex Tricon controller firmware, allowing attackers to escalate user privilege and gain control of the emergency shutdown system. This attack had not surfaced before and allowed sophisticated hackers the *potential* to cause great harm. Schneider is not the only SIS manufacturer, and certainly other brands will be targeted for similar and new attacks. Schneider's security alert gives details as well as guidance on how to harden and protect these controllers.

**Time to get started.** Candidly, it will not always be about cyber threats, per se. Sometimes employees, equipment manufacturers, supply chains and even trusted consultants will make a mistake that impacts production or causes unplanned downtime. However, if an industrial organization or C-suite and board does not yet consider increasing ICS security as a business essential—it is time. Despite unnecessary hype, cyberattacks and bad actors are real, and industrial networks and assets are being targeted. As you begin to examine your ICS security gaps and the cyber risks you may uniquely face, these lessons learned will define early steps to take in defending your production systems, as well as the bottom line.

IT-centric security solutions cannot cut it within industrial and production environments. Consider downloading Claroty's solution brief to see how we can assist your organization reduce cyber risks, secure remote access and provide continuous monitoring with real-time alerts early in the attack lifecycle—with zero impact to ICS. ●

**Katherine Brocklehurst** has been involved in cybersecurity for more than 20 years. Working with security technologies ranging from encryption, networking protocols, intrusion detection/prevention, perimeter and web application firewalls, and industrial control system security, Ms. Brocklehurst has touched every layer in the OSI model. She is a subject matter expert on security and compliance policies, with years of specialty in energy and electric utilities, NERC CIP, NIST, CIS Top 20, PCI and other security frameworks that ensure foundational controls are in place against potential threats.

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# Oil-to-chemicals: Advanced technologies, process configurations address fuels/chemicals imbalance

**JOHN J. MURPHY, CLYDE F. PAYN** and **MARK V. WILEY,** The Catalyst Group Resources

The movement toward the production of chemicals and petrochemicals such as olefins and aromatics directly from crude oil, as opposed to thermal cracking of naphtha/ethane (for olefins) and traditional refining reforming (for aromatics), is being driven by numerous factors. The most important factor is the imbalance between the demand for oil-derived liquid fuels (diesel, gasoline) and the more rapid growth in markets for petrochemicals like olefins (ethylene, propylene), aromatics (BTX) and specialty intermediate streams like $C_4$s and higher olefins. The imbalance (**FIG. 1**) has made the idea of using crude as a direct feedstock more appealing.

The technologies for these novel and important chemical/petrochemical production processes are being pursued by industry leaders like ExxonMobil and Saudi Aramco/SABIC, but are also affecting the competitiveness of peer participants (i.e., all chemical producers), EPCs, process licensors and technology developers. Traditional routes, such as naphtha cracking, are potentially becoming uncompetitive. Interest in approaches to, and justification for, these opportunities/threats is becoming strong, widespread and urgent.

**Oil-to-chemicals: Advanced technological approaches.** Noteworthy, recent catalyst and process advances relevant to olefins and BTX chemical products avoid the upfront investment in catalytic distillation units (CDUs), vacuum distillation units (VDUs) and other parts of the refinery. These advances maximize BTX and olefin yields (primarily $C_3$+ and $C_4$+) beyond typical refinery economics and normal/known process configurations that have historically been optimized for fuels production.

Major developments include:

- Advances in petrochemical FCC cracking, fixed bed/swing reactor olefin processes and BTX reactor technologies. If the objective is to maximize olefin + BTX production, then taking a light, tight oil (LTO) approach based on these high paraffin compositions is scientifically and margin justified.
- With certain feedstocks (e.g., 35+ API, 50 ppm sulfur and 30 ppm metals) the addition of hydrogen ($H_2$) is unnecessary if the product goals are either olefin or BTX. Pyrolysis approaches should be ruled out because they are inefficient, energy intensive and produce too much coke and refractory products to be useful.
- In new process configuration designs, engineers should be targeting combination schemes that yield 80 wt% olefins + BTX with only 20 wt% byproducts [such as fuels and liquefied petroleum gas (LPG)]. An inside battery limit (ISBL) + outside battery limit (OSBL) CAPEX in the $400 MM–$600 MM range, without post-treatment steps, should be sought.
- FCC olefins production has already gone through a steady progression of higher olefin production steps, leading to the commercialization of petrochemical/chemical FCCUs such as PetroFCC-UOP, HSFCC-Aramco, R2P-Total, Axens, TechnipFMC and DCC-Sinopec, among others. Most of these FCCUs will produce 35 wt%–50 wt% olefins, and perhaps using LTOs as high as 62 wt% olefins and BTX, with the byproduct gasoline of about 38 wt% maximum. Newer catalysts might advance this position in the future.

Newer technologies in various stages of commercialization include:

- The RFR proposed process considers utilizing radial flow reactors, now in commercial use in styrene (ethylbenzene) processes. New catalysts are required to optimize this approach, and advances in catalytic distillation provide intensification of a proposed configuration.
- Other noteworthy olefin processes include ACO, Gasolfin, Omega and Chiyoda. These fixed-bed swing olefin + BTX technologies provide a new approach and dimension to reconfigurations. On-purpose aromatics routes, such as UOP's Cyclar, have made advances.
- New separation processes are needed. For LTOs, adopting some upfront feedstock separations that avoid VDUs, and the incorporation of olefins/paraffins are close to commercial use.

An oil-to-chemicals SWOT analysis appears in **TABLE 1.**

**Takeaways.** Refiners that only consider transportation fuels production must think differently. Standalone chemicals producers have a real opportunity to break free from buying naphtha as the only feedstock at lower cost. For the integrated refinery/chemicals producers—a trend that is increasing—the conventional wisdom that a complex 400,000-bpd refinery, coupled with a 2 MM metric t–3 MM metric t SC with its high CAPEX, might not be the best solution. FEED studies must be more innovative in their thinking. If plant site investments are already in place, improved-margin and lower-cost retrofits should be taken into consideration, while simultaneously improving chemicals production and site margins. ●

**TABLE 1.** Oil-to-chemicals SWOT analysis

| Strengths | Opportunities |
|---|---|
| • LTOs, condensates and NGLs will be in plentiful supply and feedstock competitive<br>• At $50/bbl, LTO is equivalent to $367/metric t vs. naphtha at $550/metric t<br>• Long-term chemical growth + 5%–6% pa; fuels growth flat to 1% pa growth<br>• Higher margins by pursuit of this strategy | • Integrated refiners/chemical producers must think differently, not as primary fuel producers<br>• Lower CAPEX, modular oil-to-chemical units of 10,000 bpd (1 MM metric t/yr) are technically feasible<br>• Regional and site-specific opportunities exist; complexity and larger scale is not always the best strategy |
| **Weaknesses** | **Threats** |
| • Present commercialized options are still high in fuels production, 30 wt%–45 wt%<br>• Most of the interesting, new technologies are only in the pilot stage | • Majors (including ExxonMobil, Aramco/SABIC) are already developing technology positions<br>• Naphtha-based steam crackers are losing their competitive edge |

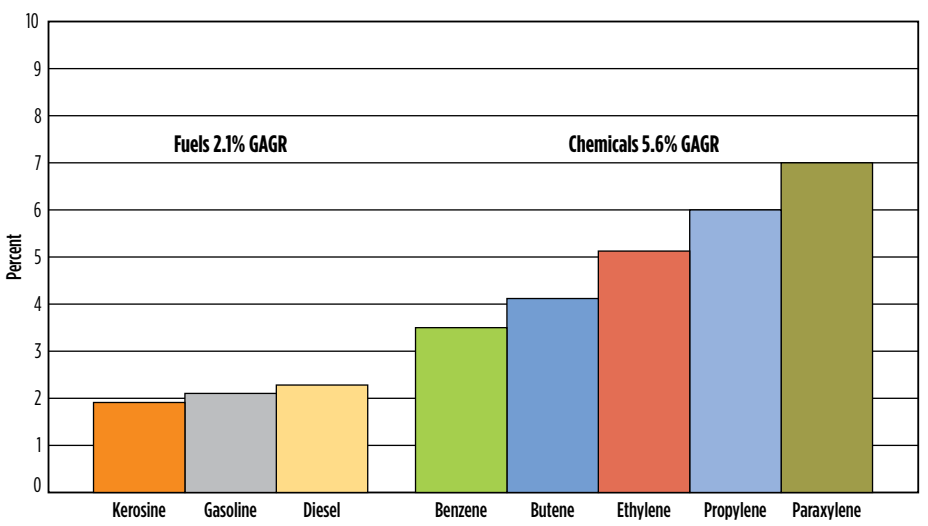


**FIG. 1.** Growth for oil-derived fuels (diesel, gasoline) vs. petrochemicals/chemicals (olefins, BTX, etc.).

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# CrudePLUS technology helps extend crude furnace run length

**CONRAD K. TERAN,** SUEZ Water Technologies & Solutions

A US refinery began processing a new blend of crude oils for the first time in conjunction with the startup of a crude unit. The slate introduced 30%–40% Eagle Ford crude to a blended stock of West Texas Intermediate (WTI) and Gulf Coast Sweet crudes. Due to the variable quality and paraffinic nature of the planned blends, the increased fouling potential on the unit was a concern, despite the light, sweet nature of the crude oil blend. Initial bench testing of the proposed fluids conducted prior to unit startup confirmed that the blend was severely incompatible.

To track crude blend incompatibility and fouling potential, SUEZ's CrudePLUS technology was deployed to enhance the fouling monitoring done onsite. Inclusion of this technology allows the team to better quantify system fouling potential, determine root causes and suggest corrective actions. CrudePLUS is a comprehensive service offering that couples advanced onsite analytical testing with proprietary predictive modeling software. The program predicts both instability/incompatibility and fouling potential of hydrocarbon fluids and blends quickly at the refinery site. The technology improves predictive accuracy over traditional approaches by directly quantifying the characteristics of the crude slate being processed and allowing these elements to be used as direct inputs to predictive models. Integral to the value provided are site-specific, recommended mitigation actions to minimize crude/blend processing difficulties. Processing difficulties addressed can include poor desalter performance, slop generation, poor brine quality and fouling.

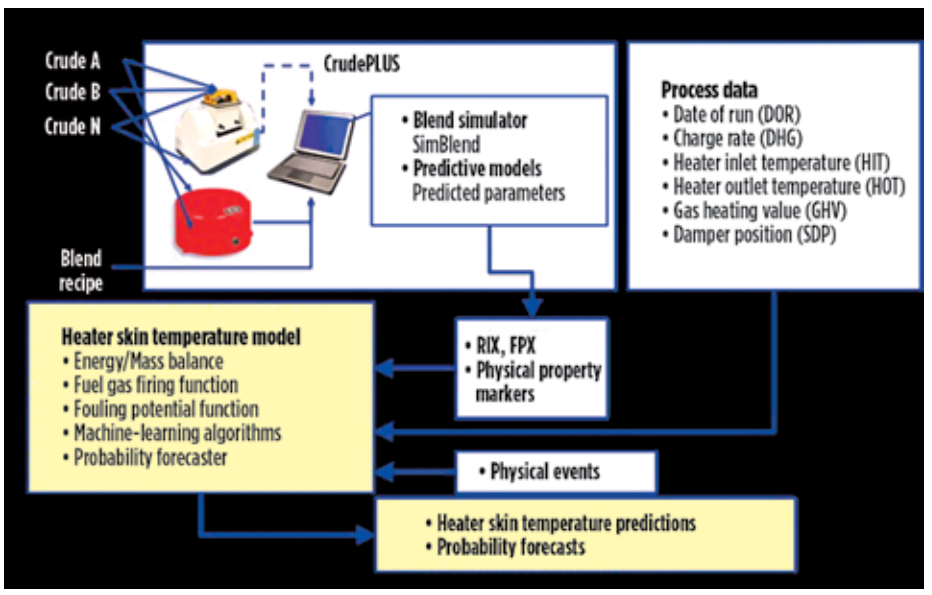


**FIG. 1.** The main components of the hybrid model.

CrudePLUS was used to provide early warning to potential processing issues and create an atmospheric heater skin temperature hybrid model to aid in monitoring, forecasting, troubleshooting and fouling mitigation.

**Analytics, instability and fouling potential, early warning.** Routine analysis of the crude blend processed on this unit continued to show consistently high blend incompatibility and fouling. It was clear from the very beginning that all the blends being processed fell in the severely unstable to critically unstable regions, with medium to severe fouling potential. This did not change over the course of the first year and is consistent with industry results when processing significant concentrations of US tight oil crudes. Given the severity of the instability observed, the preponderance of the fouling was expected at the atmospheric heater and, based on the fouling potential index, the type of fouling was deemed to be unconventional. CrudePLUS provided early warning of the severe fouling issues later observed in the atmospheric heater.

**Heater skin temperature hybrid model and forecasts.** The CrudePLUS technology also allows fluid behavioral and physical property markers to be quantified, making them digitally blendable—a break from the capabilities that have previously been possible. It allows for predictive hybrid model creation that more completely defines the fouling effects of any crude oil or blend dynamically, where pro-

▶ See CrudePLUS, page 20

## AFPM IN SESSION


**Top Left:** JERRY PRICE from Jacobs Consultancy Inc. led a well-attended session titled, "Oil to chemicals—What is it and how does it affect the US?" The session examined options that are being considered in OTC complexes, including technology configuration, petrochemical product portfolios and processing options, as well as how the this shift in products could create both threats and opportunities for the US.

**Top Right:** Stillwater Associates' MICHAEL LEISTER led the session titled, "Upcoming Changes to the RFS and potential impacts on program participants," as part of Tuesday's Priority Regulatory Issues track. Leister addressed and analyzed the changes that the US EPA will make to the RFS in 2018 and into the future, as well as the likely impact on renewable biofuels and various RIN markets.

**Bottom:** During Tuesday's technical session, "How the refining and petrochemical industries are advancing process safety," Moderator BEN MANNS (center) from Exxon Mobil Corporation guided a discussion on "Improving Human Reliability: Permit-to-work and fired heaters." Panelists WILLIS JERNIGAN (left) from Flint Hills Resources and MATT BROWN from Chevron U.S.A. Inc. offered opportunities for improvement that focused on hazard identification and practices; industry learning and outreach; human reliability; and mechanical integrity.

## AVEVA AND SCHNEIDER ELECTRIC'S INDUSTRIAL SOFTWARE BUSINESS COMBINE

AVEVA has combined with Schneider Electric's industrial software business to drive digital transformation across the asset and operational lifecycle for capital-intensive industries. This unmatched, end-to-end offering unlocks the power of two industry leaders to deliver improved profitability and operational excellence to maximize return on capital.

"88% of leaders in capital-intensive industries say that digitalization would increase their revenues," said Craig Hayman, CEO at AVEVA. "Yet less than half of these companies are actually in the process of adopting a digital strategy. This represents an incredible opportunity for AVEVA to be our customer's digital transformation partner."

The combination brings together AVEVA's design, engineering and construction capabilities with Schneider Electric's industrial software business, which ranges from simulation to real-time manufacturing operations management. This combination creates a global leader in engineering and industrial software, expanding the markets and industries the company serves. Customers can benefit from improved profitability, efficiency and performance.

"Digitalization demands a fundamental rethink of the way organizations operate. They need to be confident that their technology investment will deliver a high return on capital and can lower the total cost of asset ownership. AVEVA's combination of proven solutions, industry-specific knowledge and a global partner ecosystem will drive innovation across capital-intensive industries, as companies plan their digital transformation journey," Mr. Hayman added.

AVEVA has more 4,400 people across 80 locations in more than 40 countries. Industries served includes chemical; oil and gas (upstream, midstream and downstream); power and utilities; shipbuilding; water and wastewater; food and beverage; infrastructure and smart cities; life sciences; and mining, minerals and metals.

# Holistic approach for a secure last line of defense

The future of the process industry is digital. Digitization holds many opportunities for plant operators to enhance efficiency, increase flexibility and make their plants future-proof. At the same time, the growing level of automation and connectivity can open the door for serious threats to plant security. In recent years, large-scale professional cyberattacks and chip hardware vulnerabilities affecting industrial plants around the globe have clearly shown the need for the process industry to take cybersecurity seriously. Plant operators should implement a holistic functional safety approach that ensures plant security in times of increasing cybercrime.

In late 2017, a safety controller deployed in a Middle East process facility was successfully hacked. The safety instrumented system (SIS) was compromised and a plant shutdown was initiated. While no damage or injuries occurred, the incident should serve as a wake-up call to heighten awareness of cybersecurity in the industry, as it was the first publicly-known successful attack on an SIS—the last line of defense in any process plant. Furthermore, critical hardware vulnerabilities affecting most modern processors have recently been identified. Attack modes such as Meltdown and Spectre exploited these vulnerabilities to steal data from computers all around the world.

"In both of the above-mentioned cases, HIMA safety controllers were not affected. However, we take these incidents very seriously and work hard to always be one step ahead," Dr. Alexander Horch, Vice President of Research, Development & Product Management at HIMA, commented. "It is important to note that there is no such thing as 100% guaranteed safety or security. By choosing the HIMA holistic functional safety approach, which protects the core SIS as well as its environment, plant operators get the maximum level of safety and security possible."

**A holistic and complementary approach.** The purpose of modern functional safety solutions is to reduce safety and security risks to a minimum. A holistic approach is needed that not only includes the core SIS (final control elements, logic solver including I/O module and sensors), but also its environment, such as the engineering station, asset management tools (AMS), handhelds, field entry panels and HMIs. By complementing the SIS with the HIMA Security Environment for Functional Safety (FIG. 1), all important security-relevant aspects of industrial control systems (ICS) are taken into account, including controller hardware and firmware, engineering toolkit, PC infrastructure, communication infrastructure and lifecycle management, as shown in FIG. 2.

In terms of firmware, a dedicated operating system specifically developed for safety-critical applications runs on HIMA safety controllers. The HIMA firmware, which is 100% HIMA software, provides an extremely low software error rate and has no backdoors implemented. It is impossible to access the program code during operation, as application programs run within a container and no other parts of the CPU firmware can be accessed. On the hardware side, unused Ethernet ports can be disabled and/or locked physically. Thanks to the total separation of SIS and basic process control functions and systems (BPCS)—according to the requirements of the standards for functional safety (IEC 61511) and automation security (IEC 62443)—no common cause failures can occur.

HIMA works with its own, single-purpose engineering tool SILworX (again, 100% HIMA software), which offers various security features such as two-factor authentication for project and controller data, a well-defined user management (including security admin role) and functional blocks with password protection (locking/read-only), just to name a few. By monitoring the application program via system variables, SILworX is even able to detect changes and to issue an alarm in case unauthorized changes are made.

**Securing the communication infrastructure.** The HIMA security environment relies on the proprietary protocol for controller communication SafeEthernet, and the communication stack is Achilles certified by Wurldtech. Separated protection layers between CPU and COM modules lead to an absence of feedback. Networks are clearly separated via firewalls and demilitarized zones, and the controller is tap-proofed to prevent ARP spoofing.

For an effective cyber-defense, the PC infrastructure should be set up with a secure BIOS management, reduced access rights and with only the required Windows services activated. Office laptops should not be used as engineering stations, which should be kept completely separate. PCs should feature an intelligent password management system and work with a minimal set of application programs only.

Finally, the lifecycle management must take security into account. HIMA safety systems have received various security certifications, such as Achilles, ISASecure, EDSA and TUV. The ISO 27001 certification for HIMA's information security management systems (ISMS) is ongoing. HIMA also carries out penetration tests together with customers, service providers and universities. Development takes place in a dedicated network, and access to source codes is strictly restricted and supervised. In standardization organizations like IEC and OpenGroup, HIMA experts are proactively driving safety and security standardization forward.

"Security is an integral part of HIMA services and engineering. In addition to cyber-secure hardware and software, we provide security awareness training, basic security checks of HIMA safety systems, product security training and security lifecycle services," explained Dr. Horch. ●


FIG. 1. The HIMA Security Environment for Functional Safety takes all important security-relevant aspects of industrial control systems (ICS) into account.

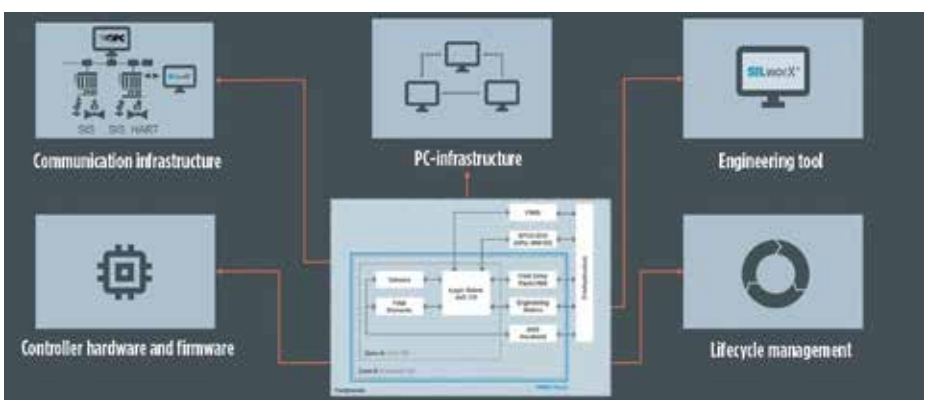


FIG. 2. Security in ICS depends on five areas.

# Signal focusing succeeds in radar level measurement in butane sphere

**TAI PIAZZA,** VEGA Americas

The VEGAPULS 64 80-GHz radar sensor for liquid level measurement is creating opportunities to use radar for liquid level measurement. A refinery in North America (NA) discovered that the non-contact radar sensor was the best available solution for accurate measurement in its butane storage sphere.

**The challenge.** The NA refinery processes between 100,000 bpd and 110,000 bpd of Alaska North Slope (ANS), Canadian and US shale crudes to manufacture a variety of products, including gasoline, diesel and residual fuel oil. One of the hydrocarbons the plant produces is butane, a low-DK compound that refineries often use for gasoline blending or as a feedstock for other products.

The refinery stores butane in large spheres, approximately 55 ft in diameter. One feature of the immense vessels is a mounting nozzle, on which sits a 2-in. process connection where a guided wave radar (GWR) sensor was installed to measure the butane inside the sphere. Plant operators paired the GWR device with a mechanical float indictor in the hopes of securing a reliable liquid level measurement. Unfortunately, the GWR/float combination worked only intermittently. The refinery did not face any danger of a shutdown or an overfill—it has a backup system in place—but the guided wave radar and float were a source of constant frustration. After seven years of inconsistent readings and frequent repairs, operators used a period of routine maintenance to find a more reliable level measurement.

**VEGAPULS 64: Last sensor standing.** The refinery refused to settle for another unreliable measurement technology, so users in the plant searched for a non-contact radar sensor that could measure butane without using a float or GWR in a stilling well. There was just one catch: the device must be mounted on a 2-in. isolation ball valve.

A valve that small on a sphere that large will provide a challenge for any radar sensor. Ball valves contain many interior surfaces that reflect radar signals (**FIG. 1**). Given that these valves are often used in combination with a bleed ring to trap any gas leftover after the valve is closed, signal noise is often amplified. These reflections make it difficult to discern which signals are from the valve and which are from the media.

VEGA Americas recommended a VEGAPULS 64, the first 80-GHz radar sensor for liquid level measurement. The instrument's high transmission frequency creates a narrow radar beam, so fewer signals are created by the valve's interior, as shown in **FIG. 2.** By comparison, a conventional radar sensor with 26-GHz transmission frequency has a beam angle approximately three times the size of a VEGAPULS 64, making it a non-starter for the tight confines of a 2-in. ball valve.

Another reason that VEGA felt confident the VEGAPULS 64 would succeed in this application is its large dynamic range. This increased sensitivity to small signals makes the sensor compatible with poorly-reflective

▶ See **RADAR,** page 19

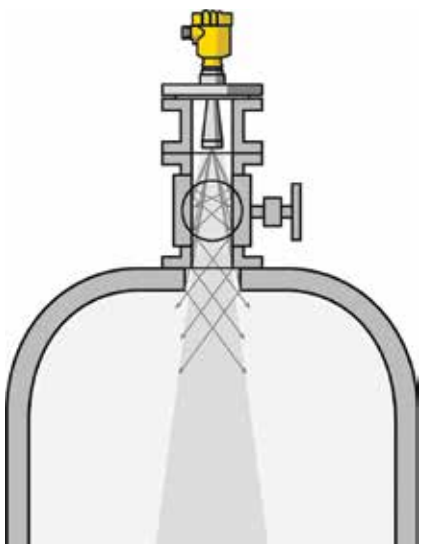

**FIG. 1.** 26-GHz radar sensors emit a wide beam that reflects valve internals, creating signal noise.

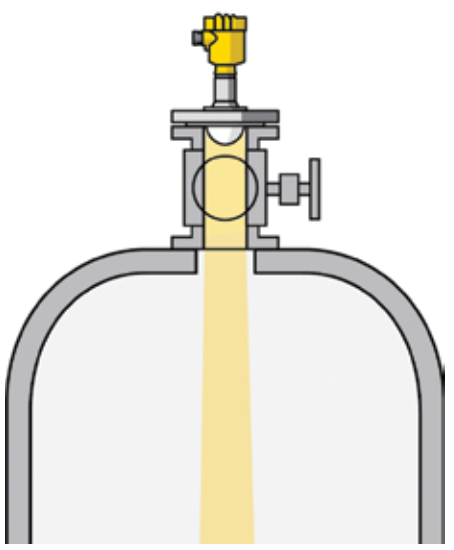

**FIG. 2.** The narrow radar beam of the VEGAPULS 64 misses internal valve surfaces.

# IIoT and the digital transformation

**TIM OLSEN,** Emerson Automation Solutions

Downstream industries like refining, petrochemical and chemical facilities are trying to better understand how the new buzz words—the Industrial Internet of Things (IIoT), Industry 4.0, big data, digital twin, IT/OT convergence and predictive analytics—can provide a viable return for any investment they make in this digital infrastructure. Frequent questions include:

- What are the vision and expected benefits associated with implementing a digital augmentation solution?
- Will this digital transformation allow for connectivity with experts within the organization, no matter their global location, and with solution provider subject matter experts (SMEs) outside the organization?
- How can I protect plant data and information from persistent cybersecurity threats?
- Can I maintain and add on to the implemented digital infrastructure, or will I always need lifecycle support from solution providers?

One digital strategy is providing information—analyzed data and actionable information that can improve the safety, availability and performance of the operation—to the right person at the right time to enable a proper response. Today, processing facilities are beginning to effectively utilize the abundance of process and asset health data and information as part of an overall IIoT strategy. Although a digital transformation will require investments in technology, one cannot forget the investment in training staff to improve and behave differently with the new timely information. It should be noted that some jobs will be replaced (e.g., manual data collection), new roles will emerge (e.g., analysts and planners), and other jobs will evolve to be more efficient.


**FIG. 1.** Control room operators should be presented with not just more data, but effective information (analyzed data) that allows timely decisions and actions.

**Providing improvements.** Online data from sensors has been available for decades, but a transformation is now taking place due to the low cost and quick installation time from IEC 62591 *Wireless*HART® sensors, when compared to their wired counterparts. Examples of wireless applications include:

- Vibration impact sensing of rotating equipment
- Ultrasonic leak detection
- Corrosion and erosion detectors (intrusive and non-intrusive)
- Flows, pressures, levels and temperature measurements.

These wireless sensors are providing additional insight into asset health at many process plants, enabling new and better ways to integrate work processes and improving the timeliness and accuracy of decisions. This awareness has resulted in lower maintenance costs and energy usage, while reducing downtime and mitigating the probability of a safety or environmental incident.

Significant improvements in plant performance are possible when the right expertise is applied at the right time, when personnel have the information they need to make quality decisions quickly, and when they have access to specialized supplemental expertise when they require it.

**Effectively utilizing the abundance of process and asset health data and information as part of an overall IIoT strategy is only the beginning—staff must be trained to effectively use this new information.**

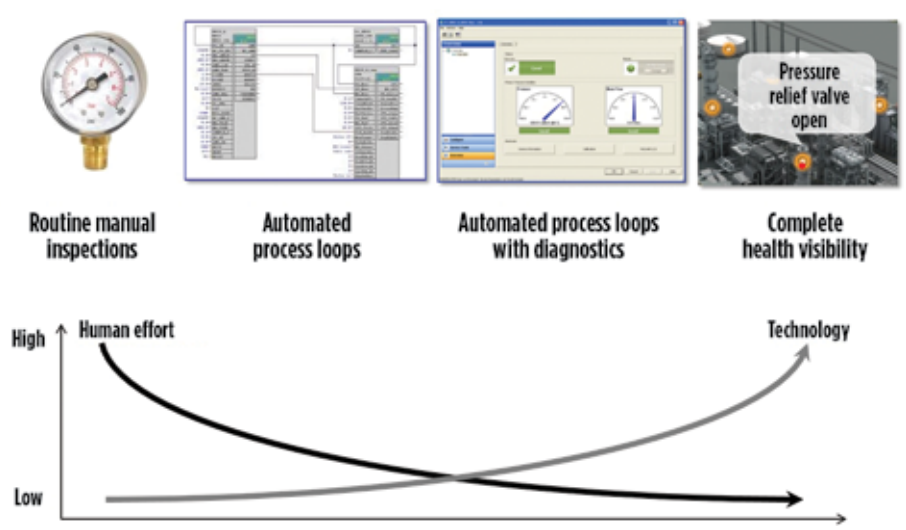


**FIG. 2.** For improved operation and profits, the new process and asset health measurements must be validated as quality data and automatically analyzed, alerted when abnormal, and acted on appropriately in time to prevent failure.

Most processing facilities are balancing the needs for safety, quality, profit, environmental compliance and reliability against the challenge of applying the right knowledge across organizational and geographic boundaries, while simultaneously reducing costs. Therefore, many companies are taking advantage of technologies such as enhanced KPIs and dashboards, remote monitoring and control, virtualization and digital twins, co-location of personnel and control room consolidation. However, questions remain about applying the correct technologies and techniques to get the greatest results, and what processes and behavior changes are required to attain these benefits.

**Understanding the complexities.** The traditional approach has been to collect and historize process data, and then only use the data to look back and evaluate *after* an incident. The new approach is to utilize the abundance of process and asset health data and predictive analytics software to automatically analyze data and turn it into information. This new approach looks forward and alerts *before* abnormal operation or imminent failure, thereby providing the ability to take appropriate timely action to avoid asset failure.

Determining how to benefit from these technologies and processes can be complex, and requires industry and technology expertise, plus a deep understanding of the company's strategic goals and the situations within its facilities. It also requires an understanding of the business workflow, operations and maintenance philosophies of the facilities, and the existing roles within the organization and the needs for collaboration between those roles. The emergence of digitization has noticeably increased the need for IT skills, and teamwork with OT is essential.

Today's modern automation systems include features not found in legacy systems, such as embedded advanced process control algorithms, statistical monitoring, smart device monitoring, asset health monitoring, data quality verification, and more. The control room operator can and should be presented with not just more data, but effective information (analyzed data) that allows the operator to make the required decisions and actions in a timely manner (FIG. 1). If the console operator continues to use the modern automation system in exactly the same way as the older replaced system, the benefits of additional functionality and information are lost. Think of the analogy of using a modern smart phone for only its phone call capability. This emphasizes the point that implementing a digital augmentation solution is only the beginning—staff must be trained to effectively use this new information, including changes in behavior, as required.

Business improvement opportunities include, but are not limited to:

- The opportunity to improve human interaction with the process equipment through the use of diagnostics and pervasive measurement and analysis.
- Lower maintenance costs through more planned condition-based maintenance rather than reactive maintenance, with consequential improvements in process availability.
- Appropriate time to analyze work practices and realize the benefits of changing to the new environment that technology offers, and to plan for appropriate training requirements
- Connectivity to experts around the world, whether for equipment or process operating advice, both within the organization and from external experts.
- Opportunity to relocate the control room and experts offsite, reducing the number of personnel that are physically located within the plant.

For operations, it will be necessary to examine what information is required in the field and to consider the benefits of replacing manual data logging with automatic transmission. Regular operator rounds can still be part of the routine for continuing to monitor abnormal situations, such as drippy pump seals, steam leaks or other noticeable leaks, odd sounds, etc. For maintenance and reliability, the best practice is to respond to work orders issued by planners utilizing automated online analysis of current asset health conditions.

**Key learnings.** Advances in automation and wireless technologies have enabled processing facilities to invest in additional measurements, but that is only the beginning. For improved operation and profits, the new process and asset health measurements must be validated as quality data and automatically analyzed, alerted when abnormal, and acted on appropriately in time to prevent failure. The new information should not create confusion when an alert is triggered, so training staff to use this new insight is part of the behavior transformation (FIG. 2). This also means that staff can now focus on higher value tasks, such as operating efficiently and reliably, while maintenance focuses on repair and maintenance rather than hunting for problems with manual checks in the field.

Combining IIoT strategies that are integrated with pervasive sensors from both process and asset health that generate timely information, with trained staff to take appropriate actions is an extremely effective way to improve plant safety, operational effectiveness, enhanced competitiveness and, ultimately, profitability. ●

# Operating intelligence software helps plant owners be ready for anything

With a lot of moving parts and a constant stream of data, oil refineries are complex. Without a single, integrated source of information, using data visualized from various sources is like using thousands of pictures to get a single view of the Grand Canyon—it is nearly impossible. However, by turning that data into value, plant owners can have one, real-time view of their entire operation *and* have it delivered directly to plant workers' mobile devices, giving them the information they need to make informed decisions faster.

Today, hundreds of hydrocarbon processing plants around the world employ Siemens' XHQ software to achieve operational intelligence, and excellence. Recently, a major US refining operation approached Siemens seeking a comprehensive, integrated solution to better monitor process conditions and protect its assets. To do this, the refinery operator needed to empower its plant workers with data in context. To achieve this, Siemens proposed its XHQ operations intelligence software.

**Maintaining the integrity of critical assets.** Integrity operating windows (IOWs) are an important means to maintain the integrity of critical refinery assets and process units. Siemens' XHQ operating intelligence software can help automate and manage many parts of an IOW program, and provide a real-time view of each refinery's operating status and performance. The software sits on top of a refinery's industrial control systems (ICSs) and several other systems (**FIG. 1**). It organizes and presents real-time operating data in context at a plant level and at a specific device level. Plant workers have remote and secure access to this data (e.g., capturing and monitoring temperature, pressure, flowrates, etc.) in the plant or wherever they are. More importantly, the data is presented in a way that is personalized specifically to provide immediate understanding.

**The goal: One view of all mission-critical data.** Today, the US refiner's operations are running much more smoothly because multiple streams of data now come together into one, easy-to-use, personalized, role-based dashboard that features live, animated views. At this operator's refineries across the US, XHQ software is pulling real-time data from process historians and many other sources, managing equipment limits, detecting excursions and issuing alerts if excursions do occur. Plant workers have access to data visualizations and animations that can be displayed on their laptops, smart phones and tablets with constant streaming updates.

The customer is pleased with this new way of gathering and viewing data, because it enables proactive management, condition monitoring, and prescriptive and predictive maintenance. Managers and designated field operatives have one consistent, common view of mission-critical operations that is updated every 10 sec–15 sec, and is available 24/7, 365 days per year. This single view of all mission-critical data in an easy-to-digest dashboard ensures faster, more informed decision-making.

Siemens' unique XHQ software program gives employees the same empowerment, flexibility and opportunity that technology affords them in their personal lives, and is redefining the way refineries operate. •

**FIG. 1.** XHQ Operations Intelligence Software delivers information in a clear, smart format for rapid decision-making.

# Sulzer designs, builds and installs 15 pump skids for pipeline conversion project

Large-scale projects typically involve many stakeholders, contractors and suppliers, which can lead to more challenges and increased complexity. Delivering such projects on time and within budget requires considerable coordination and management skills, traits that one US energy company needed to complete its most recent expansion project.

The locations of oil deposits are rarely close to a refinery, so it is necessary to use a series of pumping stations (FIG. 1) to transport oil from its source to the facility. The objective of this project was to convert an existing gas pipeline into a crude oil pipeline with a pumping capacity of 320,000 bpd of light crude.

Although this was a huge undertaking, the conversion was more cost-efficient and environmentally-friendly than constructing an entirely new pipeline. However, the project required the installation of new pumping equipment, a task that demanded considerable expertise.

**Braving the elements.** The challenge to design, manufacture, install and commission 15 pump skids in just 10 mos was awarded to Sulzer. Spanning three states, working through the cold, winter months (FIG. 2) and coordinating with seven different internal and external partners, this project presented significant challenges throughout its duration.

The whole project took years of planning and involved local authorities and power companies that, in many cases, needed to upgrade the electrical supplies to the pumping stations. These supplies dictated the size of the electric motors that could be used to power the pumps and, as such, formed the starting point for Sulzer, which supplied this equipment. New contracts had to be signed with the energy providers in each state to receive the necessary electrical supplies in line with the project's feasibility study.

The logistics required to expand the pumping stations and increase capacity were enormous, but such a project also needed expert design and management skills to succeed.

Sulzer understands the requirements of such projects, and the expectations of the client, which experienced less-than favorable results with a different supplier on a previous project, were very high. One of the most important steps was the appointment of the project manager, who would be the single point of contact for the client as well as collaborating with the other stakeholders and contractors.

**Delivering the best design.** The pumps for each pumping station were designed based on the data provided by the customer. For each location, information relating to the increase in head, pressure, flow, fluid viscosity and temperature dictated the design of each pump.

As a pump manufacturer, Sulzer has a wide range to designs that can be tailored to suit each application. In this case, the pumps were based on the HSB horizontal, axially split, single-stage, double-suction pump, which has a proven record of both reliability and efficiency in crude oil pipelines around the world.

Capable of pumping up to 45,000 gal/min (10,200 $m^3$/hr) at a head up to 1,800 ft (550 m), and able to operate with temperatures up to 400°F (200°C) and pressures up to 2,200 psi (150 bar), the HSB pump is extremely versatile. Its versatility is matched by its precision design that ensures smooth running and durability, as well as ease of operation and maintenance.

**Tailored to suit each application.** The pump skids (FIG. 3) were designed to typical pipeline configurations, but tailored to the customer's specific requirements, including figures for energy efficiency. In projects of this scale, pump efficiency can be the deciding factor in the operational profit of the pipeline. Every manufacturer that bids for these contracts must be able to deliver excellent performance in terms of reliability and efficiency.

Dana Vilsack, Project Engineer for Sulzer, said, "Every pump will have its own performance curve, and each one must meet the minimum requirements presented by the customer. Even small improvements in this figure can have a significant impact on the running costs of a pumping station. Multiplying this across 15 units will offer substantial savings in annual running costs."

A typical pump in this project might require a 2,800-hp (2,100-kW) power input to deliver a flow of 9,300 gal/min (2,100 $m^3$/hr) with a head of 825 t (250 m), depending on the specifications for the pumping station. In each case, the design was scaled and fine-tuned to meet the exact requirements for each location. In this way, the optimum pumping conditions and efficiency could be maintained throughout the pipeline.

**Keeping on track.** The customer fully understood the complexity of this project and the logistical challenges that it presented. To minimize the management burden, the major contractors on the project were chosen for their expertise and their ability to deliver large sections of the work in-house. In Sulzer's case, the pump expertise was already proven, but as a turnkey solution provider, it could also manage the transport and installation of the pumps, as well as the supply of the electric motors.

The delivery of such a complex project required in-depth planning to ensure it would be both cost-effective and delivered on time. Careful coordination of both internal and external suppliers was essential to keep the work on track. Above all, it was the flexibility of the team that would enable the successful completion of this crucial project.

"This was one of the most organized and cooperative projects I have been a part of," Ms. Vilsack continued. "The collaboration between the divisions of Sulzer and with the external partners, the supportive leadership and the display of outstanding teamwork resulted in a synergy few can match. This made for a very happy customer."

Hard work, dedication and the ability to adapt to an ever-changing schedule were just a few of the many traits that the Sulzer team exhibited throughout the duration of this project. The collaboration between the Sulzer team and the client's representatives proved to be successful, allowing everyone to concentrate

▶ See SULZER, page 20

**FIG. 1.** The conversion of an existing gas pipeline into a crude oil pipeline required the installation of new equipment at a series of pumping stations.

**FIG. 2.** Working through the winter months was one of many challenges that were overcome during the course of the project.

**FIG. 3.** The Sulzer pump skids were designed to typical pipeline configurations, but tailored to the customer's specific requirements.

RADAR, continued from page 15

products like butane. From a signal-focusing and software perspective, the VEGAPULS 64 was the right level instrument for the application.

The focused radar beam of the VEGAPULS 64 delivers clear signals even when mounted in complex applications.

**The impact of reliable level measurement.** After seven years of unreliable level measurement in its butane sphere, a high volume of maintenance calls and a mountain of frustration, users in the refinery were eager for an accurate, durable process instrument. The VEGAPULS 64 exceeds all expectations. The radar level sensor's hyper-focused beam is the ideal solution when combined with a ball valve because it minimizes signals reflected from the valve's surface, giving users a clear measurement reading.

The sensor's 98-ft measuring span means that it has no difficulty within the large sphere, and the instrument's sensitivity means it receives consistent, reliable signals from butane, a low-DK liquid. Gone are the days of frequent maintenance calls, and users in the refinery enjoy accurate level measurement in a once-trying application.

Key benefits include exact measuring results independent of process conditions, high plant availability due to reduced wear and maintenance-free operation through the non-contact measuring principle. •

# A new dawn for ICS vulnerabilities

**DAVID ZAHN,** PAS

The number of industrial control system (ICS) attacks has risen eleven-fold since 2010, according to ICS-CERT, with the biggest jump coming in 2017. Industry has seen attacks, such as TRITON/TRISIS and CRASHOVERRIDE/INDUSTROYER, achieve success asserting control in process control networks. These attacks and others have shown that traditional security controls of air gapping and security by obscurity are anachronistic. As a result, we are seeing investment flow into securing process control environments, with a first step of gaining better visibility into what assets are within a facility. In parallel, asset owners and security personnel are realizing that systems responsible for running volatile processes and ensuring safe operations are rife with vulnerabilities—many of which have remained hidden for years.

On January 16, 2018, PAS released a major version of our ICS cybersecurity software, Cyber Integrity™ 6.0. In this release, we added a new capability: continuous ICS vulnerability management. Today, it is difficult for enterprises to know where they are vulnerable in an industrial facility. When ICS-CERT releases a new advisory—in this case, for a Level 1 cyber asset—if security personnel are monitoring those advisories, they must rely on email responses from each of their facilities to know if a risk exists. The facility typically depends on spreadsheets to know which cyber assets they actually have. Unfortunately, these spreadsheets are incomplete, inaccurate and dated due to the manual nature of data collection. Email responses on vulnerability risk exposure are, therefore, ultimately incomplete and inaccurate.

PAS Cyber Integrity now imports published vulnerabilities from the National Institute of Standards and Technology (NIST) National Vulnerability Database (NVD), and automatically compares them to the multi-vendor inventory it collects for Level 0, 1 and 2 assets in a facility. With automated vulnerability assessment, remediation and mitigation workflows, closed-loop patch management and dashboards, enterprises now have a continuous vulnerability management solution that spans the major industrial control systems in a fleet.

Industry rightly continues to focus on protecting itself in this new dawn of industrial process-savvy attackers. Effective protection relies on attaining visibility into outsized risk from ICS vulnerabilities. This knowledge informs a strategy that gives asset owners and security personnel a fighting chance on maintaining safety and reliability standards. Do you know what your risk is from hidden vulnerabilities in your facilities? •

**David Zahn** joined PAS in 2014. As CMO and GM of the Cybersecurity Business Unit, he leads corporate marketing, product management and strategic development of the PAS Integrity Software Suite. Mr. Zahn has held numerous leadership positions in the oil and gas, information technology and outsourcing industries, including Vice President of marketing at FuelQuest, COO at Consero Global Solutions and Director of product management and marketing at Motive. He earned a BA degree in economics and managerial studies from Rice University in Houston, and an MBA from the McCombs School of Business from the University of Texas at Austin.

# EIA: 2017 US crude oil exports reached 1.1 MMbpd

According to the US Energy Information Administration (EIA), US crude oil exports grew to 1.1 MMbpd in 2017—or 527,000 bpd (89%) more than exports in 2016—in the second full year of unrestricted US crude oil exports. Increased US crude oil exports were supported by increasing US crude oil production and expanded infrastructure, resulting in lower domestic crude oil prices when compared with international crude oil prices.

This is the largest single year-over-year increase of a petroleum (crude oil and petroleum products) export since 1920.

**Expanded reach.** US crude oil exports reached 37 different destinations in 2017, compared with 27 in 2016. Similar to previous years, Canada remained the largest single destination for US crude oil exports, but its share of total US crude oil exports continued to decrease, down to 29% in 2017 from 61% in 2016. US crude oil exports to China accounted for 202,000 bpd (20%) of the 527,000 bpd of the total increase, and China went from being the fourth-largest destination in 2016 to the second-largest destination in 2017.

Many European nations are among the largest destinations for US crude oil exports, including the UK, the Netherlands, Italy, France and Spain. India, which did not receive US crude oil exports in 2016, received 22,000 bpd in 2017, tying with Spain as the 10th-largest destination.

The large increase in US crude oil exports in 2017 now makes crude oil the third-largest petroleum export after hydrocarbon gas liquids (HGL) and distillate exports, representing 18% of total petroleum exports. Before the restrictions on domestic crude oil exports were lifted in December 2015, most of the growth in US petroleum exports was petroleum products—mainly HGLs, such as propane, or distillate fuel and motor gasoline (FIG. 1). Previously, the largest share of total US petroleum exports for crude oil was 13% in 1999, but the total volumes of US petroleum exports were significantly lower, less than 1 MMbpd compared with 6.3 MMbpd in 2017.

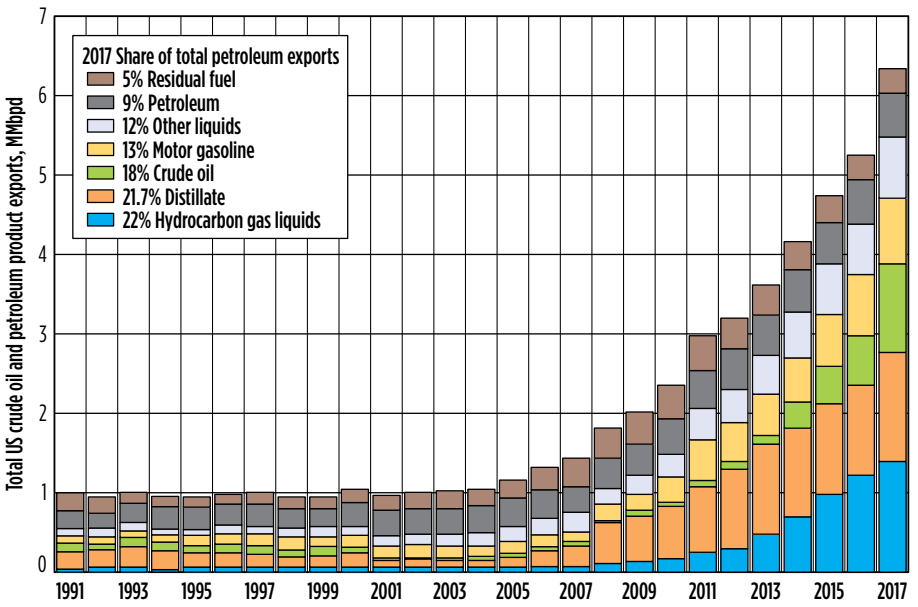


FIG. 1. Total US crude oil and petroleum product exports. Source: EIA.

**Expanded capacity and infrastructure.** Increasing US crude oil production and expansions in US pipeline capacity and export infrastructure facilitated increasing US crude oil exports. US crude oil production increased by 463,000 bpd from the 2016 level, to 9.3 MMbpd in 2017. At the same time, several new or expanded pipelines came online in 2017 to move crude oil from producing regions—primarily the Permian basin of Texas and New Mexico—to the US Gulf Coast. On the US Gulf Coast, recently expanded crude oil export infrastructure in ports such as Corpus Christi and Houston, Texas, and in ports along the Mississippi River in Louisiana allowed larger volumes of crude oil exports.

A larger discount of domestic crude oil prices, represented by West Texas Intermediate (WTI) crude oil prices, to international crude oil prices, represented by Brent, reflects these dynamics. Spot Brent crude oil prices averaged $3.36/bbl more than WTI prices in 2017, compared with just $0.40/bbl more in 2016, providing a price incentive to export US crude oil into the international market.

Similar production, infrastructure and price conditions will be necessary for US crude oil exports to continue increasing. EIA's March *Short-Term Energy Outlook* forecasts US crude oil production to increase by 1.38 MMbpd in 2018, and the Brent-WTI spread to average $3.96/bbl.

In February 2018, the Louisiana Offshore Oil Port (LOOP)—the only place in the US where very large crude carriers (VLCCs), the largest and most economic ships to transport crude oil, can fully load—loaded its first crude oil export cargo. Until this point, LOOP was only used to import crude oil. However, almost none other ports in the US are deep or wide enough to allow safe navigation of fully laden VLCCs. Widening and deepening US ports and waterways to ensure safe transit of VLCCs is costly and would take many years, making wide-scale expansions of US ports unlikely. •

SULZER, continued from page 18

on their core responsibilities. This included Sulzer's onsite teams that helped with the alignment of both the skids and the associated pipework, ensuring that it was installed with minimal strain on the pipes.

**Turnkey delivery.** The success of the project began with the decision by Sulzer's project manager to work onsite rather than in one of the remote company offices. This enabled the project manager to deal directly with all interested parties, provide more hands-on project management and maintain the momentum of the project to ensure that all milestones were met.

The greatest challenge in a project of this scale is the logistical effort required to build and install all the pumps in a way that is carefully coordinated with the build schedule of the pumping stations themselves. With so many other contractors involved with the construction of the buildings and the installation of the pipework, effective project management was essential for the timely completion of the scheme.

For Sulzer, the project involved almost every aspect of its business, from the engineers who designed the new pumps, to the manufacturing sites that produced and tested every pump, to the field service teams and electromechancial engineers who provided support to the installation teams.

Thanks to Sulzer's collaborative approach and proactive management, the project was delivered on time and within budget, with all of the pump skids commissioned and operating successfully. The client was impressed that it was possible to deliver such a demanding project successfully. •

CrudePLUS, continued from page 12

cess data is readily available. FIG. 1 illustrates the main components of the hybrid model created to predict the leading tube skin temperature for the atmospheric heater in this crude unit.

The heater model and the various events and forecasts during the first year of operation are shown in FIG. 2. In addition to the initial feedback of high fouling potential, three additional warnings were given at days 50, 100 and 140 of the run. On day 140, a probability forecast made using the model projected the skin temperature to reach its maximum limit of 1,150°F on day 299 of a planned 1,460-day run. While a chemical treatment program could have been implemented at that point to help reduce fouling on the unit, potential mechanical and operating recommendations were also discussed. Shortly after the forecast was made, a series of specific mechanical actions were implemented, as shown in the green text in FIG. 2. The new processes significantly reduced fouling rates, extending the projected run to 735 days—a significant improvement, but very short of the desired end of run.

**The path forward and further improvements.** Given the state of the heater and after exhausting all possible alternatives, and short of changing crude blends (which was not an option), the obvious question was, "Does it make sense to start an effective anti-foulant at this point?" While chemical treatment would significantly reduce the fouling rate on the equipment beyond that attained by the actions taken, the danger of potential sloughage and plugging of accumulated fouling material may outweigh the potential gains from treatment.

Given the experiences over the first year of this operating run, additional actions are recommended to be implemented immediately after the next unit turnaround or heater shutdown and subsequent cleaning. A crude stabilizer injection in the tank farm to minimize crude instability and an unconventional antifoulant injection in the crude preheat will help further reduce preheat and heater fouling rates.

Combining chemical treatments with the mechanical and operational actions implemented are expected to extend the crude heater operation an additional four years before cleaning is needed, given the present operating conditions and crude diet. The enhanced monitoring program, utilizing onsite CrudePLUS technology and heater hybrid modeling, can continue to provide rapid, dynamic feedback on unit fouling potential and suggested program modifications as conditions and crude diet continue to evolve. •

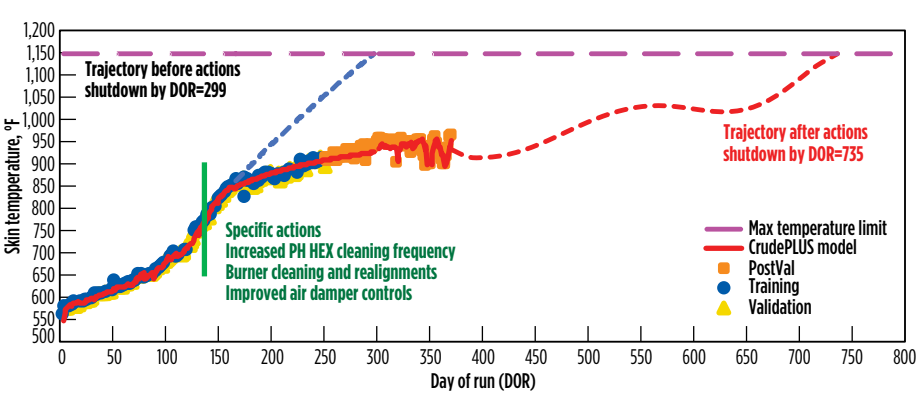


FIG. 2. The CrudePLUS heater skin hybrid model. The green text lists specific mechanical actions that were implemented.

# Ensure unit continuity with a tuned kinetic model

The rapid progress in digital technologies such as advanced analytics and high-performance computing is an opportunity for refiners to drive value through reducing downtime, increasing margins, and improving scheduling and planning. Criterion is leveraging these technologies to enable seamless sharing of data and auto-identification/notification of outliers in unit performance. Criterion's CatCheck™ Advisor is a virtual "tech services" assistant that utilizes machine-learning algorithms and pattern recognition to provide high-level recommendations based on analysis of catalyst performance data. Daily process and lab data is transferred seamlessly from the refiner to CatCheck, which filters out obvious errors, analyzes the data and highlights outliers based on predefined limits. It also compares present operation to a baseline, and provides insight into where the catalyst activity is compared to the target at that point in the run.

Criterion has been using CatCheck internally and externally with refiners at the start of a new cycle. A Criterion TSE reviews the data and selects a stable period of operation that reflects the start-of-run performance. The average data for this period is automatically set up in a kinetic model, and the model parameters are tuned to match actual performance. This tuned model is available for monitoring catalyst deactivation as well as tracking KPIs such as conversion, yields and reactor exotherm. Using a kinetic model is a rigorous way to track deactivation, as it considers the impact of key variables such as hydrogen ($H_2$) partial pressure, feed endpoint, feed composition and rate, and feed/product property (e.g., sulfur in distillate units).

**Benefits of a kinetic model.** In one case, a ULSD unit processing straight-run feed experienced a rapid increase in weighted average bed temperature (WABT) that could not be explained by simple, sulfur-based normalization. Use of the kinetic model highlighted the fact that the feed density and nitrogen were much higher than usual and were primary contributors to the high WABT. The kinetic model captured the impact of these critical feed properties and confirmed that the step change in activity was due to feed changes and not rapid deactivation.

After further investigation and discussion with the refiner, the issue was traced to the reprocessing of coker-derived feeds in the crude tower, which lead to the presence of light coker gasoil in the straight-run diesel. The use of the tools to demonstrate such causes made the process more efficient and recorded the behavior for the refiner's benefit.

Learning from our upsets ensures that future symptoms are identified more quickly and accurately. A contributing factor in refinery performance is remembering what has happened—and when and why—so that the information is available for the engineer operating the unit. Expertly designed tools now ensure unit continuity and performance.

Criterion's newest additions to one of its more-seasoned tools allows web-based and mobile tool integration to make the tuned kinetic model available for use in challenging scenarios. In addition to benefiting from Criterion's industry-leading catalyst portfolio (FIG. 1), the company's customers have access to state-of-the-art tools that access kinetic models to help them extract the highest margins from their units. These tools can be used to evaluate impacts of planned or unplanned changes, and case studies, as well as to update LP vectors. ●


FIG. 1. The Criterion technology solutions family.

# SCENES FROM THE 2018 AFPM ANNUAL MEETING

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1 Axens' **Jean-Luc Nocca** and CEO **Christian Vaute** amazed visitors at the company's suite with an AI robot that spoke, interacted, sang and danced.

2 The expansive Hilton New Orleans Riverside provided AFPM attendees with numerous comfortable areas for informal meetings.

3 The true spirit of the host city was on display at the **KBR** suite on Monday night, with Mardi Gras performers and cool jazz.

4 AFPM attendees take every opportunity to expand their industry knowledge. Networking breaks provided refreshments and a chance to discuss the informative sessions.

5 The New Orleans-inspired **Linde** Lounge offered one of Monday evening's most unique experiences: an oxygen bar.

6 Gentlemen, place your bets. Casino nights are always a popular theme, and AFPM members enjoy the chance to test their luck against the odds.

7 Monday night at **Criterion's** "Walkin' in New Orleans" hospitality suite, a giant Louis Armstrong helped Criterion Catalysts, CRI Catalysts and Shell Global Solutions to celebrate Criterion's 30th Anniversary.

8 Whether diving under the ocean's surface or battling against virtual orcs, MaverickVR provided the guests of **Norton Engineering** with an unforgettable experience.

# 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

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