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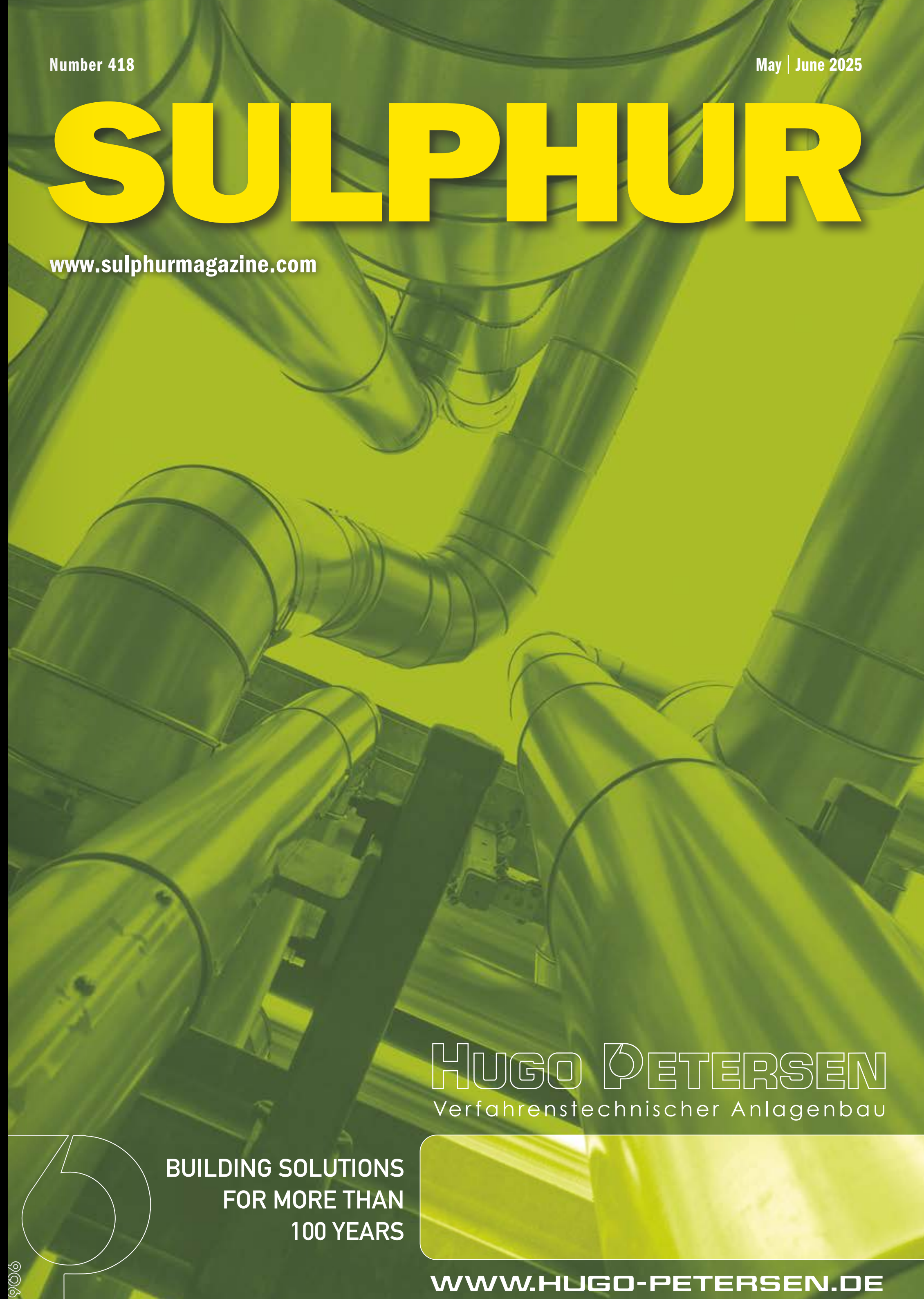

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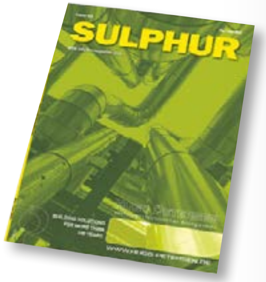
A new route for phosphates?



I am writing this freshly returned from the Sulphur Institute's annual Sulphur World Symposium in Florence (for more on that see pages 24-25), where one of the topics causing some excitement was the anticipated commissioning of a demonstration plant for Travertine Technologies' new Travertine Process. The plant is due to be commissioned at the Sabin Metals site near Rochester, New York in mid-2025 at a cost of $10.7 million. Capacity is put at "hundreds" of tonnes per year of gypsum processed, and removing "tens" of tonnes per year of CO_2 from the atmosphere.

The process converts magnesium or calcium sulphate wastes, such as phosphogypsum, into sulphuric acid and magnesium or calcium carbonate, using carbon dioxide which could come from an industrial source or, potentially direct air capture. Electrolysis is used to separate salts (and also generates some hydrogen), with sodium, calcium or magnesium hydroxides used to capture the carbon dioxide to carbonates, with potential use in cements. The sulphuric acid can then be used for any required use – Sabin will take the offtake from the demonstrator unit to cover half of their own acid needs for precious metals refining and processing – but the acid could of course equally be used for processing phosphate rock to generate phosphoric acid and more gypsum for the process. If the electrolysis uses renewable electricity (Travertine say that they plan to buy renewable energy credits) then the process is overall carbon negative, sequestering 0.75 tonnes of carbon dioxide per tonne of phosphoric acid produced. Travertine says that completely replacing the wet phosphoric acid process worldwide with its own flowsheet could potentially avoid 100 million t/a of CO_2 emissions.

> "The waste management issue is one of the things that reduces the competitiveness of the US phosphate industry..."

Feed for the demonstrator plant will come from extensive tailings from a disused gypsum mine at the site, but Travertine points out that the issue of phosphypsum wastes have effectively slowly strangled the US phosphate industry in Florida, where some of the phosphogypsum is mildly contaminated with radium – sufficient to make it unusable for industrial applications. The waste management issue is one of the things that reduces the competitiveness of the US phosphate industry against, for example, Morocco or Saudi Arabia, and no new US phosphate plants have been built since 1975. Travertine says that: "At scale, we believe Travertine can produce phosphate products at comparable cost to the WPA process, while eliminating the longstanding environmental cost and liability and definite social cost of building and managing phosphogypsum stacks."

Well of course, that remains to be seen. Converting insoluble sulphates back to sulphuric acid would certainly solve any potential issues that industry faces with falling sulphur recovery rates as refineries close or convert to biofuel production. But, as with any new process, the operating cost will be one of the key things to be determined by the new demonstrator plant. The potential application of carbon credits – assuming the Trump administration does not scrap the Inflation Reduction Act – will certainly assist with that, but I can't help remembering how the thermochemical Improved Hard Process for phosphate production has struggled with adoption against WPA due to its higher operating costs. In any event, it will be interesting to see where this leads us. ■

Richard Hands, Editor

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Price Trends

SULPHUR

Sulphur markets have been on a tear over the past few months, driven by strong demand in Asia, with buyers primarily sourcing from the Middle East and Canada through late 2024 and into the early months of 2025. Steady buying from Indonesia and China, the two largest importers of sulphur, appears to have supported the market, in China's case mainly for phosphate production as well as a variety of industrial processes, and in Indonesia's case to feed the high pressure acid leach (HPAL) plants that are producing nickel for the battery and stainless steel industries. Prices saw a notable rally following the Chinese Lunar New Year celebrations. Nevertheless, this momentum finally began to shift as April began ago as the pace of price increases in Asia started to slow. As the spring fertilizer application season in China draws to a close, domestic prices began to drop, reaching the equivalent of a delivered price of around $272/t c.fr. As well as the narrowing window for spring application of phosphates, the decline was also driven by weakening demand amid uncertainty over tariffs and export restrictions. In southern China, phosphate producers continue to purchase import cargoes. A major phosphate producer in southwest China has been reported as having bought mainstream material at a price of $303/t c.fr, according to local market sources. Total sulphur port inventories in China had declined by 22,000 tonnes to 1.86 million tonnes by 16 April 2025. The volume at Yangtze River ports increased to 825,000 tonnes, while the port inventory at Dafeng decreased to 400,000 tonnes.

Demand in Indonesia appears to have also slowed, with no reports of transactions to the Southeast Asian country in mid-April. The most recent transaction at time of writing was priced at $299/t c.fr. Despite offers around $300/t c.fr, Indonesia has yet to commit to prices higher than those seen in the last transaction.

India, which has been experiencing upwards pressure in its prices as a result of the purchasing dynamics in China and Indonesia, has also turned bearish with a wait-and-see approach now taken by buyers in the country. Domestic supply has covered some of the demand gap while importers await clearer price signals in international markets.

As a result, both the Middle East and Vancouver prices were assessed unchanged. The two regions had supported the current price environment as they were key in meeting Asia's sulphur demands. As this demand has weakened, so have the price increases across both supply locations. Indeed, the price in the Middle East has remained unchanged for around a month. While Indonesia continued purchasing from the region, China sought alternatives, sourcing from countries such as Iran and Uzbekistan. Indonesia's demand had been sufficient to maintain the current price level, but future price movements will likely depend on whether Indonesia is willing to match the Middle East price or decide to venture into alternative regions to procure volumes.

The only other price movement in mid-April occurred in the Mediterranean where the delivered price increased to reflect the latest business in the region. Although the f.o.b. price was assessed unchanged, it is bullish and likely to move upward soon. The Mediterranean has functioned as a safeguard for countries in the vicinity that can purchase from either the Middle East or the Med. As a result, the region has been impacted by market trends but has remained mostly insulated from the volatility seen in other sulphur markets.

As far as tariffs go, sulphur produced in Canada complies with USMCA legislation, imports will be exempt from the 25% tariff on Canadian goods into the US. US sulphur consumption is primarily sourced by local availability, and only a minor share is met by imports: imports account for around 20% of total demand, and Canada is the primary supplier, making up 90% of total purchases.

SULPHURIC ACID

Global sulphuric acid benchmarks were mostly stable in April, with price changes concentrated in supplying countries in Asia. Meanwhile, demand in Chile has softened, as a wait-and-see approach takes hold of the South American market. Throughout most of 2024 Q4, the sulphuric acid market was marked by limited spot activity, as tight supply coincided with weak demand. However, this shifted towards the end of February when a surge of volumes from Turkey and Bulgaria entered the market, triggering a sharp drop in European prices, from $110–120/t f.o.b. to just $60–65/t f.o.b. within three weeks.

The influx of volumes quickly met demand across delivered markets, but a furnace issue at Chile's Altonorte copper smelter forced a halt in operations, increasing demand from Chilean buyers seeking to replace lost supply. However, demand in Chile weakened recently as buyers have secured enough supplies to compensate for the volumes lost due to the Altonorte smelter shutdown, according to market participants. Even so, with the smelter still offline, demand could come back if the purchased volumes prove insufficient until the smelter resumes operations.

Prices in Europe remained unchanged. Despite tighter availability, a surge in demand from Chile previously helped push prices upward. With demand in Chile now softening, the volume of transactions from Europe has decreased, keeping prices stable. Still, with availability tightening, the price is sustained and prone to bullishness, according to market participants.

In Brazil, the recent award of the Timac tender has kept prices steady. A number of tenders across Latin America are believed to have been awarded within a similar price range, according to market participants, but this could not be confirmed at the time of writing. Demand remains stable in Brazil, and with Chile currently covered, other countries in the region are expected to help maintain the current price environment in the Western hemisphere.

Tight availability in Japan and South Korea has restricted spot transactions, and this situation is expected to persist throughout Q2. As a result, a number of forward transactions have occurred. While these transactions don't meet CRU's criteria for inclusion in its weekly assessments, they have still influenced the market, with indications suggesting a price increase.

By contrast, China is seeing more activity, but it is split between domestic and international markets. The domestic price had been driving volumes away from the export market, but improved availability has resulted in downward pressure as international market players reject higher quotations for volumes at and above $80/t f.o.b. The price range has narrowed with the previous higher end no longer considered viable.

Tariffs have the possibility of affecting the US market, which faces a significant structural deficit, with imports consistently totalling over 3.0 million t/a for the last decade. Acid production in the US has declined in the last three years due to a weak performance of the phosphate sector, which has led to reduced sulphur burnt acid supply. Total consumption has not declined at the same pace, and sulphuric acid import requirements have increased. The US imported 3.5 million t/a of acid in 2024, and Canada and Mexico were the primary sources, with a share of 55% and 18%, respectively. The EU also sourced a significant allocation, accounting for 20% of total sales. Sulphuric acid imported from Canada and Mexico should also remain exempted from tariffs as the product is understood to be covered by the USMCA legislation. However, implementing tariffs in the EU would directly impact the cost of seaborne sulphuric acid, as the region will be levied a 10% tariff.

The North American acid industry has developed with a mutual interdependence between US importers and Canadian/Mexican exporters. The introduction of tariffs would be unlikely to change these physical flows as logistical alternatives for both buyers and sellers would be near impossible to find. Canadian volumes typically enter the US in the northeast from smelters in eastern Canada, but the end-use markets span all major demand areas including southern US states. Mexican acid typically enters the US via Texas and Arizona with consumption focussed on the copper market. Mexico has more potential options to sell acid to alternative markets, but at this point some of these are theoretical. Mexico has historically exported acid through the port of Guaymas, but this route has been closed since an acid spill at the port in 2019. Seaborne exports from Mexico have fallen from around 40% of total sales in 2018 to only 20% in 2024.

The final challenge in any consumers' attempt to replace Canadian or Mexican acid is the availability of supply in the international market and limits to import infrastructure at US ports. The global sulphuric acid market is expected to have some increase in availability in 2025, but the scale of change is relatively minor. Import infrastructure is a larger challenge as seaborne imports to Texas were already at the highest ever recorded level in 2024. Similarly, volumes moving through California are at historical highs. Imports to Louisiana, Georgia and Florida are currently below historical highs, but the gap only equates to around 200,000 t/a. ■

Price Indications

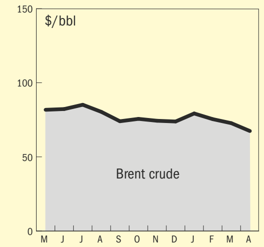
Table 1: **Recent sulphur prices, major markets**

Cash equivalent	December	January	February	March	April
Sulphur, bulk ($/t)					
ADNOC monthly contract	165	174	174	206	280
China c.fr spot	184	184	223	285	300
Liquid sulphur ($/t)					
Tampa f.o.b. contract	116	165	165	270	270
NW Europe c.fr	193	214	214	214	274
Sulphuric acid ($/t)					
US Gulf spot c.fr	143	143	137	125	143

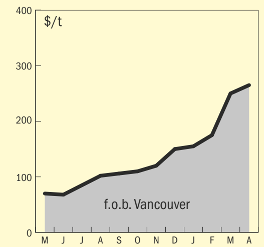
Source: CRU

END OF MONTH SPOT PRICES

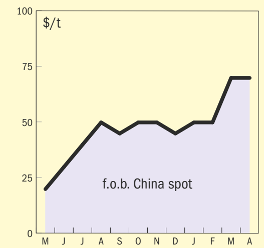
oil



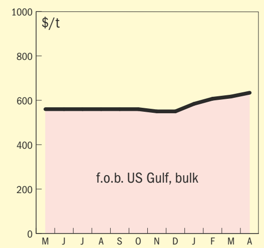
sulphur



sulphuric acid



diammonium phosphate



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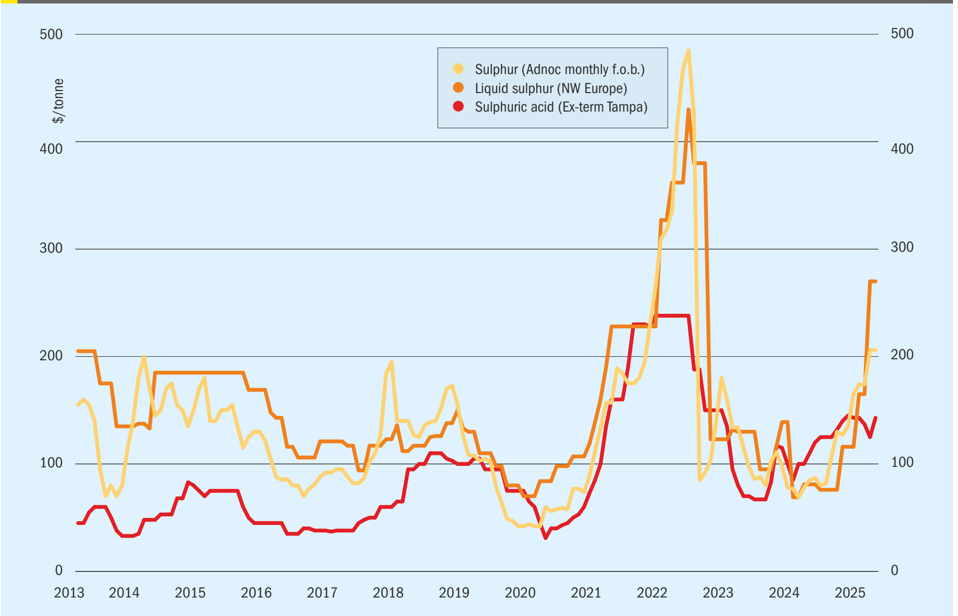
Market Outlook

Historical price trends $/tonne



Source: BCInsight

SULPHUR

- Global sulphur prices are expected to stay relatively stable as purchases in Asia slow down due to the closing of the purchasing window for the Chinese spring fertilizer application season.
- Overall, the number of transactions worldwide is likely to remain limited, as other markets adopt a wait-and-see approach to prices in supplying regions.
- On the supply side, China's below average port inventories have drawn attention from Russian exporters. This shift in trade flows could add another layer to eastern hemisphere markets, with more Russian volumes likely heading to East Asia in the near term.
- The increasing importance of Indonesia is reflected in record sulphur imports, which surged 248% year-on-year in January–February, reaching 914,000 tonnes, according to Global Trade Tracker (GTT). The volumes imported during February, which were 565,000 tonnes, represent the highest volumes imported during a single month in the last five years. In 2024 Indonesia imported a total of 3.6 million t/a, which surpassed the previous annual record of 2.7 million t/a in 2023, and which itself was 31% increase on the previous year.
- With global market prices largely stagnant, market participants are closely watching the outcome of the latest tender in Qatar as a possible price signal. It has been suggested that the tender was awarded at a price above $300/t f.o.b., but this could not be verified at the time of writing.

SULPHURIC ACID

- Overall, global sulphuric acid prices are expected to remain relatively stable in the coming weeks.
- In Chile, demand is likely to persist, but its strength will depend on the timing of the Altonorte smelter's restart. The market will likely see limited activity for the next few weeks as buyers await further developments, according to market players.
- In China, the interplay between domestic and export prices will likely limit transaction activity across the Eastern hemisphere. Availability has improved, regardless of whether placed locally or for exports, according to market participants. As a result, the price is feeling a degree of downward pressure, particularly on the high end with the market reluctant to purchase at higher than $75/t f.o.b.
- Indian buyers have also returned to the market, adding upward pressure to a supply-constrained environment. East coast demand remains quieter for now but may pick up in anticipation of future cargo requirements.
- Additional domestic availability may emerge from Adani's copper smelter, which is expected to come online around June-July. The smelter could provide incremental relief if commissioning proceeds as scheduled. The smelter has a capacity of 1.5 million t/a of acid

Sulphur Industry News

KAZAKHSTAN

Work progressing on Kashagan

Kazakh state gas company QazaqGaz says that work is progressing well and on schedule on the 1 billion m3 expansion project at the Kashagan Gas Processing Plant. A recent site report says that seven absorption columns have been installed at the sulphur treatment unit (each weighing between 50-170 tonnes); three sections of the smokestack have been installed at the sulphur recovery block, along with storage tanks and pumps for the heat carrier, instrumentation air, and nitrogen supply units; and a total of 2,177 t of process equipment has been installed. Welding works for tank assembly are ongoing, and over 12,000 meters of underground piping have been laid, and more than 38,000 cubic meters of concrete have been poured.

Once completed, the project is expected to increase the country's commercial gas reserves by 727 million m3/year, produce 115,500 t/a of gas motor fuel and feedstock for organic synthesis (LPG), 17,000 t/a of stable gas condensate for petrochemical industries, and 218,500 t/a of granulated sulphur.

SAUDI ARABIA

Axens expands TGT catalyst production

Axens says that it has completed the expansion of its Axens Catalyst Arabia Ltd site, aimed at providing local and regional partners with the latest tail gas treatment catalysts, in addition to the site's legacy catalyst hydroprocessing manufacturing capacity. This makes Axens is the first and only company to produce tail gas treatment catalysts in the Middle East. The company says that the expansion consolidates its capacity to serve its regional customers to meet regulatory requirements and maximise sulphur recovery by up to 99.9%, minimising SOx emissions. The production site supplies the region's refining and gas industries with the latest generation of Axens' catalysts, capable of operating at lower temperatures than conventional catalysts, and resulting in lower energy consumption.

Abdulkareem ALYAMI, ACAL's Managing Director said: "this site expansion is a testament to Axens' commitment to local content and promoting the local industry capacity. With this addition to Axens' local portfolio, the ACAL expansion project is for Axens Group another initiative to support our customers handling their sustainability journey in the field of energy efficiency, in line with our 2023 CSR Report United Nations Sustainable Goals roadmap objectives. Axens Group will continue to explore with our customers opportunities to enhance our offer as well as promote the local economy and support Saudi's Vision with our Made in Saudi portfolio."

UNITED STATES

Deer Park contractors died from H_2S poisoning

The US Chemical Safety and Hazard Investigation Board (CSB) has released a second update on its ongoing investigation into the fatal hydrogen sulphide release that occurred on October 10, 2024, at the PEMEX Deer Park Refinery in Deer Park, Texas. Two contract workers died during the incident, and over 13 tonnes of hydrogen sulphide gas were released. Local authorities issued shelter-in-place orders lasting several hours for the neighbouring cities of Deer Park and Pasadena.

CSB Chairperson Steve Owens said, "This was a very tragic event that took the lives of two workers and put the surrounding communities at serious risk. Maintenance events, like the ones in this incident, must be properly planned and implemented to ensure that they are done safely and that workers and nearby communities are protected."

On the day of the incident, maintenance contractors were working to removing piping isolation devices, called blinds, from ARU6, one of the refinery's amine regeneration units (ARUs). During the task, workers inadvertently opened a flange on a piping segment of another unit, ARU7, which was still pressurized with hydrogen sulphide gas. At approximately 4:23 p.m., the ARU7 piping flange was opened, releasing a toxic concentration of hydrogen sulphide gas into the air. One of the contract workers performing the task was fatally injured at the scene. The wind carried the toxic hydrogen sulphide to a nearby unit where other contractors were working. One contract worker downwind from the release also was fatally injured from hydrogen sulphide poisoning. A total of 13 workers were taken to hospital to monitor their condition after H_2S exposure.

The CSB says that its investigation is ongoing and will focus on safe work factors, maintenance policies and procedures, and emergency preparedness.

IPCO buys New Era Converting Machinery

IPCO AB has acquired web converting equipment manufacturer New Era Converting Machinery Inc. New Era is a web converting equipment design and manufacturing business, with two facilities in New Jersey, USA, and around 100 employees. Its technology platform of web handling, coating, laminating, and embossing equipment expands IPCO's presence in key industries, especially in sustainability-driven segments. It also complements IPCO's double-belt press and film casting solutions.

Robert Hermans, IPCO CEO said, "The acquisition of New Era is a perfect strategic fit with IPCO's business ambitions. It enhances our core offerings and introduces new dimensions to our double belt press and film casting capabilities, giving us the ability to offer turnkey solutions to our customers. This synergy will allow us to provide comprehensive and efficient web handling solutions on a global scale."

Paul Lembo, New Era EVP said: "Joining IPCO is the natural next step in New Era's evolution as we secure the long-term future of our solutions, team and customers, and accelerate the growth of our business."

UGANDA

New refinery construction agreed

President Yoweri Kaguta Museveni of Uganda has overseen the signing of signed an implementation agreement for the Uganda Refinery between the Ministry of Energy and Mineral Development, the Uganda National Oil Company (UNOC) and joint venture partner Alpha MBM Investments. Alpha MBM is a UAE-based company led by Sheikh Mohammed bin Maktoum bin Juma Al Maktoum, a member of the Dubai Royal Family. The agreement paves way for the design, construction and operation of the 60,000 bbl/d refinery to be undertaken at Kabaale. Construction is expected to take three years, with UNOC and Alpha MBM Investments as the project

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partners. The refinery, which will be East Africa's first major crude processing plant, aims to reduce Uganda's dependency on imported petroleum products and is expected to meet the local and regional demand for petroleum products.

FRANCE

Uhde gasification selected for biomass-to-SAF project in France

Thyssenkrupp Uhde's BioTfueL® technology has been selected for the BioTJet project by Elyse Energy and its partners (Axens, Avril, IFPEN). This project will produce sustainable aviation fuel (SAF) from end-of-life wood waste and local forestry residues. together with the addition of green hydrogen. By 2029, BioTJet will supply sustainable aviation fuel to reduce carbon intensity in air

transport, and e-bio-naphtha for road transport and bio-sourced chemistry. Axens signed a license agreement for BioTfueL® technology in 2024, which includes PRENFLO® gasification technology from thyssenkrupp Uhde and GASEL® Fischer-Tropsch and upgrading technology from Axens. PRENFLO® gasification technology is part of thyssenkrupp's Decarbon Technologies portfolio and will contribute to the sustainable production of biomass-based synthetic products, including methanol, hydrogen, and SAF.

Basic engineering on the project was completed in November 2024 and the project is currently in the detailed engineering phase. Aviation fuels are required by the ReFuelEU Aviation regulations to have a 2% sustainable quota in 2025 and to include 70% SAF in all EU airports from 2050.

Pascal Penicaud, president of Elyse Energy said: "After thoroughly examining the available and bankable technologies, we are now more convinced than ever that we have made the right choice for our project with the E-BioTfueL concept and the technology partners involved to provide cost-competitive SAF and naphtha to the market by 2030 and contribute to address climate change."

Nadja Håkansson, CEO of thyssenkrupp Uhde added: "We are proud to see how the E-BioTfueL concept – which includes our advanced PRENFLO® technology – has now turned into a first commercial biomass-to-SAF application in the European Community. The collaboration with our French partners underscores our commitment to driving the green transformation and delivering sustainable value to our customers and stakeholders."

GERMANY

Green hydrogen to decarbonise Leuna refinery

TotalEnergies has signed an agreement with the German developer RWE to supply 30,000 t/a of green hydrogen to the Leuna refinery for fifteen years, beginning in 2030. The green hydrogen will be produced by a 300 MW electrolyser, built and operated by RWE in Lingen. Green hydrogen storage will be provided locally. The green hydrogen will be delivered by a 600 km pipeline to the gates of the refinery and will prevent the site's emission of some 300,000 tons of CO_2 beginning in 2030. This is the largest quantity of green hydrogen ever contracted from an electrolyser in Germany.

"We are looking forward to developing further our partnership with RWE, our partner in several offshore wind projects in Germany and the Netherlands. This long-term contract for green hydrogen marks an important milestone to reducing our CO_2 emissions at our Leuna refinery. It will be made possible thanks to the completion of the H_2 backbone by German authorities and their efficient support to green H_2 customers like our Leuna refinery," said Patrick Pouyanné, Chairman and CEO of TotalEnergies.

"We are proud to have secured the first long-term offtake agreement for green hydrogen of this size with TotalEnergies in Germany. Six months after the investment decision for the construction of the 300-megawatt electrolysis plant in Lingen, we have acquired an important anchor customer in TotalEnergies. This shows that hydrogen works with the right incentives for customers." said Markus Krebber, Chief Executive Officer of RWE.

MEXICO

Samsung ends contract with PEMEX

Samsung E&A has announced the termination of its $1.6 billion contract with the Mexican state-owned oil company PEMEX for a sulphur recovery facility project. Samsung says that the contract, originally signed nearly a decade ago, has faced significant delays and suspensions due to budget cuts imposed by the client. It concerns a hydrodesulphurisation (HDS) facility aimed at removing sulphur components from diesel fuel at the Salamanca refinery in Guanajuato state, central Mexico. In a statement, Samsung E&A confirmed that they have reached an amicable agreement regarding the contract termination, stating, "We have been fully compensated for the expenses incurred during the project suspension, and since this project was not included in our sales or operating profit forecasts for this year, there will be no financial loss due to the contract termination."

SOUTH AFRICA

Glencore invests in sulphur removal

Astron Energy, a subsidiary of Glencore, says that it will spend $328 million to upgrade its South African crude oil refinery in order to comply with the country's upcoming cleaner fuel regulations. The investment aims to bring the facility in line with South Africa's Clean Fuels II standards, which mandate lower sulphur content in both petrol and diesel. The 100,000 bbl/d refinery near Cape Town is one of only two remaining operational refineries in the country. Astron says that construction work is already under way for a gasoline hydrotreating plant that will reduce sulphur levels to Euro 5 (<10ppm sulphur) specifications. The regulations have been delayed to July 2027 due to concerns over the cost of upgrading existing refining infrastructure.

Astron's refinery at Cape Town, South Africa.

Sulphuric Acid News

INDIA

Start-up for Adani smelter

Adani Group subsidiary Kutch Copper has commenced operations at its new Mundra copper refinery and smelter, the company announced on 28 March. The company previously indicated an expected start-up by the end of Q1. The new smelter will help boost domestic supplies of copper, demand for which is robust from the construction, transport and power sectors in particular and likely to double by 2030, with the shift towards clean energy and electric vehicles. This first phase of the project will have around 500,000 t/a copper capacity, with a similar capacity planned to be added in the second phase by 2029.

The first phase of the plant is expected to have 1.5 million t/a of sulphuric acid production capacity, while the phosphate-based demand for acid should be around 750,000 t/a once running. Acid exports from India are therefore expected to climb following ramp-up. The company also plans to add phosphoric acid capacity of around 500,000 t/a at the site, though this is not expected to come online until 2026.

India's imports of copper and sulphuric acid have surged since 2018 when Tamil Nadu's state government closed Vedanta Limited's Tuticorin smelter on environmental grounds. Last month, the country's supreme court rejected Vedanta's appeal to restart the plant.

TUNISIA

Cabinet aims to boost phosphate production and processing

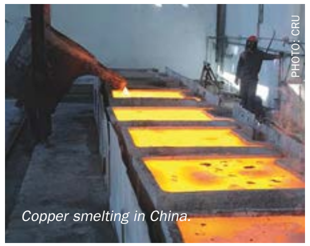
The Tunisian cabinet has met to review its future programme for phosphate production, transport, and processing for the 2025-2030 period, as well as the current situation of the Tunisian Chemical Group and its work plan for the same period, according to a government statement. The prime minister stressed the need to develop phosphate production as a national resource and a cornerstone of the national economy that must regain its role and position in supporting state revenues and wealth creation, including increasing production capacity, processing, and exports, while investing in modern technology to enhance productivity, exploring new export markets, and prioritising environmental considerations.

The Ministry of Industry, Mines, and Energy plans a phased increase in phosphate production over the next five years, aiming to reach 14 million t/a by the end of 2030, including improvements in transport and processing, water resource governance, and working conditions in all facilities operating in the Mining Basin and Gabes. GCT's operating capacity is to increase to 80% by 2028. Improvements will include upgrading sulphuric acid units and enhancing their efficiency, alongside implementing a maintenance programme for heavy machinery and trucks; establishing an industrial unit in Skhira for the production of finely ground single superphosphate and granulated calcium phosphate, with an annual capacity of 250,000 t/a; creating an industrial unit in Skhira for purified phosphoric acid production, with an annual capacity of 60,000 t/a; setting up a cadmium removal unit in M'dhilla to purify phosphoric acid, with an annual capacity of 180,000 t/a; and providing financial support to GCT for the remaining components of the Mdhilla 2 project. There are also plans for pilot units in Gabès for green ammonia production and in Skhira and M'dhilla for phosphoric acid and granulated phosphate fertiliser production.

CHINA

Production cuts at Chinese smelters

It is reported that Tongling Nonferrous is planning production cuts this year given current record low treatment and refining charges (TC/RCs). CRU estimates that the company's potential cutbacks will total



Copper smelting in China.

67,000 tonnes of copper for the year. However, the start-up of the Jinguan II and Chifeng Jinjian II projects could offset the reduction in concentrate demand at operational smelters. Tongling Nonferrous owns five operational smelters/refineries with a total of 1.28 million t/a blister capacity and 1.73 million t/a refined capacity, respectively. It is understood that the Chifeng Jintong 220,000 t/a smelter has cut operating rates by 10% since early March due to concentrate tightness.

Meanwhile Tongling Jinguan's 200,000 t/a smelter has conducted a one-month maintenance shutdown since March. This is estimated to have reduced concentrate demand by 18,000 tonnes. Tongling Jinlong's 350,000 t/a smelter has planned a 35-day maintenance in October, which is expected to remove 29,000 tonnes of concentrate demand.

Meanwhile, there are two new smelter/refinery projects – Jinguan II and Chifeng Jinjian II – with additional blister/refined capacity of 800,000 t/a. The move will enable Tongling Nonferrous to surpass Jiangxi Copper and rank as the largest smelting group in China. The new Jinguan II 500,000 t/a project held its firing-up ceremony on 26 March, marking the beginning of trial-commissioning. Although this is three months earlier than market participants' earliest expectations of a June start, the feeding of materials is not confirmed yet due to concentrate shortages, and it may take several weeks to heat the furnaces before considering feed commencement. The Chifeng Jinjian II 200,000 t/a project appears unchanged, targeting completion by the end of the year as construction work progress seems on track.

Overall, Q1 has delivered significant smelter production cuts and a smelter closure, totalling around 435,000 tonnes in China, and their market impact is expected to be felt in Q2. Nevertheless, further significant smelter cuts are still required and are expected by mid-year.

CHILE

Copper at a crossroads

CRU's World Copper Conference was run at the start of April 2025 in Santiago, Chile, with the industry facing a crossroads. The Americas account for nearly half of the world's mined copper, with South America producing 38% and North America contributing 10%. However, North

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PHOTO: NYRSTAR

Nyrstar's Hobart zinc smelter.

American copper mines face cash costs 51% above the global average and 79% higher than those of their South American neighbours, positioning the region as one of the most expensive copper-producing areas globally. These high costs create a significant challenge, especially as securing a reliable copper supply has emerged as a geopolitical priority.

Compounding this issue, global copper demand is forecast to outstrip supply, with year-on-year deficits steadily increasing. In response, the United States and Canada have designated copper as a critical mineral essential for national security and supply chain resilience. To address this growing need, several major copper projects in North America hold the potential to boost regional output. In the US, notable tier 1 projects include Resolution, Pebble, and Mason, while in Canada, the Highland Valley Extension and Yellowhead projects hold the most promise. However, these projects are often stalled by prolonged regulatory delays and permitting obstacles.

Mining projects in North America often take multiple decades to move from discovery to production. For example, the Resolution deposit, identified by Magma Copper Company in 1995, saw Rio Tinto and BHP form Resolution Copper Co. in 2004. Since then, the project has navigated a gruelling permitting process, its fate shifting with each U.S. administration—most recently stalled by Biden in 2021. However, with President Trump's early 2025 executive order to prioritise domestic critical minerals, Resolution's ramp-up phase is likely to accelerate. Its prolonged timeline reflects a broader trend among North American mining projects.

UNITED STATES

Cornerstone sells sulphuric acid operations

Cornerstone Chemical Company has sold its sulphuric acid operations to Ecovyst, a global provider of advanced materials, specialty catalysts, sulphuric acid and regeneration services based in Malvern, Pennsylvania. Ecovyst's business structure includes two core business units: Advanced Materials and Catalysts (AM&C) and Ecoservices. Ecovyst more than 900 employees throughout its 12 facilities across multiple locations worldwide and its Ecoservices division is a North American provider of sulphuric acid and sulphuric acid regeneration services.

"Cornerstone looks forward to a smooth transition of the sulphuric acid business to Ecovyst, and we are confident in the long-term success of that business and its employees," said Matthew Sokol, Cornerstone's president and chief executive officer. "The sale of our sulphuric acid business is the next step in aligning our strategic goal of operating high-performing specialty chemical assets and a world-class Energy Park in Southern Louisiana. We thank those members of our team who are part of the Sulphuric Acid business, and we wish Ecovyst much success in the future."

Situated along the Mississippi River in Waggaman, Louisiana, Cornerstone Energy Park serves as a prominent industrial hub and service provider. Established in 1952, the Energy Park is home to several state-of-the-art chemical manufacturing facilities, including site owner Cornerstone Chemical Company, LLC.

US tariff pause brings relief to fertilizer exporters

President Donald Trump delayed his 'liberation day" tariffs by three months on 9th April, while simultaneously ramping up levies on China. In this latest twist to the on-off US tariffs saga, the Trump administration's 90-day pause on additional duties should provide international suppliers to the world's biggest fertilizer market with some respite – for now. With the exception of China, the US will now cut back its so-called 'reciprocal tariffs' to 10% for the duration of a three-month suspension period. The European Union's tariff is now halved to 10%, for example, with the trade bloc also pausing its trade countermeasures against the US.

At the time of writing in mid-April, fertilizer producers that export DAP/MAP/TSP to the US will generally face a blanket 10% rate. Previous levies on granular phosphate imports from Jordan (20%), Israel (17%) and Tunisia (28%) will also now fall to the more favourable 10% flat rate. Saudi Arabia and Australia were already at this lower rate and were therefore unaffected. The additional 10% tariff on phosphate imports from Morocco is expected to be added to the existing US countervailing duties (CVDs) of 16.6%, although this has yet to be confirmed. Importantly, a number of fertilizer commodities are exempted from any US import tariffs under the Harmonized Tariff Schedule (Annex II). These include potassium chloride, potassium nitrate, potassium sulphate, phosphate rock and NP/NPK fertilizers.

The 10% blanket tariff does not apply to America's northern and southern neighbours, Canada and Mexico, either. Instead, any imports from these two countries that comply with the United States-Mexico-Canada Agreement (USMCA) are exempted from the current 25% tariff imposed by the US.

This USMCA exemption notably covers US sulphur imports. While US sulphur consumption is primarily domestically sourced, imports still account for around 20% of total demand, with Canada being the primary supplier, making up 90% of total non-US purchases. US tariffs on China, meanwhile, have increased from 104% to 145%.

While Russian fertilizer suppliers were spared from further tariffs, the country's phosphate producers already face prohibitive countervailing duties (CVDs), as does Morocco's OCP. These have largely killed off phosphate fertilizer shipments from Russia and Morocco to the US since their implementation in 2020.

New US tariff policy may also see a rerouting of ammonium sulphate (AS) trade. Europe became the largest supplier of AS into the US market last year, surpassing Canada. With the introduction of 10% duties, the flow of European AS into the US is likely to slow down, but it is unlikely to cease, given the attractive US market premium and the oversupply of AS elsewhere globally.

AUSTRALIA

Nyrstar to reduce output at Hobart

Due to an increasingly challenging market, Nyrstar will indefinitely lower production at its Hobart zinc smelter in Tasmania by around 25%. The plant's zinc capacity is 280,000 t/a. "This decision follows a thorough and extensive review and is a direct response to deteriorating market conditions and financial losses being sustained by Nyrstar Australia," the Trafigura-owned company said. "Nyrstar's Australian assets continue to face significant financial challenges due to several external factors including worsening conditions in raw material markets, negative treatment charges and increased costs."

The duration of the production reduction will depend on market and operating conditions, said the plant's general manager Todd Milne, adding: "We remain optimistic about the future and have the flexibility to lift production levels when operating conditions improve." The cutback will be implemented in stages from April. "There are no immediate job reductions planned, and the facility will continue to be maintained to retain flexibility," Nyrstar added.

Last August the company put on hold modernisation of the smelter, which is more than 100 years old, because capex costs had increased by a quarter from the original figure of A$400 million (currently US$251 million). The project included installation of an electrolysis unit and other upgrades to enable greater recovery of minerals and metals at the company's Port Pirie plant in South Australia. That plant produces commodity grade lead, copper matte, silver dore and sulphuric acid. The Hobart smelter produces special high grade zinc, zinc alloys and sulphuric acid.

Ammaroo phosphate project secures key mineral leases

Verdant Minerals says it has been granted two key productive mineral leases for its Ammaroo Phosphate Project by the Northern Territory government. The company says that this significant milestone advances one of the world's largest undeveloped phosphate resources, located about 220km south-east of Tennant Creek. Acting Chief Minister and Minister for Mining and Energy, Gerard Maley, stated, "This is a significant milestone in progressing a world-class resource project that will support jobs, drive investment, and strengthen the NT's position as a leader in resource development."

The project promises approximately 400 construction jobs and 250 operational jobs, driving local economic benefits and supporting global agricultural productivity. Verdant Minerals is nearing the final stages of securing its mining authorisation, which

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will enable construction to commence. Verdant Minerals Managing Director, Chris Tziolis, expressed appreciation for the NT Government's support, emphasizing the project's crucial role in regional economic growth.

Ammaroo is estimated to contain measured, indicated and inferred resources of more than one billion tonnes of phosphate ore (P_2O_5), making it Australia's largest phosphate resource. It is expected to ultimately produce around 2 million t/a of phosphate concentrate. Further processing will yield 500,000 t/a of merchant-grade phosphoric acid (100% P_2O_5) and 200,000 t/a of ammonia, which will be used to produce around 1 million t/a of ammonium phosphate fertilisers such as di-ammonium phosphate and mono-ammonium phosphate.

Investment to boost phosphate project

Avenira has secured an A$7.56 million strategic investment from majority shareholder Hebang Biotechnology to progress its Wonarah phosphate project in Northern Territory. The investment, in which Hebang will acquire 1.08 billion shares priced at A$0.007 each, will boost its equity holding in Avenira to 49%. Hebang has also agreed to provide Avenira with an unsecured drawdown loan facility to be repaid on completion of the placement or after the date of the first drawdown.

Avenira will use funds from the investment to advance its Wonarah phosphate project, located between Tennant Creek and Mount Isa. Wonarah is considered Australia's largest high-grade phosphate project and Avenira plans to develop it as a direct shipping ore (DSO) operation based on a simple open-cut mining operation with processing facilities onsite. Avenira intends to supply premium-quality products from Wonarah, including lithium iron phosphate (LFP), thermal phosphoric acid (TPA) and yellow phosphorus, into the electric vehicle, agricultural and industrial chemical markets.

INDONESIA

Increased royalty rates not expected to affect nickel production

Indonesia is increasing the royalty rates that the government takes on metals mined within the country. The Indonesian government has proposed a tiered royalty structure on nickel ore sales, ranging between 14–19%, depending on the prevailing nickel price. This would replace the current flat rate of 10%. A 14% rate would apply when nickel prices are below $18,000 /t, increasing progressively to 19% for LME prices above $31,000 /t. The royalty is calculated based on revenue from nickel ore sales.

Indonesia is the world's largest producer of nickel, both in mined and refined forms. It is projected to account for 64% of global nickel output on a mined basis this year. The country manufactures a diverse range of nickel products, including nickel pig iron (NPI), matte, and mixed hydroxide precipitate (MHP). More recently, it has expanded into producing nickel cathode and nickel sulphate. However, NPI continues to dominate Indonesia's nickel supply. CRU estimates that increasing the royalty rate to 14% could raise NPI production costs by approximately $190/t, assuming the added royalty expense is passed on through higher ore prices by miners. This is likely to further squeeze margins for NPI producers. However, this is unlikely to deter investment in the sector given most producers are competitive globally. Given the relatively small increase in costs, the outlook for the nickel market remains unchanged – CRU continues to expect a surplus this year with limited upside for prices.

Fatal dam collapses at nickel facilities

Two dam failures at the Morowali industrial park in Indonesia have killed three people. On March 16, during heavy rains, the PT Huayue Nickel Cobalt tailings storage facility at the Morowali industrial park failed, and tailings flowed into the Bahadopi River. The breach flooded facilities at the industrial park and the village of Labota. Five days later another tailings dam inside the industrial park, owned by PT Qing Mei Bang (QMB) New Energy Materials, collapsed, killing three workers. The affected tailings facilities store acidic waste from high pressure acid leaching (HPAL). It is estimated that for every ton of nickel, HPAL processing generates 150-200 tons of tailings. The affected facilities use filtered tailings, where some of the water is removed from the tailings before they are placed the dam. However, heavy rains, landslips and seismic activity appear to have affected the stability of some of the dams.

PHILIPPINES

Government looking to emulate Indonesia?

The Philippine government is looking to follow Indonesia's success in attracting downstream investment by banning the export of nickel ore. The Philippine Congress could ratify a bill banning raw mineral exports as early as June. The ban would come into force five years after approval to give miners time to build downstream processing plants. This development could potentially lead to higher nickel prices in the medium term if there is a delay to building domestic capacity and the Indonesian government becomes serious about restraining ore availability.

After Indonesia, the Philippines is the largest producer of nickel ore on a mined basis. The country stepped up its exports of nickel ore following the Indonesia nickel ore bans in 2014 and 2021. The main market for Philippine nickel ore is China, where it is used to produce nickel pig iron.

JORDAN

Metso awarded beneficiation plant contract

Metso has secured a two-year life-cycle contract with Ideal Development for Manufacturing Industries (IDMI) for a new phosphate beneficiation plant at the Eshidiya phosphate mine in the south of Jordan.

Metso will support the commissioning, ramp up and optimisation of Eshidiya's new beneficiation plant. Its contract with IDMI covers both maintenance and plant operations.

The latest agreement is a follow up to Metso's previous equipment contract with IDMI – its first phosphate contract in the Middle East – signed in 2023. Metso previously supplied most of the critical equipment in the beneficiation flow sheet, including grinding, flotation, thickeners, filters and pumps, as well as Metso's energy and water efficient UltraFine Series™ screens. These are the first ultra fine screens to be installed at a phosphate beneficiation plant, according to Metso.

"By utilizing Metso's key technologies and modern and safe commissioning methods at our site, we aim for a strong return on investment, leading to revenue and growth opportunities. Strong collaboration is essential for ensuring safe and productive operations," said Rami Fakhouri, IDMI's managing director.

"We appreciate our customer's trust in continuing our partnership. With Jordan holding the fifth largest phosphate reserves in the world, we are committed to supporting success in this significant industry. Our goal is to ensure a smooth commissioning process and sustained efficient production to not only meet but exceed business targets," said Rajneesh Mishra, Metso's VP, Sales and Service, Middle East.

EGYPT

KMCJNC to fund new phosphate project in Egypt

Chinese phosphate and battery chemical producer Chuan Jin Nuo Chemical (KMCJNC) has announced a $265 million plan to build a plant in Egypt to reduce its raw material and export costs. The company will construct facilities in the North African country to produce a range of intermediates and finished products, it revealed in its recent first-quarter earnings report. The plant will have a three-year construction timeline. Planned capacities for the site are 800,000 t/a of sulfuric acid and 300,000 t/a of ammonium phosphate per year. Other core products will include phosphoric acid and sodium fluorosilicate. At full capacity, the plant is expected to generate over $41 million in net profit, according to feasibility studies.

KMCJNC says that Egypt's strategic location at the crossroads of three continents, coupled with its position as the world's third-largest holder of phosphate reserves, will optimise the firm's business operations and significantly reduce raw material and export transportation costs. The company has been importing phosphate ore from Egypt since 2022 and has a comprehensive understanding of local supply dynamics, ensuring stable raw material procurement, it added. KMCJNC operates two production bases: one in Kunming and another in the southern port city of Fangcheng, in the Guangxi Zhuang Autonomous Region. Last year, more than half of the firm's revenue came from exports, mainly to South Asia, Southeast Asia, and South America.

TURKMENISTAN

Daewoo to build phosphoric acid plant

Daewoo Engineering & Construction has signed a $700 million framework agreement to build a fertilizer plant in Turkmenistan. The agreement was signed in Seoul with Turkmenistan's state-owned chemical firm, Turkmenhimiya, according to the Turkmen Ministry of Trade, Industry and Energy, noting the Korean firm was named the preferred bidder for the project in October. The project aims to construct a fertilizer plant that will extract phosphoric acid from phosphate rocks and process the substance into 300,000 t/a of annually in eastern Turkmenistan by 2029.

After the agreement signing ceremony, Korean Industry Minister Ahn Duk-geun met with his Turkmen counterpart, Baymyrat Annamammedov, and discussed expanding bilateral cooperation in other industrial plant projects, the ministry said. "Turkmenistan is a key region that we expect to serve as a strategic hub for the construction market in Central Asia," a Daewoo official said. "We will do our best to explore new markets and diversify our business portfolio." ■

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People

Worley has announced that **Tiernan O'Rourke** will step down as the company's Chief Financial Officer effective from 30 June 2025. O'Rourke is retiring from full-time work after a long and successful career culminating in nearly four years of dedicated service to Worley, though he intends to take on advisory and consulting activities in the private sector. Worley's Chief Executive Officer, Chris Ashton, said: "It's been an absolute pleasure to work alongside Tiernan since he joined the Worley team and see his decades of experience benefit the business in areas such as capital management, financial process improvements and talent development to name a few. I wish him well as he transitions away from the CFO role."

Justine Travers has been appointed to the position of Chief Financial Officer (CFO) effective from 1 July 2025. Based in Australia, Justine is currently the Deputy CFO. Her experience includes senior finance and operational leadership roles, with the finance leadership roles focussed on capital and financial management, strategy and policy. Prior to joining Worley, she worked at Newcrest Mining, and brings an in-depth understanding of public company reporting requirements and capital structure and has a strong understanding of the Worley business. O'Rourke will remain with Worley until 26 September 2025 to support her as she transitions into her new role. Worley's Chief Executive Officer, Chris Ashton, said: "I am pleased to welcome Justine as the CFO of our global organisation. She will join Worley's group executive team and I look forward to her continued contribution as we steward Worley towards delivering a more sustainable world."

Joy Archer has been confirmed as CRU's Chief Financial Officer (CFO) from 1 April 2025. Having joined CRU in 2020, Joy has successfully overseen multiple areas at CRU such as Finance, Enterprise Systems and Programme Management (PGMO) teams. Since October 2024 Joy has taken the full remit of global finance, PGMO and customer care functions for the business, working successfully with members of the board and executive committee to drive the company's financial strategy and in particular to partner with the business to achieve this through the newly created Business Partnering Team.

Bashir Bayo Ojulari has been appointed as Group CEO and **Ahmadu Musa Kida** as non-executive Chairman of the Nigerian National Petroleum Company (NNPC), following the dismissal of the previous company board. Ojulari, the former Managing Director of Shell Nigeria Exploration and Production Company, replaces **Mele Kyari**, effective immediately. Ojulari was most recently Chief Operating Officer at Renaissance Africa Energy Co., which owns Shell's former onshore subsidiary in Nigeria. Nigeria's president Tinubu also replaced the board of NNPC, appointing an 11-member team to drive reforms and boost efficiency in the oil sector. **Adedapo Segun**, who replaced Umaru Isa Ajiya as the Chief Financial Officer of NNPC last November, has been appointed to the new board by president Tinubu. Six board members, non-executive directors, will represent the country's geopolitical zones.

Imperial Oil Ltd has appointed **John Whelan** as president, effective April 1, 2025, following the retirement of chairman, president and chief executive officer **Brad Corson**, after 42 years of service and following an orderly transition. At the conclusion of the company's annual meeting of shareholders on May 8, 2025, Whelan will assume the role of chairman, president and CEO of Imperial Oil.

"On behalf of the Imperial board of directors, I would like to thank Brad Corson for his incredible leadership and dedication over the past five years," said Lead Director David Cornhill. "Brad steered the company through the challenges of the global pandemic, with the organization emerging to deliver the strongest financial years in company history. Importantly, Brad has also positioned the company and its employees for future competitive success with strategic projects, including growth projects at Kearl and Cold Lake, the Strathcona renewable diesel facility and Low Carbon Solutions business, and as a founding member of the Pathways Alliance initiative to reduce emissions from oil sands operations."

"John brings extensive experience at both Imperial and on global ExxonMobil portfolios to successfully deliver exceptional operational performance and enhanced competitiveness, which will build on this strong momentum and continue to grow shareholder value going forward," Cornhill added.

Whelan was previously ExxonMobil Upstream's senior vice president, responsible for the company's conventional and heavy oil global business line.

Calendar 2025

APRIL

28 – MAY 2

RefComm Expoconference, GALVESTON, Texas, USA
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Tel: +44 (0) 20 7903 2444
Email: conferences@crugroup.com

MAY

26-29

9th SAIMM Sulphur & Sulphuric Acid Conference, STELLENBOSCH, South Africa
Contact: Gugu Charlie, Conferences and Events Coordinator, South African Institute of Mining and Metallurgy.
Tel: +27 11 538 0238
Email: gugu@saimm.co.za

JUNE

6-7

48th Annual International Phosphate Fertilizer & Sulfuric Acid Technology Conference, ST. PETERSBURG, Florida, USA
Contact: Michelle Navar, AIChE Central Florida Section
Email: vicechair@aiche-cf.org
Web: www.aiche-cf.org

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European Sulphuric Acid Association Spring General Assembly, HELSINKI, Finland
Contact: Francesca Ortolan, CEFIC
Phone: +32 2 353 2734
Email: events@roomtrust.com

JULY

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SulGas KL Conference, KUALA LUMPUR, Malaysia
Contact: Conference Communications Office, Three Ten Initiative Technologies LLP
Tel: +91 73308 75310
Email: admin@sulgasconference.com
Web: https://sulgasconference.com

AUGUST

20-22

2025 Round Table for Smelters, Roasters and Refineries, SANTIAGO, Chile
Contact: Viviana Rojas, Holtec
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The Ambatovy nickel HPAL plant, Madagascar

PHOTO: SUMITOMO

Nickel market developments

Indonesia has become the epicentre of the world nickel industry, and is now seeking to raise royalty rates to capture more value from this. Will this impact upon the continuing expansion of HPAL capacity there?

Although Indonesia has the largest reserves of nickel in the world, it concentrated on selling ore overseas until 2014, when the Indonesian government said it would be banning exports of nickel ores and concentrates in order to build domestic nickel processing and capture more of the value chain – the ban finally came into effect in 2020. The change that this step has led to over the past 10 years has been dramatic. Indonesia is now by far the largest producer of refined nickel, responsible for 60% of production, up from 6% in 2015. By 2028, this figure is expected to be 74%, turning Indonesia into the nickel equivalent of OPEC.

Most of this has come from Chinese investment, particularly from battery manufactures such as Tsingshan, CATL and Lygend. In order to produce the high grade nickel sulphate required for batteries using Indonesia's lower grate laterite ores, they have had to use high pressure acid leaching (HPAL) on a scale not seen before.

Now, however, Indonesia is starting to look like a victim of its own success. Its rapid expansion has driven down nickel prices to below \$16,000/t, leading to closures around the world. It is estimated that the 1.5 million t/a growth in Indonesian nickel production could come at the expense of 500,000 t/a of closures elsewhere. BHP has written down the value of its Western Australian nickel mine, while Glencore announced in mid-February that it plans to sell its stake in a loss-making nickel mine and processing plant in New Caledonia.

Trade concerns

One concern, in a world of escalating trade wars, is that China's de facto control over nickel supplies could be another weapon in its arsenal, should it come to a showdown with the USA. There are nickel free alternatives for car batteries, such as lithium iron phosphate (LFP), but little use of them so far outside China. One potential symptom of this has been the recent law proposed by the government of the Philippines that they may also emulate Indonesia and ban the export of nickel ores, developing their own downstream nickel processing industry. The country's nickel reserves are only a fraction of Indonesia's, but they are already the second largest global producer outside Indonesia, home to Sumitomo's Coral Bay Nickel plant, which it recently bought outright from Nickel Asia, and recently Nickel Asia and DMCI Mining Corp. announced that they would be developing a large scale nickel processing plant in the country. DMCI operates two nickel mines in the Philippines, at Zambales and Palawan while Nickel Asia operates five mines at Palawan, Surigao del Norte, the Dinagat Islands and Isabela.

Elsewhere, tariffs will disrupt the long-standing flow of nickel between Canada and the US, but other than their potential chilling effect on the world economy and demand for stainless steel and batteries for electric vehicles, may not have much impact on nickel prices in the short to medium term.

Quota reductions

Indonesia has said that it may cut mining quotas in order to boost prices. In January the Indonesian government cut the nickel ore mining quota (known as RKAB) for 2025 to 200 million t/a from 271 million t/a in 2024. Further cuts could be on the horizon, with some reports suggesting it could be decreased to 150 million t/a. The government has been deliberating a cut in the RKAB mining quota in the face of weak nickel prices. Indeed, the LME 3M nickel price has trended lower into 2025 to below \$15,000 /t at one stage, representing multi-year lows. Given Indonesia's dominance in the nickel market, any significant reductions in Indonesian supply will be supportive to the nickel price.

The RKAB is awarded to mining companies on a wet tonne basis and covers ore grades ranging from 1.0–1.8%, with the lower grade mainly going to HPAL operations and the higher grade being consumed by nickel pig iron (NPI) smelters. In 2024, CRU calculates that ore consumption totalled 234 million t/a based on estimates for NPI, ferronickel, matte and intermediate output. The country imported around 11.0 million t/a of ore so the balance of 223 million tonnes came from domestic output and destocking.

CRU's current forecast for 2025 is that ore consumption will rise to 264 million t/a. Meanwhile, the government has not ruled out a larger cut if companies do not comply with requirements of their RKAB license, such as mine rehabilitation. A 16% reduction in supply would certainly move the nickel market into deficit and boost prices. However, there need to be more concrete signs that the government will move in this direction. In 2024, mining companies faced delays in getting RKAB approval and this was one of the key factors behind a tighter domestic nickel ore market, and constrained production growth in the middle part of the year. However, this tightness eased in the closing months of 2024 and NPI output recovered as more RKAB approvals were given.

At present CRU maintains the view that the nickel market is heading for another year of surplus in 2025 but there is increased uncertainty surrounding Indonesian output which provides an upside risk to prices, especially as short position holders rush to close out. However, the market is not pricing in significant curtailments, with the LME 3M nickel price still below \$16,000/t at time of writing.

Increased royalty rates

The Indonesian government has proposed a tiered royalty structure on nickel ore sales, ranging between 14–19%, depending on the prevailing nickel price. This would replace the current flat rate of 10%. A 14% rate would apply when nickel prices are below \$18,000/t, increasing progressively to 19% for LME prices above \$31,000/t. The royalty is calculated based on revenue from nickel ore sales.

Nickel Industries has said that, based on the PT Hengjaya Mine sales revenue of \$205 M in 2024, the proposed changes to royalty rates would have increased their royalty payment by around \$8 million. The proposal has been met by resistance from the Indonesian Mining Association, citing a need to protect cashflows in the current price environment.

CRU's Nickel Cost Model suggests that increasing the royalty rate to 14% could raise NPI production costs by approximately \$190/t, assuming the added royalty expense is passed on through higher ore prices by miners. This is likely to further squeeze margins for NPI producers. However, this is unlikely to deter investment in the sector given most producers are competitive globally. Given the relatively small increase in costs, CRU continues to expect a surplus this year with limited upside for prices.

Effects on sulphur

At the moment Indonesia's nickel dominance is leading to rapidly increasing demand for sulphur and sulphuric acid. CRU projects that Indonesian sulphur demand will surge in 2025 with the ramp-up of the Huafei and PT Lygend projects and further growth in sulphur burning capacity at PT Lygend and Huayue, along with the startup of PT Blue Sparking and PT Meiming projects in 2025. Sulphur demand is projected to rise from 3.4 million t/a in 2024 to 4.2 million t/a in 2025 and 4.8 million t/a in 2026, and an additional project (PT Vale's Pomalaa project) will come online in 2026. ■

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Middle East sulphur

The Middle East remains the world's largest regional exporter of sulphur, with additional capacity continuing to come from both refineries and particularly sour gas processing.

The Middle East produced 21.9 million t/a of sulphur in 2024, up from 19.9 million t/a in 2023. With domestic consumption relatively small at 5.2 million t/a, mainly for phosphate production, and imports limited to 2.2 million t/a, mostly to Jordan and Israel, this mean that exports from the region were a record 19.1 million t/a of sulphur in 2024, up 15% on 2023, bolstered by stock drawdowns in Saudi Arabia.

Refinery production

While global demand for oil and oil products is heading towards a plateau, there is increasing output from refineries in the Middle East as the balance of refining capacity continues to shift, away from Europe, North America and Japan, where refineries are closing or converting to bio-based feeds and other renewable fuels, to Asia and the Middle East. The Middle East in particular has abundant low cost oil available for processing.

Historically the region focused on the export of oil, with relatively simple local refineries and very lax standards on sulphur content of fuels. However, refineries have been forced to recover more sulphur as sulphur standards continue to tighten in major export markets such as Europe, India and, increasingly, Africa. The global push to reduce sulphur levels in vehicle fuels has, over the course of the past three decades, brought sulphur content of fuels from around 800 ppm in Europe and North America down towards the so-called Euro-V standard of 10 ppm worldwide. Even where Euro-V is not implemented, most places have now adopted at least a Euro-IV standard of 50 ppm sulphur, including in most of southeast Asia and the Philippines, east and south Africa and parts of South America. Reduction in sulphur content for maritime fuels is also leading to increased investment in processing refinery bottoms with high sulphur content. The only real exceptions to these fuel standards are, ironically, Kuwait, Qatar and Saudi Arabia, where domestic fuel quality standards continue to lag international standards, meaning that fuels for the domestic market can still be sold with higher sulphur content, but these countries too are moving towards lower standards, with Saudi Arabia looking to implement Euro-V soon.

At the same time, most regional crudes are classed as sour. Abu Dhabi produces some of the sweetest crude, with its Murban grade having a sulphur content of around 0.7-0.8%, but the average sulphur content from Abu Dhabi closer to 2%. Qatar Land grade is 1.35% sulphur but Medium Saudi crude is 2.2-2.9%, and Iraq's Basrah Heavy is as high as 3.8% sulphur. This means that, as with most refiners handling Middle Eastern crudes, refineries must recover more sulphur than, for example, US sweet crudes.

Overall, Middle Eastern refinery capacity continues to increase, as shown in Table 1. This is on top of recent large refinery startups, such as Al Zour in Kuwait (615,000 bbl/d), Abadan in Iran (205,000 bbl/d), Karbala in Iraq (140,000 bbl/d) and Duqm in Oman (230,000 bbl/d). New sulphur from oil refineries is expected to reach an additional 0.7 million t/a over the period 2024-2029, according to CRU estimates.

Table 1: **New Middle East refinery capacity, 2024-2030**

Location	Operator	Capacity, bbl/d	Onstream date
Baiji, Iraq	NRC	150,000	1Q 2024
Haditha, Iraq	NRC	20,000	2Q 2027
Dhi Qar, Iraq	SRC	100,000	2Q 2028
Sitra, Bahrain	BAPCO	113,000	2Q 2026
Jubail, Saudi Arabia	SATORP	20,000	1Q 2024
South Adish, Iran	NIORDC	60,000	1Q 2025
PGS, Iran	NIORDC	120,000	4Q 2025
Aftab, Iran	Aftab Refining	60,000	2Q 2026
Duqm, Oman	KPI/ORPIC	45,000	1Q 2026
Total		**708,000**	

Source: Oxford Institute for Energy Studies

Sour gas

The other main source of sulphur is from processing of sour gas. Global natural gas consumption increased by 2.8%, or 115 bcm year on year in 2024, above the 2% average growth rate between 2010-20. Natural gas met around 40% of the increase in global energy demand in 2024 – a greater share than any other fuel. This relatively strong growth was mainly due to the Asia Pacific region, which accounted for almost 45% of incremental gas demand in 2024 on the back of continued economic expansion.

Gas expansions continue to happen across the Middle East, some of it to feed increasing domestic requirements for electricity. The UAE, for example, is expected to increase domestic gas consumption by 50% over the period 2020-2030. Saudi Arabia's requirements are increasing by nearly 4% year on year as the country pivots away from generating electricity from burning oil to utilising gas instead. Saudi Arabia has already cut its share of energy production from oil from 65% in 2015 to 32% today, but this is projected to drop to 11% under the country's Vision 2030 plan. Much of this gas production must come from non-associated gas, as associated gas production remains dependant on OPEC quotas. Globally around 40% of all gas resources are classed as sour, but in the Middle East this figure is as high as 60%, particularly for non-associated gas in Abu Dhabi and Saudi Arabia.

As well as for domestic consumption, the rise in global consumption of gas is also leading to increased exports of LNG from the region. Qatar, which operates the largest natural gas field in the world; the North Field, is developing the massive North Field Expansion Project. The field already feeds Qatar's 77 million t/a of LNG exports, as well as domestic GTL production and the Dolphin export pipeline. Qatar is now aiming to lift LNG exports to 110 million t/a. Although North Field gas is only around 0.5-1.0% H_2S, the large volumes that will be processed mean that there will nevertheless be significant sulphur produced.

Other major new sour gas projects that will produce additional sulphur volumes are centred on the UAE and Saudi Arabia. Abu Dhabi in particular has pioneered sour gas extraction to supply the UAE's own burgeoning gas demand at the same time that it exports LNG. The massive Shah project is undergoing an expansion. Gas at Shah is highly sour; around 23% H_2S. Production has already been lifted from an initial 1.0 bcf/d in 2016 to 1.28 bcf/d, and is set to rise to 1.45 bcf/d. Sulphur capacity, currently at 4.2 million t/a, will rise concomitantly. Further down the timeline is the offshore Hail/Ghasha field expansion in Abu Dhabi. Here ADNOC is targeting production of 1.5 bcf/d gas with 15% H_2S content, partnered by Eni (25%), Wintershall (10%), OMV (5%) and Lukoil (5%). EPC contracts are expected this year and ADNOC says that first gas may flow as early as 2027, though production will take a couple of years to ramp up. Final sulphur output could be up to 3.7 million t/a.

Table 2: **New sour gas sulphur production, 2024-2029**

Project	Country	Sulphur	Onstream date
Shah Expansion	Abu Dhabi	1.0 million t/a	2025
Hail/Ghasha	Abu Dhabi	3.7 million t/a?	2027
North Field	Qatar	0.6 million t/a	2026
Al Fadhili Expansion	Saudi Arabia	0.9 million t/a	2027
Tanajib	Saudi Arabia	0.9 million t/a	2026
Others	Various	1.0 million t/a	2024-29
Total		**8.1 million t/a**	

Source: CRU

PHOTO: SAUDI ARAMCO

The Al Fadhili gas processing plant, Saudi Arabia.

Saudi Arabia is also developing the Tanajib gas plant as part of the Marjan oil field expansion programme. Output is to rise from 500,000 bbl/d to 800,000 bbl/d, with the Tanajib plant processing associated offshore gas. It will have a capacity to process 2.5 billion scf/d, and completion is expected in 2026. Sulphur production capacity is around 1.0 million t/a.

Overall, new sulphur from sour gas processing could reach 8.1 million t/a over the next few years (see Table 2).

Sulphur exports

Middle East exports will continue to dominate the traded market for sulphur, and indeed, are likely to expand their share of globally traded sulphur. Since 2016, the Middle East region has accounted for 41-46% of global trade. The addition of new capacity has pushed this share up to 49% in 2024 and is set to continue increasing to 59% by 2029; of the 12.8 million t/a of additional sulphur production expected over the period 2024-29, two thirds will come from the Middle East.

The UAE in particular will reinforce its position as the world's leading exporter of sulphur. UAE exports are expected to increase from 7.0 million t/a in 2024 to 11.4 million t/a in 2029. Additional capacity at Ghasha plans to transport sulphur to forming capacity at Ruwais via pipeline but additional forming and loading infrastructure at the port is likely to be necessary by 2028/29. Saudi Arabia will be the second major exporter, with sales increasing from 4.8 million t/a to 5.5 million t/a in the same time frame. Similarly, the boost in supply will be reflected in Qatar's exports jumping from 3.1 million t/a in 2024 to 4.1 million t/a in 2029.

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The impact of US tariffs

While the US tariff situation remains subject to considerable uncertainty, there has already been an impact on short term trade flows, as well as investment decisions.

On Saturday 1 February, President Trump followed through on his tough talk on trade, announcing a 25% import tariff on Canadian and Mexican goods. This was followed on March 4th by a 25% tariff on imported automobiles, and on March 12th by a 25% tariff on all steel and aluminium products. On April 2nd, what Trump called 'Liberation Day', a series of so-called reciprocal tariffs were enacted on all countries, with those running a surplus trade in goods facing up to 50% tariffs in some cases, and all other nations a 10% baseline tariff. China faced tariffs of up to 86%, and when they imposed reciprocal tariffs on the US, this was increased to 145%. While the higher tariff rates were suspended for 90 days, the 10% tariff rate remains, as do the tariffs on China, although Trump has signalled that it could be relaxed depending on how trade talks go. In addition, while some designated 'critical minerals' and other goods that formed part of the United States-Mexico-Canada Agreement (USMCA) from Mexico and Canada have been exempted from the 25% tariff rates, they still face a 10% tariff rate.

The short term impact looks likely to fall most heavily upon goods travelling to and from the US and Canada and Mexico. The NAFTA and subsequent USMCA agreements have encouraged supply chains across North America to become highly interdependent, sometimes crossing borders multiple times before the finished goods reach the consumer. In most cases, US manufacturers cannot simply sever ties with such suppliers in the short term.

The supply of a number of base metals and other manufactured goods will have an impact on sulphur and sulphuric acid markets. These are detailed individually below.

Nickel

Over the last five years the US has imported on average more than half of its primary nickel requirement from Canada, with all of this coming from Vale. Tariffs are likely to disrupt trade flows and result in higher spot premiums for consumers. However, the immediate impact may be minimal as CRU understands that some players have moved more material to the country ahead of a risk of tariffs on Canadian nickel imports. As there is no trade between Mexico and the US in nickel - both countries do not have any domestic finished production - tariffs will not have any impact.

The US has one operating nickel mine located in Michigan, owned by Lundin. This mine produces a concentrate that is exported, given the US has no domestic nickel smelters or refineries with the capability to process nickel-bearing concentrates. However, this mine is anticipated to exhaust its production by the end of 2025, leaving the US with no domestic nickel industry. As a result, the US will be completely reliant on imports to meet its primary nickel requirements. Depending on the permanence of tariffs, US domestic nickel refining may become an attractive proposition and there is at least one company with plans to build a carbonyl nickel refinery producing high-purity nickel. However, the challenge this plant will have is sourcing intermediate feed.

Although Canada is home to several large nickel producers, only one has the right surface assets and ore sources to be able to supply the US market from Canada. Vale produces high-purity nickel from its Sudbury and Long Harbor operations. However, its Canadian assets sit in the third and fourth quartile of CRU's industry costs curve.

Zinc

Around three quarters all refined zinc consumption in the US is reliant on imports: 50% of the imported material comes from Canada and 16% from Mexico. Therefore, tariffs will directly affect about half of all zinc consumption in the US. Export tariffs will be passed onto customers almost entirely - CRU does not expect producers to absorb much of the tariffs charges. The total negative effect of the tariffs on the demand will, however, be partially offset by changes to the supply chains. Given weak demand in Europe, European smelters might be interested in exporting more to the US, but they will not be able to replace full Canadian and Mexican volume at least in the short and medium term. The average zinc price for US consumers will rise significantly initially, eventually finding its new equilibrium at the level less than the total tariff but still significantly higher than before. This will lead to some domestic galvanised sheet demand destruction from substitution effects. Canadian and Mexican smelters can do only three things to deal with the falling US demand: find new consumers in countries that do not impose tariffs, try to sell extra material to China or curtail production to accommodate lower demand from the US. Curtailing production may seem the best option to some as otherwise heavy price discounting would be needed.

Steel

A significant amount of US steel demand is met by imports (15% on aggregate). This varies by product: 10% for steel sheet and over 20% for long products and plate. Canadian imports will be impacted most, these making up around 35% of total steel imports: 40% of steel sheet and as high as 50% of plate. Domestic US steel prices will increase following the introduction of tariffs on semi-finished slab, steel scrap, and finished steel imports from Canada, Mexico and China. There will be a wide-ranging impact that will be felt most by steel end-use sectors, including automotive manufacturers. The specific quantum of price increase will vary by product depending on substitution options, and we do ultimately expect some destruction of demand in steel end use sectors.

PHOTO: WOLFGANG WEISER/PEXELS

Container ships at the port of Hamburg

Copper

Domestic output, with US refined copper production dominated by Freeport McMoRan and Rio Tinto, is insufficient for local consumption and the US imports some 50-60% of its domestic cathode requirements. While Chile accounts for almost three-quarters of the total c.130,000 t/a of imports are from Canada (primarily Glencore CCR, Montreal) and c.10-15,000 t/a imports from Mexico. The US exports cathode (163,000 t in 2023), mainly across the southern border into Mexico, and this could in theory be retained and sold into the domestic market and its net trade position with its northern and southern neighbours is almost balanced.

Battery metals

Lithium refiners located in the US currently only source feedstock from South America, while the cobalt supply chain in the US is not well-developed currently for both supply, and battery demand. However, Canada is one of the largest suppliers of cobalt metal to the US via Vale. CRU estimates that around two-thirds of the US market is alloy grade (e.g. for aerospace applications) and there are few other established alloy grade producers globally – China, Japan and Norway, with volumes of Chinese-origin cobalt metal into the US limited after having declined significantly during Trump's first presidency, when tariffs of 25% were imposed.

Supply of alloy grade metal is generally agreed via long-term contracts, with limited spot availability. Prices of Canadian-origin material will increase accordingly in the US, which in the longer-term may disrupt established trade flows. More Japanese and Indonesian cobalt metal is likely to move into the US, while Canadian material may flow more into Europe or Asia. Indonesian metal operations are Chinese-owned, and currently pass through China before reaching the US - it remains to be seen whether these will remain tariff free.

Lead

Higher US import tariffs on refined lead from Canada and Mexico make little sense in a national market that is structurally short of this battery metal. The imposition of higher tariffs on its two neighbours are likely to raise the cost of importing to fill the domestic lead shortfall. However, the degree of increase to the US consumer in the dominant lead end-use of batteries could be mitigated by the supply chain upstream absorbing some of the costs, be it importers or even exporters taking a cut in their profit margins. As a result, in the medium term, tariffs will likely result in the redirection of Mexican and Canadian cargoes towards Asian markets, and instead fulfilment of US demand with either additional domestic supply, or higher-copper South American concentrate previously destined for Asia.

Oil

In early April 2025, global oil markets experienced a sharp downturn triggered by escalating trade tensions and anticipated supply increases. President Trump's executive order introducing broad-based tariffs on US imports led to Brent crude prices falling by 17% within a week, dropping from early April levels to $64/bbl by April 8. Oil prices have recently staged a modest recovery, with the spot price nearing $68/bbl. This movement is driven by tightening US sanctions on Iranian oil flows, which have primarily impacted independent Chinese refiners with a strong preference for discounted Iranian crude.

Expectations for global oil demand growth have been downgraded by 500,000 bbl/d this year and 240,000 bbl/d in 2026. These revisions reflect weaker global growth expectations and increased uncertainty stemming from recent trade measures. The impact is most acute in the US and Asia, where US tariffs are likely to weigh on oil consumption growth. Nonetheless, non-OECD Asia, particularly India and China, is still expected to be the primary engine of global oil demand expansion over the forecast period.

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TSI World Sulphur Symposium 2025

PHOTO: SHUTTERSTOCK.COM

Florence.

The Sulphur Institute (TSI) held its World Sulphur Symposium in Florence from April 8th-10th.

This year the Sulphur Institute's annual symposium came to the beautiful city of Florence for its 65th anniversary meeting. In his opening remarks, TSI president and CEO Craig Jorgensen said that this year 127 delegates from 22 countries were in attendance, covering the whole sulphur and sulphuric acid value chains.

Global economic outlook

Professor Alessandro Sforza of the University of Bologna had the unenviable task of presenting the global economic outlook. He predicted global GDP growth of 3.3% for the 2025-26 financial year, split between 4.2-4.3% for emerging markets and 1.8-1.9% for the industrialised economies. The global figure is below the long term historical average of 3.7%, because of economic instability centring on US tariff policy and geopolitics in general, but he felt that a global recession was still unlikely. European rearmament will lead to larger than projected growth in Germany, albeit balanced by lower US consumer confidence and expectations of higher inflation. However, US trade policy and the prospect of a trade war with China added considerable uncertainty to the picture, along with the Russia-Ukraine war and troubles in the Middle East. We are seeing the highest levels of uncertainty and currency fluctuation since at least 1960. Growth may suffer not just in the short term but potentially over the rest of the decade. Could this be an end to dollar denominated trade and/or of globalisation itself? Professor Sforza foresaw reshoring and a new wave of industrial policy leading to more fragmented markets.

Oil and gas outlook

Francis Osborne of Argus gave the global energy outlook. OPEC+ is currently unwinding 2.2 million bbl/d of previous oil production cuts over the next 18 months, but the market does not need this crude. There is talk of compensating for this by getting those who have overproduced their quotas to take additional production cuts, but will this work? At present there is an implied stock build of 4.6 million barrels by 2027 and possibly an end to the market management that has lasted the previous 40 years. OPEC continues to lose market share by managing the market, but is resisting a fall to a more 'natural' oil price level of as low as $30/bbl.

Restraint by OPEC+ tends to remove more sour barrels from the market (around 1.5 million bbl/d of >4% sulphur crude). Meanwhile there has been no significant loss in Russian crude supply, but rather a switch from Europe to India and elsewhere in Asia. India is thus processing more sour crude and Europe receiving more sweet crude from the US leading to lower sulphur output from refineries.

Around 7 million bbl/d of refining capacity has ben closed since 2019, though new capacity has outpaced closures. But there is less and less new capacity ahead, almost none outside India and China. Overall refining remains relatively balanced, while refinery sulphur capacity is rising, mostly in India.

Global gas demand is growing out to 2050 by around 1.5-2.0% year on year, with new production mainly from Middle East sour gas, leading to a significant increase in sulphur output. Peak oil demand is expected around 2030, as transport moves to electric cars, and low carbon shipping and aircraft fuels. Upstream oil capex has already peaked, and investment is becoming slanted to gas. Non-OPEC+ oil supply will fall faster than OPEC+ after 2030, leading to more heavy sour crude on the market and more sulphur, but there is likely to be a prolonged period of refinery closures, around 14 million bbl/d out to 2050.

Chemical industry

The present and future of the chemical industry, particularly in Europe, was the topic of Dr Moncaf Hadhri of CEFIC. In 2003, Europe was the largest chemical producing region in the world, representing 28% of production, with the US at 23% and China 9%. Twenty years later in 2023, China represented 43% of production, the USA 11% and Europe 13%, even though global chemical sales had quadrupled during that time. Europe has faced weaker domestic demand, a lack of competitiveness for exports and a lack of investment, though it is still – just - the largest exporter (and exports more than twice what it did in 2003). The European industry is bedevilled by high energy costs, and the prospect of US tariffs only adds to its potential problems.

Caprolactam

Jincy Varghese of ICIS looked at the global caprolactam market. The caprolactam industry has gravitated inexorably to China and northeast Asia, where 79% of demand now sits, as compared to just 8% each in Europe and North America. China continues to build capacity, which is why the utilisation rate is only around 70-75%. End uses are mainly (62%) for nylon fibre production, with 35% for resins. There is not much inter-regional trade – instead derivatives like nylon are traded; 90% of nylon produced is exported. For caprolactam, 2/3 of trade is represented by sales from Russia to China. Europe has been a net exporter historically, but is now roughly balanced. Northeast Asia has been a net importer, but new capacity in China means it may become a net exporter from 2026, with capacity closures expected in Europe and Asia outside China.

Battery metals

Anna Fleming of Benchmark Mineral Intelligence surveyed the market for battery metals with reference to sulphur, particularly lithium, nickel, cobalt, manganese and copper. Electric vehicle sales remain dominated by China, where sales were up 36% in 2024, as compared to % in the US and a contraction of 4% in Europe as tax credits were removed. Battery demand was up 28% in 2024, including a 25% rise in EV demand, and a 56% rise in stationary storage applications. Overall the expected CAGR over the next decade is 15% year on year, while the price per kWh has dropped to 25% of its 2014 level.

The impact on metal demand is determined by battery chemistry. Lithium demand is forecast to rise 12% year on year to 2035, with 90% going to battery production, while nickel demand will rise 6% year on year, and cobalt 7%. There is oversupply in many metals markets at present, but demand is catching up rapidly. For nickel, Indonesia represents 82% of new supply and 52% of new copper supply, while the DRC is another 34% of new copper supply. Lithium production is forecast from the US, China, Argentina and other countries, while China will represent 55% of new manganese supply.

Clean technologies represent an increasing amount of copper demand, with copper requirements for wind, solar, EVs, new grid connections etc rising from 2.5 million t/a in 2025 to 4 million t/a in 2030.

Recycling is also becoming increasingly important, especially for lithium and cobalt – this is good news for sulphuric acid as it represents one of the cheapest methods of recovering metals.

Phosphate market

The annual phosphate outlook was presented by Alan Pickett of S&P Global (formerly Fertecon). There has been a slight recovery in demand for phosphates in 2023-24, but demand remains fairly flat. Major impacts in the past few years have included high EU gas prices and the Ukraine war, and Chinese export restrictions. Prices are historically high at present, with a strong correlation with sulphur prices. Fertilizer affordability looks challenging in 1H 2025, especially for DAP, similar to the situation in 2018-19, when demand fell by 1.6% over two years. Overall demand for finished phosphates is likely to be negligible over the next ive years, with the CAGR to 2050 around 0.5% year on year, leading to more static sulphur demand growth as there is increased efficiency in fertilizer application.

Regionally, the US is still just about a net exporter, making it vulnerable to counter-tariffs from Canada, Mexico, China and the EU. The US has already imposed countervailing duties on Russia and Morocco, leading to a switch to imports from Saudi Arabia, Australia, Israel and Jordan. Chinese exports remain restricted, though it is still the second largest phosphate exporter after Morocco. For 2024, exports of MAP and DAP from China were 7.8 million t/a. Technical MAP production in China is increasingly going to LFP battery production. Supply growth favours lower cost exporters like Morocco and Saudi Arabia, with closures likely in China, and relatively static production in Russia, India and the US. Trade remains relatively concentrated, with the top five exporters controlling 80% of trade, and the top five importers 50% of trade.

Alan finished by looking at the possible impact of carbon capture measures on sulphur production. From the 2030s there will be an undersupply of sulphur under most scenarios, and metals markets can probably outbid phosphate fertilizer production for what sulphur there is. Where will additional sulphur come from? Options include melting down existing sulphur blocks (representing 20-30 million tonnes), a return to Frasch mining, using more pyrites for acid production, switching to other agricultural sources of sulphur such as polyhalites or gypsum, using non-sulphur acid technologies like nitric or hydrochloric acid, and recycling more spent acid.

Sulphur and sulphuric acid

Finally, Freda Gordon and Fiona Boyd of Acuity gave the usual sulphur and sulphuric acid market roundup. Sulphur production in 2025 is forecast to be 73 million t/a and consumption 71 million t/a, with a surplus of around 2.5 million t/a – not much in terms of existing port stocks. The Middle East remains the production giant, with new production in Saudi Arabia, Kuwait, Qatar and the UAE over the next five years. The US is seeing supply decrease as refineries close, while demand is increasing for lithium production. However, US demand is increasingly away from ports and supply centres, leading to higher costs for the new lithium mines. Indonesia is a rising powerhouse in sulphur and sulphuric acid. There have been some delays in smelter startups, but once operational they will displace sulphur burning acid production locally. Chinese sulphur consumption is rising for LFP batteries, caprolactam and titanium dioxide production. Imports were up 12.7% to 10 million t/a in 2024, while domestic production rose to 10.8 million t/a last year. Chinese acid production was around 120 million t/a in 2024, with exports of 2.7 million t/a. Europe is facing a molten sulphur shortage due to refinery closures and processing of more sweet crude from the US, possibly leading to more remelter capacity. Africa is seeing new consumption for mining, phosphates in Morocco and Tunisia, uranium in Namibia, and copper and cobalt in the DRC.

For acid markets, 2025 is forecast to see 329 million t/a of production against 308 million t/a of demand. But production may be lower due to shortages of copper concentrate for smelters. There is new smelter capacity in China, India and Indonesia and new sulphur burning capacity in Morocco and Indonesia. Higher sulphur prices may limit sulphur based acid availability. Peru is competing with China to supply Chile, but the Tia Maria startup, now scheduled for 2027, will reduce Peruvian export availability. In Australia, the idling of Nickel West is leading to lower sulphur demand but higher acid requirements locally, though nickel projects are facing cost issues. New Indian smelter capacity will lead to lower sulphur imports.

Next year's Symposium will be held in Vancouver, Canada, from the 28th-30th of April 2026.

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A sulphuric acid pump for high-temperature applications

The GVRN sulphuric acid pump has been established in the market for many years. Rheinhütte Pumpen has further developed this special pump so it can also be used in high-temperature applications such as in heat recovery systems.

Sulphuric acid is one of the most important basic chemicals in numerous global industries. More than 200 million tons are produced worldwide every year. However, production causes enormous amounts of CO_2, which pollutes the environment, and valuable resources, such as the waste heat generated in the process, are wasted. Heat recovery systems (HRS), which utilise the highly exothermic processes in the production of sulphuric acid, provide a remedy. These systems can be integrated into sulphuric acid plants and adapted to the respective requirements of the plant. The aim is to recover waste heat in the form of high and medium pressure steam. Users can use this process steam for other processes or to generate electricity. In a typical process cycle for sulphuric acid production, around 60% of the total energy can be used and 35 to 40% is available as low-level heat in the acid cooler system. The HRS comes into play with this weak heat in order to utilise it - which would otherwise end up in the atmosphere or in the cooling water system. This means that users can utilise almost all of the waste heat by using a heat recovery system. The challenge for pump manufacturers in this application lies in the highly aggressive and extreme temperature of the acid as well as the size and efficiency (> 80 to 85%) of the pumps.

In 2013, Rheinhütte Pumpen started with HRS prototypes for a sulphuric acid plant of a European fertilizer manufacturer. Existing pumps from another manufacturer were to be replaced. Vertical pumps were required that could pump 99.5% sulphuric acid at 224°C. The GVRN pump was selected, which had already proven itself in sulphuric acid plants for decades. The only difference to the previous projects was the extremely high temperature of the sulphuric acid. However, the special material previously used in sulphuric acid proved to be resistant even at these temperatures.

In addition to the specific choice of materials, other design features are also crucial in this application. One key factor is the sealing of the pump. Single-acting, gas-lubricated mechanical seals in cartridge design with a throttle on the tank side are the optimum choice for vertical HRS pumps. The throttle reduces the sealing gas consumption by creating a gas cushion. This protects the seal and minimises the leakage of the container atmosphere. The gas also keeps unwanted atmospheric oxygen or humidity away from the gas seal. Alternatively, a stuffing box packing can be used in vertical pumps that operate at lower temperatures. Both sealing variants were already tried and tested sealing variants of the GVRN.

There was a need to optimise the hydraulics and design in order to avoid crevice corrosion. Due to the highly corrosive properties of the medium, screw connections were avoided wherever possible. Screw connections that are located in the medium are fitted with cap nuts and additional O-rings. The flanges are cast onto the pipes instead of bolted to prevent crevice corrosion. The pumps also have a double volute, which greatly reduces the radial loads, resulting in less stress on the shaft and rolling and plain bearings. In order to minimise partial load recirculation (reduction of NPSHr), the suction covers have been fitted with swirl breakers.

In order to cover a wide performance range, the high-temperature version of this series has been developed in several sizes. Five sizes are already available and more will be released this year. ■

PHOTO: RHEINHUETTE PUMPEN

Sulphuric acid pump GVRN for high-temperature applications.

PHOTO: RHEINHUETTE PUMPEN

The vertical pump is installed in the tank of the sulphuric acid plant.

MEScon welcomes you to Abu Dhabi

The Middle East's premier event for the sulphur global industry, MEScon 2025, returns to the Conrad Abu Dhabi, Etihad Towers from 19 to 22 May 2025.

The 2025 Middle East Sulphur Conference (MEScon 2025) organised by CRU and UniverSUL Consulting and hosted by ADNOC will reconvene at the Conrad Abu Dhabi, Etihad Towers in Abu Dhabi, UAE, from 19 to 22 May 2024.

Located at the epicentre of global sulphur and sour hydrocarbon production, this premier sulphur event will gather representatives from along the entire sour gas / sulphur value chain to promote technology and innovation, lessons learned, best practices, knowledge transfer, and R&D.

Taking place over four days, the event starts off with a workshop day consisting of pre-conference workshops, the MEScon Annual Operations Roundtable and Technical Showcases, followed by a three day conference featuring technical and market presentations, panel discussions and poster sessions. An exhibition with companies showcasing their latest technologies and products serving the sulphur supply chain will take place alongside the conference throughout the event.

Key themes on the 2025 agenda are:

- State of the industry and sulphur innovation in the Middle East
- Smart sulphur: Harnessing digitalisation and AI for industry innovation
- Going green in a yellow world: Suphur sustainability and circular economy
- Sweet solutions for sour gas: Innovations in production and treatment
- Mastering sulphur recovery and tail gas treating in a changing world
- Shaping sulphur: Forming and handling in the heart of global production

Angie Slavens, Managing Director, UniverSUL Consulting, provides a taste of what you can expect at MEScon 2025:

"We've always said MEScon is more than just a conference – it's a community. But this year, it's also a catalyst. As the sulphur industry's centre of gravity continues to shift to the Middle East, MEScon is where innovation is taking root. From the ADRIC competition for new sulphur applications to new developments in digitalization, green initiatives and the circular economy, we're spotlighting bold ideas and regional leadership. And through MESconnect, our new mentorship program, we are actively preparing the next generation to carry that momentum forward."

PHOTO: CRU

The exhibition is where delegates gather to network, meet with exhibitors and take refreshments.

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WORKSHOP DAY – Monday, May 19, 2025

WORKSHOP 1 (09:00–12:30)
STEAM AND HEATING CONSIDERATIONS IN SULPHUR PLANTS

CSI Ametek

Join CSI Ametek for an engaging 4-hour workshop led by experienced industry professionals, designed to deepen participants' understanding of steam heating systems and process heating technologies.

The session will begin with an introduction to steam heating theory, followed by a detailed look at steam tracing technologies and the thermal requirements for various applications, including liquid sulphur, tail gas, sour water acid gas, sulphur vapor sweep air, and sulphur storage tanks/vessels.

Instructors will share real-world "war stories" involving undetected corrosion and the challenges that arise during upset conditions, such as run-down plugging, quenching, process mixing, re-boiling, cold spots and supports, and circuitry mistakes.

WORKSHOP 2 (09:00–12:30)
NAVIGATING SULPHUR RECOVERY CHALLENGES – A CHOOSE YOUR OWN ADVENTURE WORKSHOP

SGS Sulphur Experts

Join Sulphur Experts for an interactive workshop where participants will decide which of the most common sulphur recovery issues will be addressed:

- Operations and Emissions
- Corrosion
- Plugging
- Fires, Overheating and Explosions
- Process Gas / Fluid Release

This will be based on real-world examples of helping hundreds of clients, though attendees are encouraged to share their own story with any of these topics, preferably with a picture (no shame!) so we can apply the group's knowledge and our experience in an interactive format to ensure everyone leaves with valuable insights and practical solutions to improve their sulphur plant reliability.

WORKSHOP 3 (09:00–12:30)
MIDDLE EAST SULPHUR SUMMIT: EXPERT INSIGHTS ON FORMING & HANDLING

Hany El Gheriani, *Enersul*; Varun Mathur, *IPCO*; Khalid Ghazal, *Samref*; Francis Bernard, *ASRL*; Jeff Cooke, *DuBois Chemicals*

Join us for an engaging and informative workshop exploring key aspects of sulphur forming, handling, and logistics. This session will feature a series of short presentations from industry experts, followed by interactive discussions and Q&A. Attendees will gain insights into the latest technologies, best practices, and solutions for optimizing sulphur product processing and transportation.

Topics & Presenters:

- Sulphur Forming – Granulation, *Enersul*
- Sulphur Forming – Pastillation/ Granulation, *IPCO*
- Sulphur Forming – Wet Prill, *Samref*
- Sulphur Product Quality and Testing, *ASRL*
- Dust & Acidity Control, *DuBois Chemicals*
- Remelting, *Enersul*

TECHNICAL SHOWCASES
15:00–16:15

Hybrid Solvent System Development & Phenomena – Ashraf Abufaris, *BASF*

Decarbonization Opportunities in SRU of Gas Processing Plants to Reduce Greenhouse Gas Emissions – Rakesh Wasnik, *NMDC*

Breakthrough in Modeling Technology – A Mass Transfer Rate-Based Model for Liquid-Liquid Treating – Hari Vamsi Duggirala, *Optimized Gas Treating*

Brake the Breakthrough – Stopping SO_2 before it Clouds the Quench System – Marcus Weber, *Fluor*

MEScon OPERATIONS ROUNDTABLE (open forum Q&A) 13:00–15:00

The MEScon Operations Roundtable is a premier platform where industry experts gather, in the world's largest sulphur-producing region, to facilitate open discussions on critical topics within the realm of sour gas treating, sulphur recovery, tail gas treating, sulphur forming & handling, and CO_2 capture along the sulphur value chain. This open forum Q&A session is designed to foster collaboration, encourage the sharing of lessons learned, and address challenges faced by professionals working in these specialized fields. Key highlights of the MEScon Operations Roundtable include:

- **Expert facilitated discussions**: Industry leaders with extensive experience in sour gas treating, sulphur recovery, and related areas lead engaging discussions on pressing issues, trends, and innovations.
- **Open exchange of ideas**: Participants have the chance to share their experiences, challenges, and successes, fostering a collaborative environment conducive to learning and problem-solving.
- **In-depth exploration of hot topics**: The forum covers a wide array of topics spanning the entire sulphur value chain, from gas treatment to sulphur handling and CO_2 capture, ensuring comprehensive coverage of relevant industry issues.
- **Networking opportunities**: Attendees have the chance to connect with peers, potential partners, and solution providers, facilitating valuable networking opportunities and potential collaborations.

MEScon

Middle East Sulphur Conference 2025 | 19-22 May 2025 | Conrad Abu Dhabi Etihad Towers

Co-organisers: CRU, UniverSUL Consulting | Hosted By: ADNOC

(Correct at time of going to press)

CONFERENCE DAY 1 – Tuesday, May 20, 2025

OPENING CEREMONY
09:00–09:30

Opening Video(s)

Welcome – Mr. Musabbeh Al Kaabi, CEO, *ADNOC Upstream*

Setting the Scene for MEScon 2025 – Angie Slavens, *UniverSUL*

STATE OF THE INDUSTRY AND SULPHUR INNOVATION IN THE MIDDLE EAST
09:30–12:20

Sulphur Market Overview – Dr. Peter Harrisson, *CRU*

Chinese Sulphur Market Overview and New Demand Sources – Stefan YU, *Unilink*

Indonesian HPAL Plant – Nasser Aljunied, *Neo Energy*

Presentation of Sponsor Awards – Michelle Bingham, *CRU*; Angie Slavens, *UniverSUL*

FORMAL EXHIBITION TOUR

The Crown Molecule: Recent Advances and Breakthroughs – Saeed Alhasan, *Khalifa University*

Sulphur Innovation: New Uses for a Sustainable Future – *Various*

LUNCH

SMART SULPHUR: HARNESSING DIGITALIZATION & AI FOR INDUSTRY INNOVATION
13:20–17:00

Session Overview/Objectives

AI Driven Decision Support for Control Room Operations – Ivan Novendri, Reem Mohammed Al Mansoori, Suresh Kumar, *ADNOC Gas*

The Digital Process Monitor (DPM): Digitalization for SRU Process and Environmental Excellence – Francesca De Mauro, *KT-Tech*

Real Time UT Corrosion Monitoring System in Sulphur Recovery Unit – Fatma Alshamsi, Nasser Al Qahtani, *ADNOC Sour Gas*

The Successful Story of Samref's SRU's Muffle Furnace PLC Control Panel & Logic Modification – Khalid Ghazal, *Samref*; Santhosh Fernandes, *Sensia Global*

COFFEE BREAK

Reliable Multi-Component CEMS Measurement after the Sulphur Recovery Unit – David Inward, *Endress + Hauser*

SRU/TGTU Water Balance Intelligent Control – Dedik Rahmat Ermawan, *Aramco*

Increasing Efficiency in Sulphur Rail Car Loading via AI Models – Saood Al Marzooqi, *ADNOC Sour Gas*

SMART SULPHUR PANEL SESSION (Q&A for all speakers in session)

QUIZ

PHOTO: CRU

Peter Harrison, CRU Principal Analyst, Sulphur and Sulphuric Acid, will present the sulphur market overview.

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CONFERENCE DAY 2 – Wednesday, May 21, 2025

OPENING

09:00–09:10

Welcome from MEScon Executive Committee – Adel Al Jaberi, *ADNOC Sour Gas*

GOING GREEN IN A YELLOW WORLD: SULPHUR SUSTAINABILITY & CIRCULAR ECONOMY

09:10–12:10

Session Overview/Objectives

Greening the Green Refineries with Innovative H_2S Recycling – Ayan Dasgupta, *Fluor*

Greening the Sour – Vijay Algule, Aisha Waheed Alkayyoomi, *ADNOC Sour Gas*

Advancing Gas as a Transition Fuel Through an Inclusive Decarbonization – Saqib Sajjad, *ADNOC Gas*

Energy and Cost Optimization Opportunities in an SRU – Jan-Willem Hennipman, *Worley*

COFFEE BREAK

Energy Efficiency Opportunities in Sour Gas Treatment Units to Improve Sustainability – Vikrant Parmar, *NMDC*

SRU/TGTU Hydrogenation Catalyst Lifecycle Best Practices – Abdulrahman Muabber, Yahya Almousa, *Aramco*

GOING GREEN IN A YELLOW WORLD PANEL SESSION (Q&A for all speakers in session)

SWEET SOLUTIONS FOR SOUR GAS: INNOVATIONS IN PRODUCTION & TREATMENT

13:40–17:10

Session Overview/Objectives

Sulphur Deposition in Sour Gas Production Systems: Getting the Native Sulphur Composition Right – Dr. Rob Marriott, *ASRL*

Advanced Analysis of Elemental Sulphur Deposition in Gas Systems: Challenges and Mitigation Strategies – Hatem Hamed Gouhar, *ADNOC Offshore*

Optimization of Sulphur Solvent Regeneration Processes in Sour Gas Treating Facility Grossenkneten – Djakhongir Ravshanov, *ExxonMobil*

Unlocking Hidden Potential: A Success Story in Existing Facilities with Proprietary Amines – Feras Kordi, *BASF*

COFFEE BREAK

Optimizing SRU Operations: Upstream Units Operation and How They Can Impact SRU Performance – Mostafa Shehata, Ganank Srivastava, *BR&E*; TBD, *Glencore*

Maximizing Existing Asset Utilization in Context to Global Shift Towards Increased LNG & NGL Demand – Muhammad Rehan Afzal, Arunkumar Jayachandran, *Wood*

Non-Immersive Temperature Measurement Technology – Asadullah Malik, *ADNOC Gas*

SWEET SOLUTIONS FOR SOUR GAS PANEL SESSION (Q&A for all speakers in session)

QUIZ

POSTERS

12:10–12:40

Transforming SRU Operations – Minimize Carbon Footprint and Improve Efficiency – Ivan Novendri, *ADNOC Gas*

SRU Spent Catalyst Reuse in Cement Industry – Yahya Almousa, Adel Najjar, *Aramco*

Innovative Shutdown Procedures in Gas Treating Units: Elimination of Flaring Through Processing of Sweet Gas in Hot Circulation Stage – Mohammed Alruwaii, *Aramco*

Probabilistic, Time-based Economic Analysis of Sulphur Recovery Technologies – Frank Scheel, Jan-Willem Hennipman, *Worley*

H_2S Decomposition to H_2 Using Catalyst: Upscaling and Energy Efficiency Studies – Anton Manakhov, *Aramco Innovations*

Condensation Drives Corrosion – Stop Corrosion of SRU Equipment at the Source – Brandon Forbes, *CSI Ametek*

PHOTO: CRU

Poster sessions give delegates an opportunity to learn directly from operating and supplier companies.

(Correct at time of going to press)

CONFERENCE DAY 3 – Thursday, May 22, 2025

OPENING

09:00–09:10

Welcome from MEScon Executive Committee – Ahmad Shams, *ADNOC Gas*

MASTERING SULPHUR RECOVERY & TAIL GAS TREATING IN A CHANGING WORLD

09:10–12:10

Session Overview/Objectives

Lessons Learned from Saudi Aramco Jazan Refinery SRU/TGTU Commissioning and Start-up – Edward Douglas, Rajeev Dubey, *Aramco*

Optimize Reliability at Petronas Melaka O2-Enriched SRU Through Operational Improvements – Mohamad Azahar Bin Ahmad, *Petronas*; Jan Kiebert, *SGS Sulphur Experts*

Identifying and Responding to COS and CS_2 in a Sulphur Recovery Unit – Jochen Geiger, *Ametek*

Comparative Analysis of Above-Ground Sulphur Sealing Technologies for Sulphur Recovery Units – Stefaan Gouhie, *CSI Ametek*

COFFEE BREAK

Simulation-based Thermo-hydrodynamic Analysis of a Claus Process Catalytic Reactor – Elmo Nasato, *NCL*

Finding NiMo: When Novelty Meets TGT! – Johann Le-Touze, *Axens*

MASTERING SULPHUR RECOVERY & TAIL GAS TREATING PANEL SESSION (Q&A for all speakers in session)

POSTERS

12:10–12:40

Autonomous Operations: Improve Asset Performance, Energy and Production Efficiency in Sour Gas Fields – Vineet Lasrado, *Honeywell*

Handling Irregular Feeds to an SRU – Ganank Srivastava, Mostafa Shehata, *BR&E*

BHEEU Analysis by UV-Vis Spectrophotometer – Syed Masood Ali, Edgar Cruz Fernando, *ADNOC Sour Gas*

SRU Reaction Furnace Successful Thermocouple Pilot – Ahmad Almousa, *Aramco*

Maximizing SRU Reliability by RCA-driven methodologies – Mohammed Al Mazrouei, Syed Ather, *ADNOC Gas*

Introduction of AI to Predict SOx Emission in Acid Gas Removal Plant of MAA Refinery – Fatemah Mohammad, *KNPC*

SHAPING SULPHUR: FORMING & HANDLING IN THE HEART OF GLOBAL PRODUCTION

13:45–16:55

Session Overview/Objectives – Saood Al Marzooqi, *ADNOC Sour Gas*

Sulphur Handling Best Practices – Jacobus Kotze, *Aramco*

Why Solidify Sulphur, How and for What Purpose? – Varun Mather, *IPCO*

Reliability Enhancement of the Sulphur Granulating Plant – Dr. Hussain Al Hashimi, *ADNOC Sour Gas*

COFFEE BREAK

Samref Folds the Final Chapter of the Sulphur Dust Challenges – Khalid Ghazal, *Samref*; Jeff Cooke, *DuBois Chemicals*

Progressive Strategies for Sulphur Spill and Dust Control Management – Ibrahim Ali Alali, *ADNOC Gas*

SHAPING SULPHUR PANEL SESSION (Q&A for all speakers in session)

QUIZ

CLOSING CEREMONIES / END OF CONFERENCE

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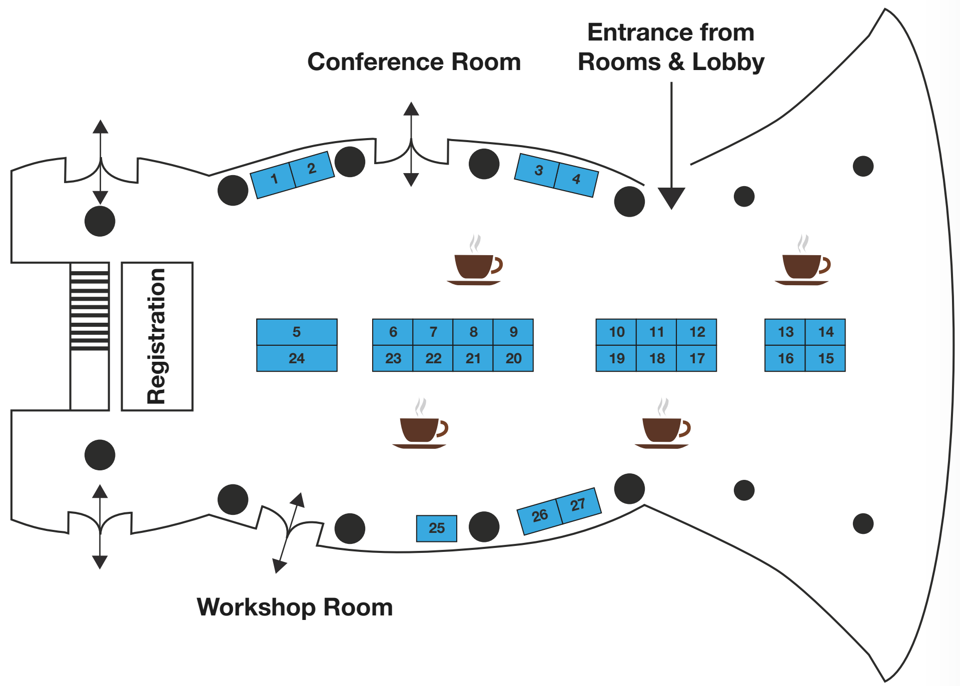
EXHIBITION FLOORPLAN



EXHIBITOR LIST

1 BASF
2 Enersul Limited Partnership
3 IPCO
4 HEC Technologies
5 ADNOC
6 Industrial Ceramics
7 Zeeco Middle East
8 Aecometric Corporation
9 Euro Support
10 Worley Comprimo
11 OHL Gutermuth Industrial Valves
12 SGS Sulphur Experts
13 Axens
14 Delta Controls Corporation
15 Unilink Commodities Trading Platform DMCC
16 Endress+Hauser
17 Bryan Research & Engineering
18 Wilson International Trading DMCC
19 Blasch Precision Ceramics
20 AMETEK Process Instruments
20 Controls Southeast
21 Optimized Gas Treating
22 AZ Armaturen
23 Gouda Refractories
24 Sankyu Saudi Arabia
25 Envitrack
26 Duiker Clean Technologies
27 Fluor

EXHIBITOR LIST (A-Z)

5 ADNOC
8 Aecometric Corporation
20 AMETEK Process Instruments
13 Axens
22 AZ Armaturen
1 BASF
19 Blasch Precision Ceramics
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15 Unilink Commodities Trading Platform DMCC
18 Wilson International Trading DMCC
10 Worley Comprimo
7 Zeeco Middle East

EXHIBITOR PROFILES

Aecometric Corporation — Stand 8

For over 50 years Aecometric has been a trusted name in providing industrial combustion equipment. The Aecometric Customised High Intensity Burner technology stands alone in performance, quality and reliability. The Aecometric burner design lends itself perfectly to the combustion needs of the sulphur and sulphuric acid industry by providing maximum contaminant destruction, exceptional reliability and a high level of operational flexibility.
Contact: Sany Cao Email: sanycao@aecometric.com
www.aecometric.com

IPCO — Stand 3

IPCO is a high-technology engineering business with advanced products and world-leading positions within selected areas. We benefit from the strength and stability that comes with being an internationally active, mid-size company owned by the Wallenberg foundations. As a world leader in sulphur processing and handling solutions, IPCO has delivered complete end-to-end systems to hundreds of companies around the globe since 1951.
Contact: Varun Mathur Email: varun.mathur@ipco.com
www.ipco.com/sulpur

AMETEK Process Instruments — Stand 20

AMETEK Process Instruments is a worldwide manufacturer of process analyzers and instrumentation. Reliability is one of AMETEK's top priorities and many of its analyzers have been in service for well over 20 years. AMETEK's core competencies include sulphur recovery processes, combustion efficiency control and process heating, natural gas processing and transmission, and analysis of moisture in hydrocarbon gases and high purity gases.
Contact: Karla Graves Email: Karla.Graves@ametek.com
www.ametekpi.com

Fluor — Stand 27

With unique experience and knowledge in the design of sulphur recovery plants and tail gas treating units, Fluor offers a full range of services from technology licensing, feasibility studies, final start-up, normal plant operation to troubleshooting. Fluor experts are experienced in commercially proven sulphur technologies and have the knowledge to devise optimum solutions that cost-effectively satisfy your client's environmental requirements.
Contact: Marcus Weber Email: marcus.weber@fluor.com
www.fluor.com

Blasch Precision Ceramics — Stand 19

Blasch's unique and innovative ceramic systems provide significant process improvement benefits for SRUs. Blasch VectorWall™ for the reaction furnace and incinerator provide higher reliability, ammonia/BTEX destruction, faster installation, capacity increase, energy savings and lower emissions. Blasch ProLok™ ferrule designs require no castable refractory and offer far superior tube sheet and boiler tube protection preventing costly shutdowns.
Contact: Samuel Mancuso Email: smancuso@blaschceramics.com
www.blaschceramics.co

Worley Comprimo — Stand 10

Worley Comprimo is a global provider of gas treating and sulphur recovery technology focused on reducing emissions, increasing site reliability and improving plant economics. For over 60 years, its technology has been at the forefront of sulphur recovery. Worley Comprimo's portfolio covers the full range of technologies in gas treatment, sour water stripping, sulphur recovery, sulphur degassing and sulphur handling, storage and transportation.
Contact: Frank Scheel Email: Dallie.Hoetmer@worley.com
www.worley.com/comprimo

Duiker Clean Technologies — Stand 26

Duiker is a specialised combustion engineering and contracting company based in the Netherlands, providing advanced thermal process solutions, related equipment, and after-sales services for applications such as sulphur recovery, ammonia-to-hydrogen, and ammonia-to-heat conversion. With extensive experience in designing, supplying, and servicing sulphur recovery burners and associated equipment, Duiker integrates proven engineering with innovative features that enhance plant performance, safety, reliability, and overall operation.
Contact: Ernst van Koert Email: sales@duiker.com
www.duiker.com

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Next generation filtration for liquid sulphur

PHOTO: SULPHURNET

Self-Cleaning Liquid Sulphur Candle Filter.

The Self-Cleaning Liquid Sulphur Candle Filter (LSCF) is setting a new benchmark in liquid sulphur filtration. With its innovative candle arrangement and advanced back-flushing technology, it enhances filtration rates significantly and minimises downtime for cake discharge. **Jan Hermans** of Sulphurnet explores the LSCF design, process parameters, and operational advantages.

Filtration of liquid sulphur is a critical step in the sulphur melting process for the sulphuric acid industry. After the sulphur has been melted and neutralised, it is necessary to remove impurities like insoluble organics, ash, gypsum and over-dose lime in order to meet industry purity standards. While, historically, pressure leaf filters have been the common solution, these systems are not always optimal for modern industrial needs, particularly when it comes to safety, efficiency and automation.

In recent years, Sulphurnet has introduced the Self-Cleaning Liquid Sulphur Candle Filter (LSCF), a modern alternative to overcome the limitations of traditional pressure leaf filters. This new technology employs candle elements with an automatic system for filling and cleaning which minimises manual intervention, which improves efficiency, operational reliability, costs, and safety standards.

A historical overview of sulphur filtration

In 1942 E.I. Dupont patented the first self-cleaning candle filter. This filter included vertical candles, and the application of precoat material to facilitate the filter cake discharge.

A decade later, researchers J.R. Donavan and B.J. Barnett from Monsanto Chemical Co., presented a publication on the flowrates and filtration efficiencies of the pressure leaf filter versus the carbon tube filter.

Although the filtration efficiency of the later prevailed, the market leaned towards pressure leaf filter technology, mainly because of its capacity, and it has been the standard for decades ever since.

Nevertheless, pressure leaf filters come with their own share of disadvantages: They need to be cleaned in open position by operators that come in contact with hot vapours and high temperature filter cake; they also present a high risk of fires due to the presence of FeS in the filter cake; and the operation process overall is not an easy or straightforward task.

Fast forward to today, with more stringent industrial standards for Health, Safety, and Environmental regulations, the low availability of labour and process downtime are becoming increasingly important factors in decision-making when choosing an industrial filter, influencing business operations across all industries.

Nowadays, due to its high labour involvement and safety matters, the pressure leaf filter is no longer an ideal solution for sulphur filtration. The low level of automation, operational costs and efficiency issues have opened the path for alternatives like the ones developed by Sulphurnet.

The Self-Cleaning Liquid Sulphur Filter (LSCF) is a direct response to the modern-day challenges. It has been designed to enhance operational efficiency, reduce downtime, and meet stringent health, safety, and environmental standards, specifically for sulphur filtration applications.

Understanding the filtration mechanisms

The LSCF is a pressure filter which employs vertical hanging candles in a vertical positioned tank with a cone bottom, for dry cake discharge. The filter candles are made of stainless steel, covered with filter media suitable for the extreme process conditions.

The general process steps of the LSCF can be summarised as follows:

Filling: The pressure vessel of the filter with the candles inside is filled with clean liquid sulphur after which the precoating process is started.

Precoating: To obtain a good efficiency in sulphur filtration, the application of filter aids is essential. The type and grade of the precoat material is responsible for the filtration performance as well as the flow rates (pressure drop).

Fine grade filter aids, (low Darcy number) give a high efficiency in filtration, but also a high pressure drop and lower flowrates. Course filter aids, (high Darcy Number) give a lower efficiency with high flow rates and low pressure drops. It is always of importance to make the right selection to obtain good contaminant removal efficiency.

Adding the precoat layer provides two filtration principles, which are similar for both the candle type or pressure leaf filter. Particle removal occurs either by means of surface filtration (used for cake filtration) or depth filtration (the precoating layer). The filter medium retains particles in two principal ways: When the particles are predominantly larger than the size of the filter medium pores, solids are deposited on the up-stream side of the thin filter medium during what is referred to as surface filtration.

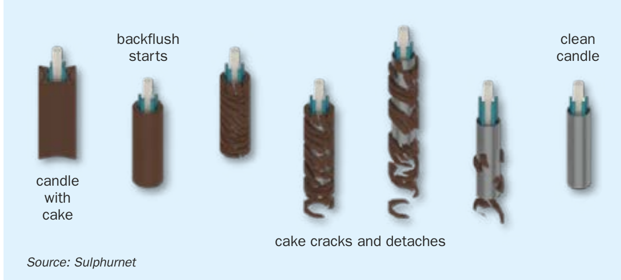
Sulphurnet's recommendation is the application of cellulose filter aids. They have a lower consumption in comparison with mineral filter aids. And at the same time, due to the fibrous structure, rough surface, and large porosity, higher flow rates and longer cycle times can often be obtained. In the case of the pressure leaf filter, easier cake discharge helps reduce manual cleaning which leads to longer lifetime of the filter leaves and the filter in general. And last but not least, the lack of harmful crystalline components also reduces health hazards.

Filtration: The liquid sulphur passes the filter cloth from the outside to the inside of the support candle. Liquid sulphur flows downwards to the bottom of the candle into the centre tube. The filtrate flows up into the horizontal register and out of the pressure vessel through the filter outlets. The centre tube is essential for effective candle drainage and optional drying of the cake.

Cake extraction-drying: During the pumping out of the heel volume from the filter vessel and the drying phase, steam is forced through the filter cake in the direction of the filtration towards the inside of the filter element. At the same time, the central tube guarantees that the cake on the filter element is extracted and that the remaining sulphur in the filter element is displaced by the steam leaving the minimum of sulphur. The extraction can be improved by executing these steps per individual manifold.

Cake discharge: After emptying the filter vessel, and possible cake extraction, each filter manifold is subjected to a reverse gas flow pressure shock. As the filter medium expands, vertical cracks are generated in the cake. When the medium reaches its maximum deflection, its movement stops, and the cake is thrown off. This backflushing is done per manifold/register, so the filter cake is completely dislodged from the candle. The cake drops downwards into the conical section of the pressure vessel and can be discharged (see Fig. 1).

Fig. 1: **Shows the cake discharge schematically**



Source: Sulphurnet

Superior filter media design

The filter medium used in this application is suitable for the elevated temperature as well as the high-pressure backflush. The combination of multifilament and monofilament fibres provides a balance between strength and efficient cake discharge, which is crucial for maintaining operational efficiency. The cylindrical weave is the multifilament that adds durability and structural integrity, while the monofilament in vertical orientation improves the removal of filter cake.

The lifespan of the filter medium is more than ten months in operation without needing replacement. It is a reliable and long-lasting solution for sulphur filtration under tough conditions.

Automation and process control

The biggest advantage is the possible automation of such a system. By adding functional process instrumentation and automated valves, the complete procedure from filling to cleaning can be fully automated, providing the following benefits:

- reliable, controllable, and reproducible process;
- semi- or fully automatic operation;
- real time monitoring (MMI);
- data logging of level and pressure changes;
- reduced operator workload.

Advantages over standard pressure leaf filters

Compared to standard pressure leaf type filters, the LSCF offers the performance and operational advantages:

Superior cake discharge: With its backflush system that cleans the filter cloth and dislodges the cake in a single step, the LSCF improves cake removal efficiency and drastically reduces the manual cleaning stage. No high-maintenance nozzles are needed for discharge, reducing failure and maintenance downtime.

Enhanced filter cloth performance: The cylindrical seamless cloth design ensures longer cloth life and delivers more consistent filtration performance overtime.

Higher filtration efficiency: The LSCF achieves higher filtration rates and shorter cycle times thanks to its compact vertical layout and efficient cleaning mechanism.

Simplified filter maintenance and automation:

- no moving parts except for the filter cloth;
- no nozzles or mechanical scrappers needed;
- fully enclosed system improving operator safety;
- real time process monitoring;
- reliable cake removal.

This flexibility enables integration into a wide range of plant setups with minimal re-engineering.

Conclusion

In a modern industry landscape where process efficiency, safety and automation are more critical than ever, the Self-Cleaning Liquid Sulphur Candle Filter marks a significant advancement. With features that deliver a higher filtration efficiency, minimal maintenance and fully automated operation, this filter redefines the best practices for liquid sulphur purification.

For producers in the sulphuric acid industry looking to upgrade and automate their systems, the technology presents a compelling modern solution.

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Detecting and preventing SO_2 breakthrough

Debopam Chaudhuri, **Ayan Dasgupta** and **Marcus Weber** of Fluor discuss the main causes, detection techniques, management methods and prevention procedures of SO_2 breakthrough in the quench water system of a TGTU, with some unique design features for Fluor's Desuperheater Contact Condenser.

In a typical sulphur recovery unit (SRU) most of the sulphur recovery takes place in the thermal and catalytic stages. But since the reaction is limited by equilibrium, complete conversion cannot be achieved. A sulphur recovery unit with two catalytic reactors can typically recovery around 95% of the sulphur. Most modern plants target a sulphur recovery of well in excess of 99%, hence a tail gas treatment unit is provided. Purification of sulphur produced in the thermal and catalytic stages is achieved via degassing, while unconverted sulphur compounds are typically incinerated in a thermal oxidiser (see Fig. 1).

A reduction-absorption-regeneration tail gas treatment (TGT) unit is recommended to achieve high sulphur recovery numbers. In the TGT section, all the sulphur components are first converted into H_2S in the TGT reactor or the hydrogenation reactor using a catalyst. The reactor effluent is then cooled in a quench column which also removes a large amount of water vapour, the H_2S in the acid gas is then absorbed in an amine solution and regenerated and recycled back to the reaction furnace. In this way, this amount of sulphur is never lost from the process, allowing an almost complete sulphur recovery from the overall unit. Typically, a recovery of 99.9% is achieved by this configuration.

The reduction-absorption-regeneration process

The tail gas from the Claus section contains small amounts of unconverted H_2S, SO_2, small amounts of COS and CS_2, and traces of sulphur as mist or vapour. The amount of these species is dependent on the sulphur recovery efficiency of the Claus section. The reduction-absorption-regeneration process is based on the concept of reducing the SO_2 to H_2S, CS_2 and COS to CO_2 and H_2S and the sulphur is reduced to H_2S in the hydrogenation reactor; then absorbing all the H_2S in an amine solution, and finally regenerating the H_2S from the amine solvent to recycle the gas back to the Claus thermal stage (Fig. 2). The reactions are as follows:

$$SO_2 + 3H_2 \rightarrow H_2S + 2H_2O$$

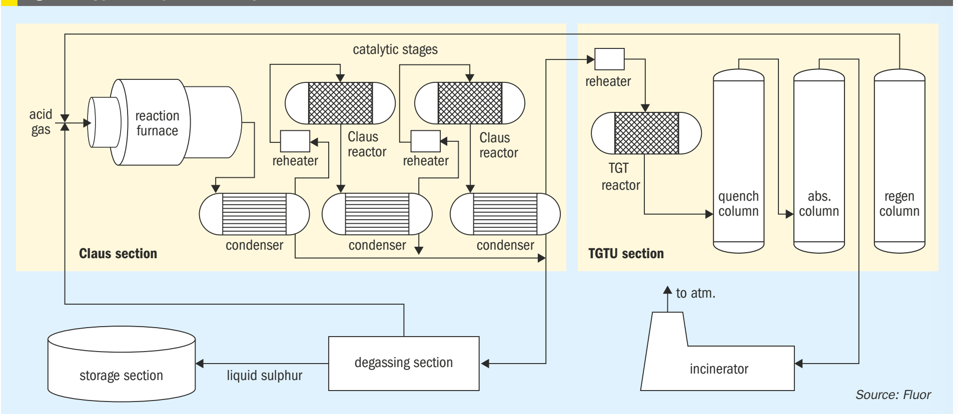
$$COS + H_2O \rightleftharpoons CO_2 + H_2S$$

$$CS_2 + 2H_2O \rightleftharpoons CO_2 + 2H_2S$$

$$Sx + xH_2 \rightarrow xH_2S$$

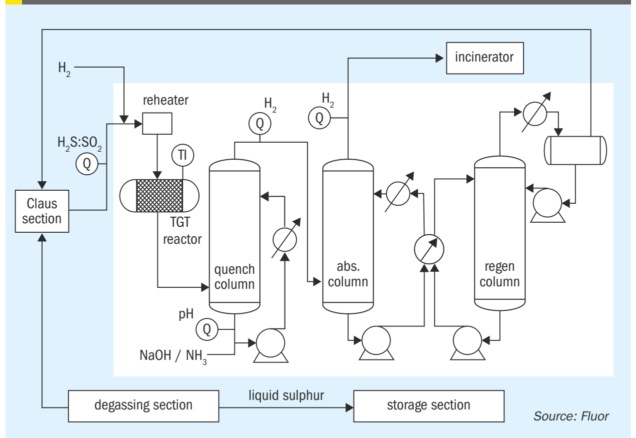
The tail gas from the Claus thermal and catalytic section is first heated up in the reheater, and then reduced in the TGT or the Hydrogenation reactor over a bed of CoMo catalyst. The required reduction atmosphere is maintained in the reactor such that all sulphur species in the tail gas are reduced to H_2S. The process gas is then cooled. A heat exchanger to generate LP steam is implemented in some designs as the first cooling element in the scheme. It is then cooled in the quench column with direct contact with water. The additional amounts of water in the process gas are also removed in this column. The H_2S in the cooled process gas is then absorbed using a suitable amine solution in the absorber column, and process gas containing trace amounts of H_2S is incinerated in the thermal oxidiser. The rich amine is regenerated in the regenerator column to liberate the H_2S stream and that is then recycled back to the reaction furnace.

Fig. 1: **A typical sulphur recovery unit**



Source: Fluor

Fig. 2: **A typical tail gas treating unit**



Source: Fluor

SO_2 breakthrough in quench column

The TGT design includes a quench column downstream of the hydrogenator reactor, mainly to cool the reactor effluent gases before it encounters the amine solvent in the absorber column. Quenching of the process gas is achieved by direct contact of water in a packed bed column. The quench tower, while cooling down the process gas, also condenses an appreciable amount of water thus helping in maintaining the solvent strength in the amine circuit. The quench column also serves as a guard against possible SO_2 slippage from the upstream hydrogenation reactor into the amine solution. The circulating water in the quench column circuit is maintained at a slightly basic condition with a target pH of 8 to 9. SO_2 breakthrough into the quench column is manifested by turning the quench water cloudy due to precipitation of sulphur and is indicated by a sudden and/or a remarkable reduction of the pH value. Hence there is always an analyser measuring pH in the quench water circuit. An immediate caustic or ammonia injection into the quench water is recommended to maintain its basicity. But one needs to look for the real reasons for SO_2 breakthrough.

How bad could SO_2 breakthrough be?

The "milky" quench water has the potential to result in major plant upsets and can be the cause of permanent damage and losses in the SRU.

In case the tail gas analyser is not working properly, thus losing control over the Claus furnace combustion, the tail gas composition can become very abnormal, meaning the H_2S:SO_2 ratio would be extremely skewed. With very high amounts of SO_2 entering the TGT reactor, the reactor exotherm may even lead to catalyst damage, and a potential for SO_2 slippage in the downstream quench water circuit.

The SO_2 slippage in the quench column can wreak havoc in the quench water system. The quench water turns acidic in nature, with pH values reaching as low as 3 under extreme conditions of SO_2 slippage. The acidic quench water can lead to excessive corrosion in the quench water systems, which might not be visible right away, but leads to choking of filters and strainers in the quench water system and damages equipment and piping in the long term.

The SO_2 neutralises the small amounts of ammonia or caustic in the quench water immediately and starts to slip downstream into the amine system. SO_2 can form heat stable salts thus reducing the selectivity and absorption capacity of the amine. The H_2S is not completely absorbed by the amine, and passes through with the process gas to the incinerator, which ultimately leads to higher emissions of SOx from the incinerator. This also leads to loss of sulphur and hence not meeting the required sulphur recovery efficiency for a unit.

H_2S and SO_2 in "milky" quench water medium also has a very high potential of forming elemental sulphur via the Claus reactions. The sulphur formed can lead to deposition, choking of filters and blockages in the piping elements in the quench water system.

The symptoms and looking for the cause

Typically, the SO_2 breakthrough is associated with a reduction in the pH readings as measured by the pH analyser in the quench water circuit. The immediate recommendation for this is the dosing of the neutralising agent (ammonia or caustic); this helps in bringing the pH readings back in the normal range but does not address the real reasons behind this reduction in pH. Thus, the ammonia or the caustic dosing addresses the "symptom" without providing the real "cure" for the condition.

The reasons behind SO_2 slippage into the quench column can be attributed to multiple reasons, and the actual reason could easily be understood by a verification of certain other parameters. The most important ones are:

- tail gas analyser reading;
- TGT reactor exotherm;
- hydrogen analyser reading.

Tail gas analyser reading

The reaction furnace operates on a sub stoichiometric air requirement supply such that only 1/3 of the total amount of H_2S is combusted to form SO_2. The air supply guide to the reaction furnace is controlled in two steps; the major control for the main air flow is dependent on the amount of acid gas sent to the furnace while a fine control for the trim air flow is done by checking the tail gas composition. The tail gas composition is measured by an analyser, also

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known as the air demand analyser, which measures the amount of H_2S and SO_2. The ideal ratio between these two components is 2, and based on any deviation from this target ratio the trim air flow to the reaction furnace is controlled.

Firing the Claus furnace without proper air stoichiometry may result in higher amounts of SO_2 in the tail gas. This could easily be detected by the tail gas analyser reading, and if the deviations are minor it should automatically be controlled by the trim air flow controller. But any major and a sudden change in the feed gas composition or failure in the air controller can lead to abnormal firing in the reaction furnace thus leading to abnormal ratio between H_2S and SO_2 in the tail gas.

Improper firing in the reaction furnace when detected by the tail gas analyser, measuring higher amounts of SO_2 would also show via a higher TGT reactor exotherm due to the fact that more SO_2 is being reduced in the reactor. This would also be accompanied by either a higher-than-normal hydrogen import or show a slight dip in the hydrogen concentration downstream of the quench column, depending on the normal hydrogen balance for the unit. Typically, the tail gas contains enough reducing power such that there is no hydrogen import required. With this being the normal condition, the expectation is that, when there is a major SO_2 breakthrough, the normal hydrogen concentration would start to reduce, and then based on the set point of the H_2 analyser would start an automatic hydrogen import to maintain the required reducing atmosphere in the hydrogenation reactor.

TGT reactor exotherm

SO_2 slippage into the quench column can also be attributed to reduced catalyst activity in the hydrogenation reactor. This condition is typically easier to detect, as this would be evident from a low reactor exotherm even though the hydrogen concentrations are healthy, or even the tail gas compositions are normal.

Reduced catalytic activity in the TGT reactor means improper or incomplete conversion of SO_2 to H_2S. The unconverted SO_2 would pass to the quench water system, which would ultimately be detected by a low pH. In this condition, the hydrogen import value would be lower than normal, or the hydrogen concentration would be slightly higher at the quench column outlet. Since loss of catalytic activity is typically a time consuming and gradual process, the loss of reactor exotherm would be a slow process and typically would extend over a long period. Hence proper monitoring of the reactor exotherm is always recommended to check the TGT reactor and catalyst health.

A higher than normal reactor exotherm also can be the cause of SO_2 breakthrough. This is typically initiated by a higher amount of SO_2 in the tail gas leading to more reactions and hence a higher exotherm in the TGT reactor.

Hydrogen analyser reading

The hydrogen concentration as recorded by the hydrogen analyser is always an indirect monitoring of a potential SO_2 breakthrough condition.

A higher than normal hydrogen concentration reading can mean incomplete reactions in the TGT reactor. Thus, if a high hydrogen concentration reading is accompanied by a low reactor exotherm, that then becomes a clear indication of SO_2 slippages from the TGT reactor.

A lower than normal hydrogen reading is an indication of an inadequate reducing atmosphere in the TGT reactor based on the process gas compositions. This condition should typically be accompanied with higher than normal reaction exothermicity or even higher SO_2 readings in the tail gas.

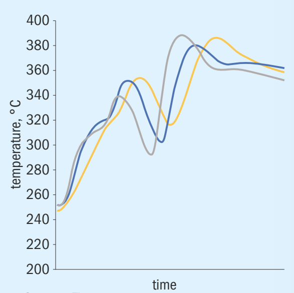
Thus, there are multiple reasons for an SO_2 breakthrough from the TGT reactor, and the actual reason can be easily investigated and concluded by looking at various other parameters in the unit. Hence while we monitor lowering of pH values in the quench water system it is always recommended to look at other parameters around the unit to assess the actual reason of SO_2 breakthrough.

A case study

In this case study, a sulphur plant lost air flow control due to the malfunction of the air demand analyser or the $H_2S:SO_2$ tail gas analyser. The air flow to the reaction furnace was much more than the required amount for a considerable period of time leading to much higher amounts of SO_2 in the tail gas flow into the TGT. The outcomes of such a catastrophic SO_2 breakthrough are immense as defined here:

- The reactor exotherm was very high, and the reactor temperature measured by the temperature elements measuring the catalyst bed temperature reached elevated temperatures nearing 400°C. Exposure to such high temperatures led to permanent damage in the catalyst as was evident when the plant was restarted after taking a shutdown. The unit was not able to operate at capacity greater than 70% of its nameplate capacity due to reduced catalyst activity, and partial replacement of the catalyst was required.
- The quench water circuit reported symptoms of a massive SO_2 breakthrough. Multiple change overs were required for the quench water pump due to choking of the suction filters. A detailed inspection was recommended for the quench water circuit to determine the extent of corrosion issues in the system.
- The amine solvent also reported reduced activity as was evident by higher amounts of H_2S slippage in the absorber column, leading to high SO_2 emission numbers in the incinerator, higher than the normal or permissible values.

Fig. 3: **TGT reactor temperature profile**



Source: Fluor

The graph in Fig. 3 shows the temperature excursion in the TGT reactor for the above-mentioned case study. The three separate lines are for the temperature measured at various depths of the catalyst bed in the TGT reactor over the period where the unit continued to operate with higher than required amounts of combustion air in the Claus furnace.

Prevention is better than cure

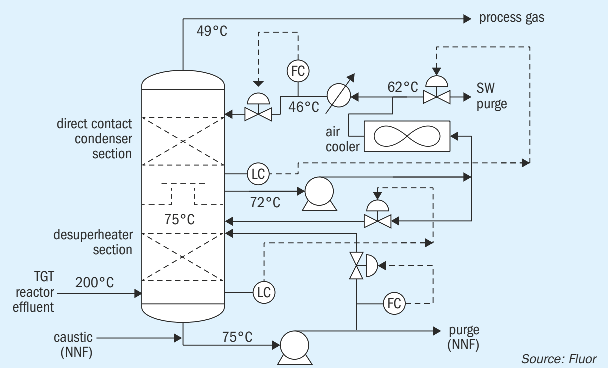
SO_2 breakthrough can be a painful experience for any TGT hence it is always preferred to prevent it from happening. Especially because a low pH alarm already indicates a considerable amount of SO_2 in the quench water, and its subsequent consequences. Proper monitoring is extremely important, to note the important parameters of the process which could indicate the potential for an imminent SO_2 breakthrough. All analysers in the SRU have a specific purpose and hence proper monitoring and maintenance of each of them is essential.

The design of the quench column may also be reviewed using proper software based on actual operational data to see how much margin is available. Process simulation software is available which can be used to model the quench water system appropriately. The height of the packed bed required for the necessary cooling can be determined and then compared with the actual bed height available, thus allowing measurement of the expected removal of SO_2 from the process gas in the quench water. Cooling of the process gas happens very rapidly, removal of water (condensation) from the process gas requires a little more extended contact, while removal of SO_2 (or for that matter ammonia slipped from the upstream Claus section) even more contact with the circulating water. Thus, accurate simulation of the quench tower can benefit operations by predicting how much sulphur dioxide from an SO_2 breakthrough will actually reach the TGT amine section and how much will be removed in the quench water.

The Fluor licensed TGT includes a Desuperheater Contact Condenser (DCC) column design, which provides a two-stage cooling process thus providing an additional protection layer for SO_2 breakthrough. The first stage or the lower packed bed, the desuperheating section, provides just enough contact and residence time for process gas cooling until its saturation condition, while the second packed bed allows the process gas to cool further allowing the excess water to condense. There are separate water circulating systems for the two separate beds, where the lower packed bed water maintains a pH between 9 and 10 to capture any SO_2 slippage from upstream, thus providing an additional layer of protection against SO_2 breakthrough and subsequent damage to the amine system compared to a conventional quench column design where caustic/NH_3 is only injected after as a response to a decrease in pH of the quench water and in many cases this response is delayed causing damage to the amine system. A simplified sketch of the Fluor DCC column is shown in Fig. 4.

The reactor effluent is fed to the bottom section of desuperheater contact condenser where it is adiabatically desuperheated with a circulating weak solution of buffered caustic. The circulating caustic is drawn from the bottom of the DCC and pumped with the Desuperheater Pump on flow control to the top of a bed of grid packing. The circulating caustic is saturated with sulphide and carbonate and has a normal pH of about 9.5 at operating temperature. Fresh and dilute caustic solution is periodically introduced by the operator via a manual throttling valve as needed. The caustic solution is buffered, as dissolved H_2S and CO_2 from the process gas form sodium bisulphide and sodium bicarbonate in the buffered solution. The circulating buffered caustic is filtered via the desuperheater pump discharge filter.

Fig. 4: **The Fluor Desuperheater Contact Condenser column**



Source: Fluor

A slipstream of spent caustic is periodically discharged via the desuperheater pump when determined by the operator as needed to ensure normal pH is maintained. The circulating caustic solution protects against SO_2 breakthrough to the downstream sections. Water saturated process gas flows from the bottom section to two bubble cap trays to wash any entrained caustic from the vapour. The bubble cap trays are used in this section because it operates in a region with a very high gas-to-liquid ratio, making it unsuitable for any other tray or packing type

Process gas then flows through a chimney tray to the upper section in the DCC where it is cooled, and water vapour is condensed by counter-current direct contact with cooled circulating water in a bed of random packing. Water is circulated with the contact condenser pump, which draws liquid from the chimney tray below the top packed section. The circulating water is cooled in the forced draft contact condenser air cooler and water trim cooler (if applied) and returned to the column above the top packed bed on flow control.

A small amount of condensed water recovered in the top section is sent to the top bubble cap tray on bottom section level control. Condensed process water with low concentrations of H_2S and CO_2 is sent to the sour water system on chimney tray level control.

Conclusion

SO_2 breakthrough has the potential to wreak havoc in a SRU-TGT, depending on the extent of the breakthrough. Typically, the first response to tackle this is to address the "symptom" of the lowering of the pH in the quench water circuit. Neutralising agents (ammonia or caustic) are injected or dosed to bring the pH back to normal values and in many cases due to delayed action from the operator causes significant damage to the downstream amine system. Fluor provides a design which provides sufficient time for the operator to prevent SO_2 from reaching the downstream amine system. However, this does not address the real cause and does not provide a "cure" to this condition.

It is important to find out the real cause for this condition. Continuous monitoring of key operating parameters has the potential to reduce and even eliminate the chances of any SO_2 breakthrough in the unit, thus providing longer run lengths and longer operating lives for SRU. ■

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SRU energy and cost optimisation

Together with Slovnaft, Worley Comprimo has developed a near real-time monitoring dashboard using data sharing via the Cloud. Using a two-year data set containing minute average data, trends and insights were used to optimise performance. This paper describes the main learnings and improvements with respect to energy optimisation, which supports sustainability targets for Slovnaft.

Jan-Willem Hennipman (Worley Comprimo) and Martin Gensor (Slovanaft, a.s.)

Energy saving is an important topic in achieving the net-zero strategy to limit global warming. But next to global warming, using less energy in conversion and separation processes in refineries and gas plants also means direct cost savings in utility consumption and costs for emitting CO_2 as regulated for example in the European Unit – Emission Trading Scheme (EU-ETS).

The main energy consumer in an SRU is the incinerator. Minimising the fuel gas consumption in the incinerator as needed to just comply to the environmental permit could have the largest energy saving. But also, other no-cost measures to reduce energy consumption must be explored, e.g. feasibility of reducing the reactor inlet temperatures or the necessity of co-firing in case the temperature readings in the main combustion chamber are below e.g. 1,250°C for ammonia destruction or below 1,050°C for BTEX destruction. Although the total energy consumed by an SRU is only minor compared to the whole site, every easy win, even if it's small, must be pursued.

But apart from direct energy saving opportunities, this article also discusses opportunities to save costs by extending the lifetime of the catalyst using the latest monitoring capabilities by data sharing technologies and technical services offerings by subject matter experts (SME).

To enable the in-depth analysis of the energy consumption savings and extending the catalyst lifetime, Slovnaft and Worley Comprimo have worked together on a data sharing platform. By sharing the data near real-time, the Worley Comprimo SME gets familiar with how the SRUs are operated in normal plant load, but also during turndown and special operating scenarios. This is needed to find the opportunities to improve the performance and for Slovnaft being best in class.

This article starts with the journey to develop a data sharing infrastructure that is then used as the basis for identifying opportunities to monitor and improve SRU performance based on the shared data. A couple of examples are provided related to energy savings.

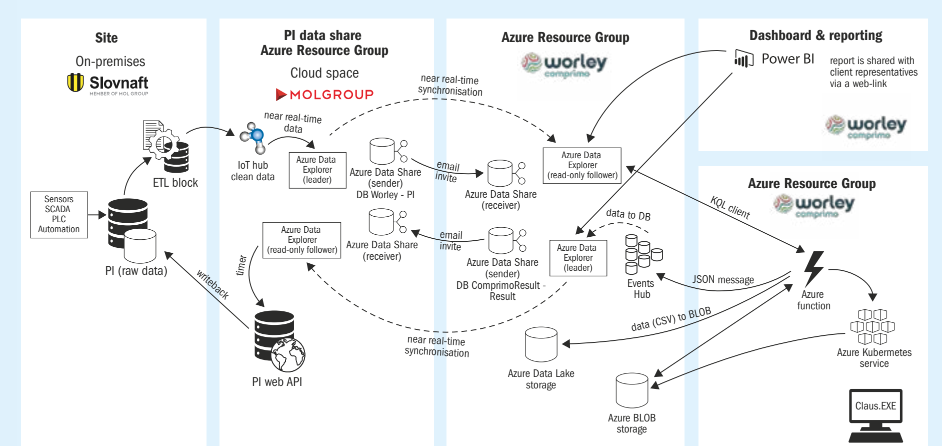
Historical background

Slovnaft is a refining company in Bratislava, Slovakia, and part of the MOL group. Worley Comprimo is a licensor of sulphur technologies and part of the Worley group. Slovnaft and Worley Comprimo have had an excellent working relationship that has lasted for several decades. In 2017 a technical service agreement was signed meaning that Worley Comprimo would do a yearly review of the performance of the units in the sulphur complex, consisting of two identical sulphur recovery units (SRU), two amine regenerator units (ARU) and two sour water stripper units (SWS). As part of the assessment, the historical data of most of the instruments in the different units was collected in hourly average values and downloaded in a large Excel sheet. The Excel sheet was shared by email, and it took the assigned technology specialist weeks to prepare all the trends, set-up the calculations of the key performance indicators (KPI) and make the analysis for each unit.

The second year, the exercise went a little faster, but still manipulating the large sets of data was quite cumbersome in Excel. Also, the unit engineer in Slovnaft was not in favour of the yearly trouble to download and configure the data from the historian. Therefore, other means than Excel and email for sharing data were explored. The cloud technology was rapidly developing and after several attempts, in 2021, the right set of people and the best available cloud environment came together successfully. And as of May 2022, the data sharing was running stable, plant data from the instruments was shared by Slovnaft to Worley Comprimo and the KPI and virtual analyser data was shared by Worley Comprimo to Slovnaft. A virtual analyser means that the value of an analyser or instrument is calculated based on other measurements. For example, the temperature rise in the Selective Oxidation (SelOx) reactor is related to the H_2S concentration at the SelOx reactor inlet. The calculated temperature rise, reactor inlet temperature minus bottom bed temperature, is a measure of the H_2S concentration and the calculated H_2S concentration can be compared with the actual measured H_2S concentration from the tail gas analyser.

Using streaming data via the cloud, much more data can be exchanged, and the optimum time interval was set at minute average data to follow fast changing trends of flow rates and H_2S concentrations that can result in trips in the unit. The delay of data transfer was optimised to about 5 to 10 minutes, so

Fig. 1: **IT architectural diagram**



Source: Worley Comprimo

near-real time, which provides adequate assistance of a Worley Comprimo SME in case immediate trouble shooting assistance would be required.

Architectural overview

It took quite some time to develop the right IT infrastructure with people who have the appropriate skill-set, mindset and system knowledge of the different disciplines. The historian vendor, in the case of Slovnaft, OSI-PI, which is part of the AVEVA group, and the Microsoft Azure consultant worked together closely with the MOL IT and Worley IT departments. The schematic overview of the IT architecture as it is in use today is provided in Fig. 1. It shows at a high level the components used to share data in a cyber secured way, that was adopted by both IT organisations.

On the left side of Fig. 1, the data from the sensors is collected in the historian database. The data from this data historian is then uploaded to the cloud database, Azure Data Explorer (ADX), which is well suited to process streaming data. The ADX environment of Worley has many different databases, for different clients and per client there is a historian database and a result database which are both used for visualisation of the dashboard in PowerBI. The result database is shared with Slovnaft, for accessing the KPI and virtual analyser data points.

The time delay is about five minutes. Only a defined subset of the data as needed for the sulphur complex is then shared for view only with the Worley ADX via a secured email invite within the same cloud region. Using an Azure Function which is triggered every 5 minutes, a set of subroutines in Python code is carried out, which include the following sequence of actions:

- Read data from read-only ADX database, which contains the data from the data historian.
- Add/delete records in new time stamp queue. New time stamps are added to a table that lists all time stamps that need to be processed. In case a time stamp is available in the Worley ADX, it was already processed, and the time stamp in the table will be deleted.
- Send to ADX, historian database.
- Data processing by selecting the time stamps from the table that need to be processed.
- Read data from read-only ADX database.
- Add/delete records in data processing time stamp queue. This table keeps the overview of the time stamps that are new brought in for processing and keeps track of the time stamps that are in progress. Once the processing is finished, the time stamp in the table will be deleted.
- Calculate the KPIs.
- Simulate using a sub-set of the sensor data.
- Send to ADX, Result database.
- Save CSV to datalake (BLOB storage container)

Monitoring and performance improvement

Data sharing and processing has been in production since May 2022. Since then, quarterly reports have been prepared and discussed in regular calls with the unit engineer of Slovnaft and the SME of Worley Comprimo. And based on the observations, a good understanding of the operating philosophy was obtained and advice was provided on e.g. improving the sulphur recovery efficiency (SRE) for aged catalyst. After more than a year of monitoring and optimisation, it was time to prove the added value of Comprimo Insight as a data sharing and dashboard service to save cost. Slovnaft indicated their interest in saving energy and therefore, it was decided to study natural gas savings in the SRUs. The points where natural gas is consumed are indicated in the SRU schematic overview of Fig. 2.

The main natural gas consumer in normal operations is the incinerator, so the main savings can be expected there. However, lowering the reactor inlet temperatures can also provide an interesting contribution without spending money or reviewing the operating procedures for the necessity of co-firing.

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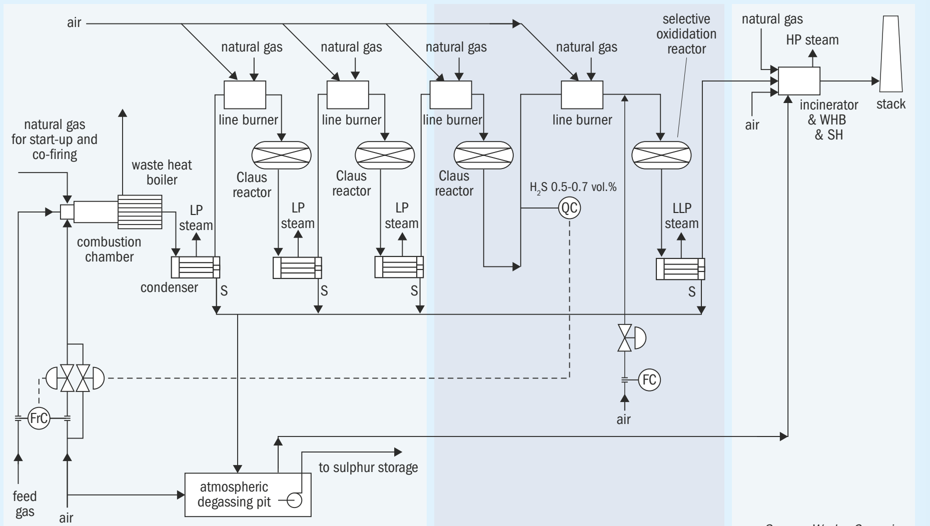
Fig. 2: **Schematic overview of Slovnaft SRU 100 and SRU 200 (natural gas consumers indicated)**



Source: Worley Comprimo

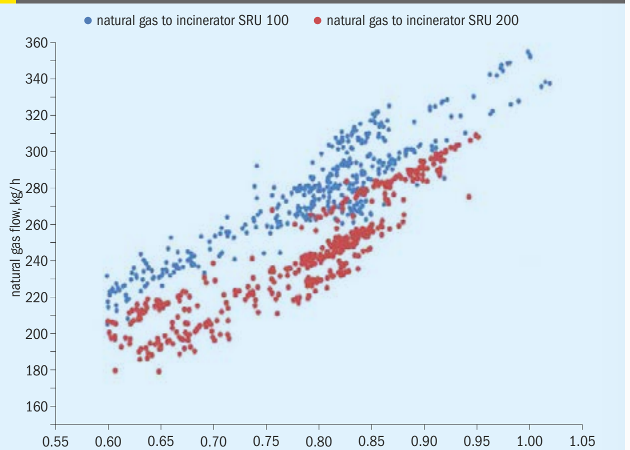
Natural gas saving potential in the incinerator

The incinerator is the largest natural gas consumer in an SRU. Operating at the right conditions to balance destruction requirements at minimum fuel is covered in Ref. 1. For Slovnaft the only requirement is that the H_2S concentration is limited to 10 ppmv in the stack as measured by the CEMS. Although the oxygen concentration in the flue gas is occasionally higher than 3 vol-%, by having the dashboard and regular unit review, operations is aware to target the oxygen concentration between 2 to 3 vol-%.

The heat recovery, consisting of a waste heat boiler followed by a superheater, downstream of the incinerator needs adequate attention. Generally, a site steam boiler is much more efficient and provides better heat recovery than an incinerator heat recovery system. Slovnaft experiences limitations in the superheater, because the waste heat boiler takes up too much duty. A superheater directly after the incinerator followed by a waste heat boiler is more expensive due to a higher design pressure and more exotic material, resistant to high temperatures, but assures sufficient superheat.

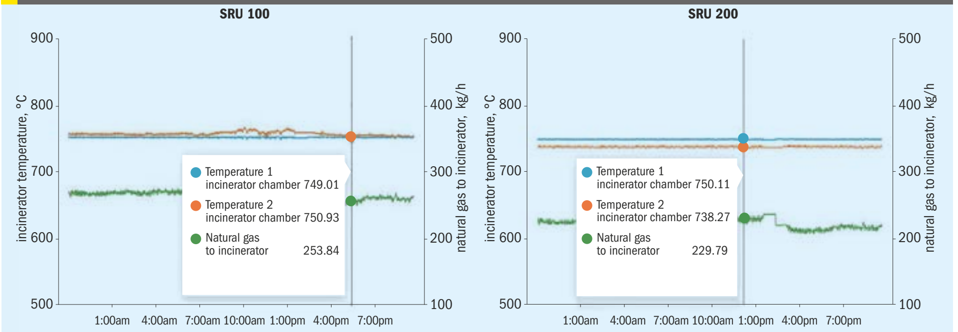
The temperature in the incinerator chamber is strictly controlled at 750°C, so there are no other datapoints at other temperatures than 750°C. To quantify the potential savings of natural gas for the incinerator and to compare actual savings in the future, a baseline consumption was established from the large amount of data available. But to keep the dataset manageable, the data was averaged per day for the variables that were assumed to correlate with the natural gas consumption. Especially the plant load was the main parameter. During normal operation, the SRUs run at a plant load between 78% and 86% most of the time. Below 60% plant load, natural gas co-firing is started in the thermal reactor. Therefore, all days with a plant load below 60% were left out of the working dataset. The correlation between the daily average natural gas flow versus the plant load is shown in Fig. 3. Notably, the natural gas consumption in SRU 100 is higher than for SRU 200 at the same plant loads.

Fig. 3: **Daily averaged natural gas consumption as function of plant load for SRU 100 and SRU 200**



Source: Worley Comprimo

Fig. 4: **Temperatures in the incinerator and natural gas consumption for SRU 100 (L) and SRU 200 (R)**



Source: Worley Comprimo

After further evaluation it appears that the thermocouple used for controlling the temperature in the incinerator, Temperature 1, indicates a different temperature than measured by the second thermocouple, Temperature 2, as is clearly shown in Fig. 4, which is a snapshot of 21 September 2024 when the SRUs were running at about 70% plant load.

For SRU 100, Temperature 2 is very close to the control temperature of 750°C, while for SRU 200, the Temperature 2 is slightly lower. This difference in temperature is supported by the temperatures measured at the outlet in the incinerator WHB.

The base lines for the Incinerators of SRU 100 and SRU 200 for different plant loads are shown in Fig. 4. SRU 100 consumes about 25 kg/h more natural gas than SRU 200. It should be evaluated if the temperature in the incinerator of SRU 100 can be reduced to the same performance as for SRU 200.

The incinerator temperature could be reduced as low as 650°C for an adequate conversion of sulphur species into SO_2. In case of low frequency vibration noise produced by the incinerators, reducing the temperature in the incinerators could also result in a reduction of the low frequency noise. Reducing the temperature also reduces the combustion air flow rate considerably, which in case of noise issues is the main factor in the vibration of the incinerator burners.

However, a low incinerator temperature will have a direct impact on the steam superheat temperature at the battery limit. The minimum required high pressure steam temperature at the refinery grid is 300°C to prevent the risk of condensate droplets in the steam turbines. Therefore, a reduction in incinerator temperature may not be feasible in the current line-up and operation.

Several options can be considered to reduce the natural gas consumption in the incinerators, which also need to be balanced against requirements in the high-pressure steam super-heat temperature and high-pressure steam capacity for the whole refinery:

- The super-heat requirement can be dropped if the saturated steam will be routed directly to steam heaters in a nearby unit.
- Install electrical heater to superheat the high-pressure steam further.
- Replace existing incinerator WHB with a shorter one or even leave out the WHB and replace the superheater. This will result in less heat transfer in the WHB and sufficient duty for the superheater to reach the required grid temperature. In case of the option without a WHB, a de-superheater may be necessary.
- Increase the flue gas temperature downstream of the incinerator WHB and reduce the steam flow to the superheater by plugging tubes in the waste heat boilers. This option was studied, but plugging tubes results in an increased process gas flow and hence improved heat transfer. Therefore, the steam production is reduced only marginally, and the high-pressure steam superheat improvement was negligible. Increasing the gas flow was limited to a maximum velocity of 120 m/s, to prevent equipment damage due to vibration issues in the WHB.

A remarkable difference was found between simulation and plant data for the incinerator. Where SRU 100 uses only 279 kg/h natural gas and about 7700 kg/h combustion air at 80% plant load to achieve 750°C temperature, the simulation shows 379 kg/h natural gas and 9,637 kg/h combustion air. This could mean that the simulation assumes more heat losses than actual or the plant data for flow rates or temperatures are not correct.

Based on the relative difference of natural gas consumption for the incinerator from the simulation, a saving of 60 kg/h per unit of natural gas is expected in case the incinerator temperature could be dropped to 650°C.

With an assumed price of €0.40 per Nm³ natural gas and €74 per tonne CO_2 emission, the total saving could be as high as €800,000 per year. A test is recommended where all turbine positions will be switched to electrical, and the incinerator is gradually reduced in temperature until 650°C without adverse effects.

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Can we lower the reactor inlet temperatures to save energy?

As part of a licensor package, a heat and material balance and an operating manual is provided specifying the reactor inlet temperatures. For most clients these inlet temperature setpoints are fixed and not to be changed. Also, for Slovnaft, the setpoint range for the DCS operator is limited to 5°C below the value in the operating manual. But to find the minimum energy consumption, some more margin in the ranges can be beneficial. On the other hand, experimenting with the SRU also requires sufficient basic understanding for the process, because there are potential negative effects on the overall unit performance.

Inlet temperature 1st Claus reactor

The bottom bed temperature from the first reactor needs to be sufficiently high for COS and CS_2 conversion. Typically, the bottom bed temperature must be maintained between 290°C to 310°C. The bottom bed temperatures during normal operation for Slovnaft are between 305°C to 310°C. Therefore, it was proposed to decrease the inlet temperature setpoint of the first Claus reactor from 240°C to 235°C. When reducing the temperature, the emissions must be monitored. A lower bottom bed temperature may result in slightly more COS and CS_2 slip, which can be detected indirectly via the continuous emissions monitoring systems (CEMS) in the stack gas.

Reducing the inlet temperature to the first reactor will still provide ample margin to the sulphur dewpoint. A 10°C margin to the sulphur dewpoint is considered as sufficient. If the hydrocarbon content in the acid gas is very low and with that minimum CS_2 formation, the first Claus reactor inlet temperature can be reduced further, which is favourable for the Claus equilibrium.

Inlet temperature 2nd Claus reactor

It is also recommended to test the second Claus reactor for an inlet temperature reduction of 5°C, from 210°C to 205°C. For the second reactor, only the consideration of the sulphur dewpoint is to be taken into account, but during normal operation sufficient margin is assured.

Inlet temperature 3rd Claus reactor

The third Claus reactor inlet temperature is currently set at 190°C. In case the inlet temperature is reduced to 180°C, the margin to the sulphur dewpoint would still be 6°C. Although a margin of 10°C is recommended and on the safe side of operation, 6°C margin can also be accepted.

Apart from saving natural gas, according to the theory, the recovery efficiency of the SRU is also expected to improve. The Claus equilibrium shifts towards sulphur and water at lower reaction temperature. When keeping the H_2S setpoint at the SelOx inlet constant, the SO_2 is further reduced. Especially for aged catalyst, this setpoint change could have a notable impact on the SO_2 measured in the stack. Note however, that in case the third Claus reactor is kinetically limited, there is also the possibility that a temperature decrease will not result in a better recovery.

Inlet temperature SelOx reactor

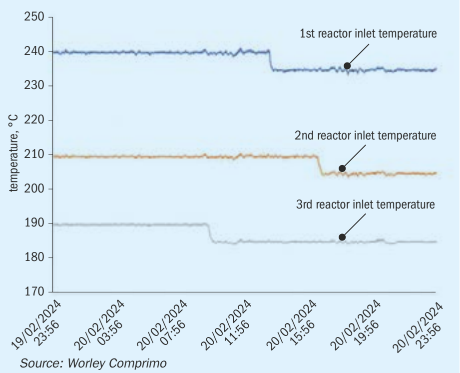
The SelOx inlet temperature is controlled at 215°C. Lowering the temperature may have a direct negative impact on the yield. In a 3+1 SUPERCLAUS® configuration as in Slovnaft, the normal operating setpoint for the H_2S setpoint in the tail gas is 0.5 mol- %. However, increasing the setpoint to 0.6 mol-% generates more heat and depending on the catalyst activity, the temperature setpoint could be reduced by 5°C to achieve a comparable reactor yield.

Testing the reduction of the reactor inlet temperatures

A test was done to verify the potential natural gas saving by just reducing the reactor inlet setpoints for the three Claus reactors with 5°C. The third Claus reactor inlet temperature was reduced first, then the first Claus reactor and the second reactor last. In Fig. 5 the inlet temperature trends of the test are provided. It was not possible to extend the test to the SelOx reactor, also because the H_2S setpoint was at its maximum range, being 0.60 mol-%, according to the operating instructions.

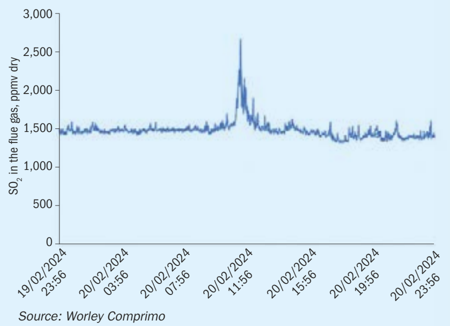
Each setpoint change was followed by a couple of hours to stabilise the SRU and verify the effect on the SO_2 in the flue gas from the stack, which is trended in Fig. 6. The SRU was running stable, except for a short peak in the sour water acid gas flow rate at 11:30. The H_2S concentration dropped in the tail gas dropped as the feedback controller in the Advanced Burner Control (ABC) system needs time to compensate with the combustion air flow rate for this sudden change. As a

Fig. 5: **Lowering the Claus reactor inlet temperatures**



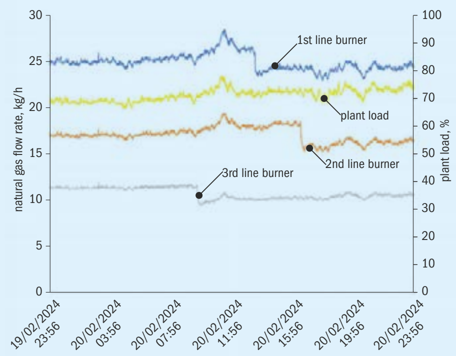
Source: Worley Comprimo

Fig. 6: **The influence of lowering the Claus reactor inlet temperatures on the SO_2 in the flue gas from the stack**



Source: Worley Comprimo

Fig. 7: **Natural gas consumption in the line burners to the three Claus reactors and the plant load trended over time during the reduction in inlet temperature test**



Source: Worley Comprimo

Table 1: **Natural gas flow rates, SO_2 in the stack and plant load before and after the temperature reduction test.**

Parameter	Average value at normal operating inlet temperature	Average value at 5°C lower inlet temperature	Difference
1st line burner natural gas flow rate, kg/h	25.2	24.3	-0.8
2nd line burner natural gas flow rate,kg/h	17.2	16.2	-1.0
3rd line burner natural gas flow rate, kg/h	11.4	10.5	-0.9
SO_2 in the flue gas from the stack, ppmv dry	1487	1412	-75
Plant load, %	70	73	3.0

Source: Worley Comprimo

result via the Claus equilibrium, the SO_2 in the tail gas rises when the H_2S drops. The SO_2 is not converted in the SelOx reactor and is measured by the stack gas analyser.

As was clear from the test, lowering the reactor inlet temperatures has no negative impact on the SRU performance, and even a positive result by a very small reduction in SO_2. The next item to investigate was the natural gas savings because of a 5°C reduction. In Fig. 7 the natural gas consumed in the line burners to the three Claus reactors is trended on the primary y-axis and the plant load on the secondary y-axis.

To estimate the reduction in natural gas flow rate to the line-burners, the flow rates before, from 0:00 to 9:00, and after, from 17:00 until 0:00, the test are averaged. The result is summarised in Table 1.

It's clear from the test that in this operating mode, reduction in inlet temperatures of the Claus reactors can be done without any investment cost, only clear operating instruction, providing a potential saving of almost 24,000 kg/year in natural gas. This is equal to the consumption of 19 average Dutch households or about €18,000 per year natural gas and CO_2 emission costs.

With the result of the test to lower the Claus reactor inlet temperatures, the next step is to update the operating instruction to the shifts. The lower setpoint range for the reactor inlet temperatures has been advised to be reduced by 5°C and awareness needs to be created to operate at lower inlet temperatures to reduce energy consumption. The DCS operator needs to understand that sub-dewpoint can occur at too low reactor inlet temperatures and needs to know which system parameters to monitor, such as the bottom bed temperatures, SO_2 and H_2S concentrations in the tail gas and the SO_2 concentration in the stack flue gas.

Modelling of the natural gas consumption of the line burners

Fig. 7 shows a clear correlation of the natural gas flow rate to the line burners with the plant load and the temperature increase over the line burner. The correlation with the ambient outside temperature was tested but not found to be statistically relevant. To predict the potential savings of natural gas to the line burners, a baseline consumption was prepared from the large amount of data collected over time. But to keep the dataset manageable, the data was averaged per day for the variables that were assumed to correlate with the natural gas consumption.

Based on the linear regression trends for the individual line burners and considering the temperature increase over each line burner, a second regression was done to find the correlation between the natural gas consumption, temperature increase over each of the line burners and the plant load. This results in a straight line through three points, one for each line burner. The slope of each of those lines is also a linear correlation with the plant load. The deviation of natural gas consumption obtained from the model and as measured in the unit deviated more than 25% and therefore this model is not considered being accurate. Maybe a machine learning model could be trained and tested as the natural gas flow rates from simulation are also not all in acceptable correspondence with the measured natural gas flows.

What about co-firing?

Many operators in a refinery where sour water stripper acid gas is also processed are tempted to start co-firing if one of the temperature measurements in the main combustion chamber (MCC) is below 1,250°C. But the temperature readings of these measurements, pyrometer and thermocouple, are far from accurate. Many times, the difference in reading between those two instruments is easily over 100°C! Typical causes for this large deviation are that the instruments are very sensitive to how they are positioned and the setting of the purge flow rate. An additional reason to relax on co-firing below 1,250°C is that the industry wide accepted rule for adequate ammonia destruction to prevent plugging might not be so firm as was concluded in Ref. 2.

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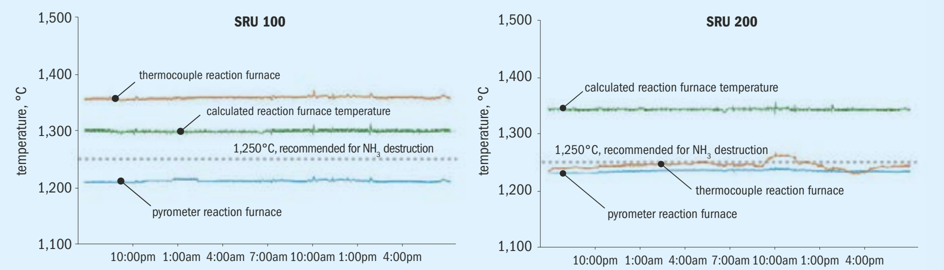
Fig. 8: **MCC temperature, measured by the thermocouple, pyrometer and estimated by the MCC model "Temp Protect" for SRU 100 (L) and SRU 200 (R).**



Source: Worley Comprimo

MCC Reliability temperature reading

A good example on the lack of accuracy of the temperature readings in the MCC is provided in Fig. 8, which shows screenshots of one of the trends in the Comprimo Insight dashboard. Both SRU trains are identical, except that SRU 200 has a combustion air preheater. Both plants are operated at equal load, around 70% of the maximum plant load, based on the maximum combustion air flow rate. Surprisingly, the temperature in the MCC of SRU 100 according to the thermocouple is higher than for SRU 200. The pyrometer in SRU 200 is about 20°C higher than in SRU 100, so the trend is credible, but still below 1,250°C, suggesting co-firing should be considered.

The Comprimo Insight includes a Worley Comprimo model called "Temp. Protect" to estimate the MCC temperature based on the flow rates to the main burner and an assumed feed gas composition. This model gives more credible numbers for the MCC temperature. Since the calculated and simulated data is shared back with Slovnaft, the estimated MCC temperature is configured as a DCS tag in the historian database and is therefore called a virtual analyser. And from the historian database, the calculated MCC temperature is available to operations as a third independent temperature value. A second parameter to monitor the assumed feed gas composition is the actual and expected air-to-gas ratio. If those two parameters are showing a close correspondence, the assumed feed gas composition is in accordance with the actual feed gas composition.

Review and test plant turndown to minimise co-firing

At Slovnaft, co-firing is started if the thermocouple reading is below a value of 1,250°C or in case the combustion air flow drops below a certain value, which causes instabilities in the blower controls. In case line burner flame stability issues are experienced below a turndown of 50% for example, then co-firing is a logical step. If co-firing is started because of outdated knowledge, inaccurate temperature measurement in the combustion chamber or some control issue, it could be interesting to assess if the amount and occasions of co-firing natural gas can be reduced. This can save potentially quite some natural gas and unnecessary cost.

The load on the SRUs fluctuates nowadays more than in the past due to different crudes since the troubles in the neighbouring countries. Depending on the crude being processed in the refinery, co-firing takes typically 50 kg/h of natural gas during a week, so 8,400 kg of natural gas in a week. If co-firing operation is typically occurring 8 weeks per year for each unit due to low sulphur load and this operation can be prevented, then this would save €100,000 per year.

Conclusions and summary

Applying monitoring tools to share data near real-time between the operating company and the licensor, enables a knowledge exchange between the unit engineer/operations and the Technology Specialists. Together they explore and implement optimisation opportunities.

Although the SRU is only a minor energy consumer in the whole refinery, still an interesting saving was identified for reducing the natural gas consumption in the incinerator of up to €800.000/year. However, this reduction might require some investment for this particular plant and will be first tested in practise to see if the predicted saving is achievable.

Minor reductions in natural gas consumption can be achieved in the line burner operation by reducing the reactor inlet temperatures of the three Claus reactors with 5°C. It was shown in a test that there were no negative effects on the SRU. Although this saving is relatively small, about €18,000/year, it can be implemented without spending capex and only updating operating procedures.

The last potential saving in natural gas is the co-firing. From experience, the temperature measurements in the MCC are not very accurate and having a temperature estimate from a model provides extra information if the temperature would be really too low for adequate ammonia destruction. And also, the operating instructions for co-firing below 60% plant load, which could be based on outdated insights, should be reviewed. A year of unnecessary co-firing easily adds up to €100,000 wasted money.

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The pros and cons of SRU extended downtime

Reduction of sulphur loads in refineries with multiple sulphur train complexes often allows for one train to be put into an idle state for a prolonged period of time. **Baylee Thompson** of Wood presents the pros and cons of leaving a unit on hot-standby versus long-term idle taking into consideration reliability, safety, and operations responsibilities during extended downtime.

Many refineries throughout the world are experiencing changes in overall sulphur loads due to changes in crude slates and various economic and environmental considerations, creating instability in plant operation. For those sites, especially those with multiple sulphur recovery unit (SRU) trains, a lack of sulphur available to be processed by their units can be equally as difficult to manage as too much sulphur. In a low refinery sulphur case, there are three main options for managing the units: 1) co-firing at reduced acid gas rates across multiple trains, 2) hot-standby or firing exclusively on a utility gas stream, and 3) a long-term idle state. Understanding the pros and cons of each option is critical to making a decision on which run state is best when sulphur rates are below SRU turndown capability.

A co-fire or even hot-standby condition of the unit allows the plant to maintain a more typical run state. Fewer procedural changes are needed to maintain, and there is less overall deviation from the normal unit conditions. Hot-standby does, however, present a concern of waste of fuel gas, electricity, steam, and overall utility cost associated with keeping the units warm. There is also a potential risk of safety when operating the units in co-fire and hot-standby states for long periods of time, frequently operations is much more familiar with shorter time frames for both.

A long-term idle state refers to a planned outage of the unit for longer than that of a typical refinery turnaround. A long-term idle can eliminate the costly utility concerns associated with hot-standby or co-firing, as well as help stabilise online units that are still operational in a multiple SRU facility. Long-term idle still does, however, present its own unique challenges. If there are any plans to reuse the equipment in the future, including restarting the unit, these challenges are increased. Long-term idle with plans for equipment re-use will be the focus of the discussion in the following sections, highlighting considerations that need to be taken to safely and reliably plan for, execute and maintain, and restart the unit.

Even if refiners do not foresee the unit needing to be brought online, preserving the assets for use as spares or in other applications throughout the plant allows for a more integrated and sustainable path forward in response to the ever-changing economic demands and refinery processing priorities.

Prior to shutdown

Planning for a long-term idle of a unit should begin as soon as possible to allow for adequate preparations to be made. Facility planning should first determine if the remaining sulphur complex capacity is sufficient to sustainably run the expected sulphur rates produced by the refinery for the foreseeable future. The restart of an SRU after long-term idle should not be planned to be performed at a moment's notice, or quick fashion. Once available capacity is confirmed the process of long-term idle can proceed.

Process evaluation

The process engineer should be the driver of long-term idle of the unit and oversee all aspects of the change including facilitating a management of change (MOC) procedure for any unit change. The MOC procedure is used to document and organise actions that will be taken on the idle SRU and is critical for plant safety.

First, the process engineer should begin by evaluating any unit pinch points and determining any work that should be performed while the unit is down or out of service. Where is the unit experiencing corrosion? Is there any routine maintenance coming up that should be performed? What work is planned for the next turnaround and how far away is the next turnaround? The initiation of a long-term idle will take a unit out of its conventional turnaround cycle and these factors should all be considered. It is recommended that any maintenance needed be performed upon shutdown of the unit. This allows for a quicker start-up in the event the unit is needed for refinery operational demands, while still allowing the mechanical integrity of the unit to be maintained.

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In addition to mechanical turnaround considerations made for the long-term idle, catalyst should also be evaluated. The age and activity/performance of the catalyst should be evaluated using all available data to determine its health and speed of aging. What is the estimated run length between present day and required catalyst changeout date? Is the plant comfortable taking another shutdown of the unit after that duration or should the catalyst be changed upon shutting down? If the catalyst is changed upon shutdown, it should be communicated and coordinated with the catalyst vendor.

Lastly, the process engineer should compare the unit operating data to the heat and material balances or unit models as closely as possible, considering various unit monitoring points including an overall unit pressure survey. This can facilitate in identifying any "go do" or opportunistic changes that should be pursued during the shutdown.

Procedures and safety

New procedures for start-up, shutdown, and idle state must be created due to the differing needs of the plant during long-term idle.

Shutdown procedures should be written in conjunction with the SRU operators and allow for extended time to "drop out" or remove as much sulphur as possible from the unit and cool down at a very slow rate. Because this unit will not be in use after the shutdown, the motivations for speed are reduced and the additional time should be taken as available. Once this extended shutdown time is taken this is when the above detailed process evaluation should be referenced. Does the unit need to be prepped for entry or catalyst removal? If so, proceed accordingly based on site confined space entry and catalyst changeout procedures.

Once the unit maintenance and or catalyst changeout has been performed, the long-term unit idle shutdown procedure should continue. All liquids need to be thoroughly drained and dried out of the unit including amine, quench water, and all steam generating pieces of equipment. Passivation of the steam generating side of equipment should be strongly considered to maintain reliability. This prevents degradation of the metals and often a liquid level of passivation chemical is maintained inside of the vessel for the duration of the idle period. Recommended passivation chemical levels should be noted in the shutdown procedure and monitored by the board operator while prepping the unit for the idle period. The passivation chemicals themselves should be included in the safety data sheets of the unit as part of the MOC.

Refractory vendors should be consulted to understand if any special refractory considerations and/or procedures are needed for dry-out or for idling the unit for a long-term period.

If the existing tail gas catalyst is left in the unit, it is critical to ensure that no oxygen reaches the catalyst to prevent a exothermic reaction from occurring. In addition, overall oxygen in the unit should be minimised as much as possible to reduce potential for corrosion due to a humid, oxygen, and sulphur rich environment. As a mitigation step, it is recommended that the entirety of the process side of the unit, aside from the incinerator, be maintained under a nitrogen blanket for the duration of the idle period. The nitrogen blanket should be implemented at the acid gas battery limits and include a pressure regulator and pressure safety valve and continue throughout the unit. Once the unit is initially inventoried with nitrogen, it should require little makeup to maintain pressure and therefore is a minor expense to the site in utility cost. Proper signage must be installed in the unit and verification included as a step in the procedure to notify plant personnel of the presence of a nitrogen blanket in the unit.

An additional section to be added to the procedure should be the de-inventory of the unit steam tracing. All steam tracing should be isolated from the overall plant steam system and disconnected and drained at all available low points. Where the tracing has been disconnected should be recorded in the procedure documentation for reference at a later date when it is reassembled and when the unit is to be restarted. Depending on integrity and design pressure of overall tracing system, the site should consider "blowing down" or "sweeping" the tracing system with nitrogen to ensure any remaining water is removed. This is all in an effort to minimise potential for corrosion while the unit is down and also helps reduce steam leaks upon unit restart.

The sulphur pit, or sulphur storage system must also be taken into consideration in the long-term idle procedure and should warrant its own section. How high is the water table in the facility's region? Is the storage system above or below grade? Is it water/air-tight? Will there be carbon steel exposed to air during the idle duration? These are all questions that should be asked and accounted for in how to safely idle the sulphur storage system of the unit.

In addition to these special considerations for shutdown, main tenants of the site's typical shutdown procedure should still be followed. Proper isolation and blinding of lines, locking and tagging out any necessary equipment in the unit, proper barriers and notification to overall plant personnel that a shutdown is ongoing.

Operations

Training to inform operations to all updated and new procedures for the shutdown, long-term idle, and startup states of the unit must occur prior to shutting down the unit. It is critical to the safety and effectiveness of the idle that all operations personnel are properly trained on this abnormal unit state.

This training should include not only a deep understanding of procedural changes but also the changes necessary for the day-to-day roles of operations while the unit is on long-term idle. What monitoring points will need to change from current operator rounds? What will stay the same? Do new/temporary alarms need to be associated with this change to be monitored by board operators? How many operators need to be in the unit and does this differ from current staffing needs?

Any changes to operator requirements or databases, alarms, or even control room/distributed control system (DCS) board visuals and graphics should be included in the MOC to allow them to be reverted to their original state on restart of the unit.

Analyser vendors should be consulted to determine whether all analysers should be pulled out of service and stored for the duration of the downtime.

During shutdown

While the unit is shut down or during long-term idle, the SRU should not be treated as an "offline" piece of equipment. It is critical to the longevity of the equipment and the ability to re-use the equipment either as spare parts or restarted as a full unit, that the system is continually monitored.

Once the unit is down, it is critical to double-check all DCS or control room screens and alarm points to ensure nuisance alarms are not clouding board operator judgement. This will enable the board operators to better monitor the unit to ensure it stays under nitrogen blanketing, free of air in the process section, and passivation chemical levels maintained during this idle period.

Equipment, piping, and steam tracing inspection frequency should be maintained to verify no degradation of mechanical integrity is occurring during the downtime.

One approach to managing the unit downtime is a temporary MOC to implement and document all changes. Upon start-up the temporary MOC can then be reverted to its prior state and will allow for the undoing of all of the changes in the MOC in a stepwise approach.

Restarting the unit

Restart procedures should be defined prior to the unit ever being put into an idle state as additional care should be taken to ensure the unit is in a safe state to restart properly. Has all of the maintenance that needed to be performed completed? Is everything returned to a normal state? Check with the safety group, are all MOCs that were opened during the downtime now complete?

Starting with the MOC as a guide you should methodically return the unit back to a normal state after inspections have been performed to determine if this is feasible. Before ever removing any process blinds from the unit, all passivation chemicals from steam generating equipment should be drained, steam tracing should be reassembled and verified as working for each circuit throughout the unit.

Does the catalyst in the tail gas reactor need to be activated or sulphided? Do operators need to be retrained? Are all car seals still in place as needed? Is the sulphur pit or tank free of water? Have PSVs been checked and tested as needed, is the temporary PSV removed? Have any parts been taken from the idle unit while down? Has a thorough walkdown and pre-start-up safety review (PSSR) been performed?

Once all changes to the unit for the long-term idle have been addressed and returned to "normal" or pre-idle state the site can then proceed with a more typical restart procedure. This includes but is not limited to pressure testing the unit, catalyst dust blow, verifying bolt tightness throughout the unit, and evacuating all non-essential personnel from the unit prior to re-light.

It is crucial that this restart is not completed in haste. As the unit has likely been down for an extended period of time a thorough inspection should be performed to verify everything is as intended for the internals of all vessels. Normal pipe inspections for corrosion should be performed. A slow heat-up should be pursued to prevent the risk of thermal shock.

Conclusion

Ultimately the choice for long-term idle is not right for every facility or every situation. The pros and cons should be evaluated with great care to understand the impacts to the site and its personnel. This includes weighing the feasibility of a hot-standby or co-fire state and comparing to the long-term idle option. Outside guidance from a technical expert and the benefit of a new set of eyes is always recommended when undertaking a change such as this. The safety of the facility hinges on the detail and care taken when making this decision and that should always be at the forefront.

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Next issue: July/August 2025

Brimstone Sulfur Symposium, Colorado, 10-13 September

- Sulphur forming project listing
- The titanium dioxide industry
- Changing patterns of sulphur trade
- Safety aspects of sulphur forming and handling
- Digital solutions making an impact

Closing date for advertisement space booking is 2 July 2025
For further information and to book advertisement space contact:
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Don't forget the next issue of Sulphur July/August 2025

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