

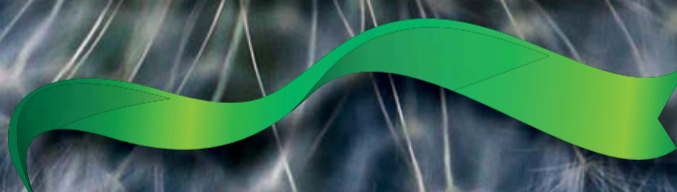
Fertilizer INTERNATIONAL

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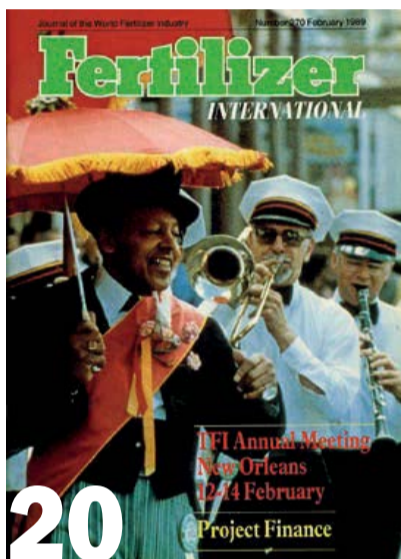


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Fertilizer International at 50



World's largest potash mine

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Fertilizer INTERNATIONAL

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Women in the fertilizer sector

In June, Montreal play host to IFA2019, the 87th Annual Conference of the International Fertilizer Association (IFA). This long-standing fixture of the conference circuit is generally recognised as *the* global fertilizer event of the year.

The event's reputation as the fertilizer industry's biggest and highest level international meeting is well-deserved. IFA2019 is expected to attract around 1,300 delegates, including company CEOs, presidents, board directors and senior managers. Executives from the large fertilizer producers, exporters and trading companies are all well represented.

IFA's Annual Conference is rightly renowned for its authoritative supply and demand outlook sessions. Many delegates will therefore be attending to update themselves on the latest global production and consumption trends.

IFA2019 also offers unrivalled networking opportunities, with some 1,500-2,000 individual meetings expected to take place on the conference margins in Montreal. Indeed, an army of analysts will no doubt be locked in discussion with clients in every available hotel suite, bar and restaurant of the main conference venue, Le Westin Montréal.

Equality is also on the agenda at IFA2019. The event will be championing the role of women, with the 'Young Professionals' session at Montreal having women in the fertilizer sector as its theme. The session will look at how the fertilizer industry – traditionally a very male preserve – can encourage greater gender diversity. Some of the exemplary diversity programmes already run by IFA member companies will be highlighted as part of this.

Importantly, the Young Professionals session at IFA2019 will provide an opportunity to hear from young women currently charting a career in the fertilizer sector. Women in industry leadership positions will also be sharing their own career experiences and lessons. The mentoring of young women professionals – a powerful tool for unlocking potential and improving confidence – will also be examined.

All these issues are expected to be aired during a conference roundtable discussion on 'Women in the Fertilizer Sector' on Wednesday 12th June. This will be moderated by Candace Laing, Nutrien's vice president for sustainability and stakeholder relations. The discussion panel includes some high-profile industry names such as Jeanne Johns, Incitec Pivot's CEO, and Valerie Renard, Prayon's director of sales & marketing. Raviv Zoller, ICL's president and CEO, will also be lending his support.

IFA's focus on the career prospects of women is commendable and timely. A recent global analysis by the World Bank found that women's economic status has improved over the last ten years, but that gaps remain. The Bank has been tracking the progress made by women in the workplace over the last decade, publishing its findings in the *Woman, Business and the Law Report 2019* in March.

The report looked at how female employees and entrepreneurs are affected by legal discrimination. It revealed "how women must navigate discriminatory laws and regulations at every point in their careers" and how this was "limiting their equality of opportunity".

The report scored gender equality using a host of workplace indicators such as: starting a job, getting paid, getting married, having children, running a business, managing assets and getting a pension. These were used to calculate a national equality index for countries globally.

The report found that just six countries grant equal rights to women and men currently. Only Belgium, Denmark, France, Latvia, Luxembourg and Sweden were awarded full marks, scoring 100 on the World Bank's equality index.

But significant progress has been made over the last ten years, with the average global equality index rising from 70 to 75, for example. More than 130 economies have also improved women's economic rights by enacting a total of 274 legal and regulatory reforms. Despite this, only 13 economies have introduced laws mandating equal remuneration for work of equal value.

"If women have equal opportunities to reach their full potential, the world would not only be fairer, it would be more prosperous as well," commented, Kristalina Georgieva, World Bank Group's interim president. "Change is happening, but not fast enough, and 2.7 billion women are still legally barred from having the same choice of jobs as men."

By making the role of women a headline theme of this year's Annual Conference, the International Fertilizer Association is signalling its high-level commitment to gender equality – and a fairer and more prosperous future for us all

Simon Inglethorpe, Editor

“If women have equal opportunities to reach their full potential, the world would not only be fairer, it would be more prosperous as well.”

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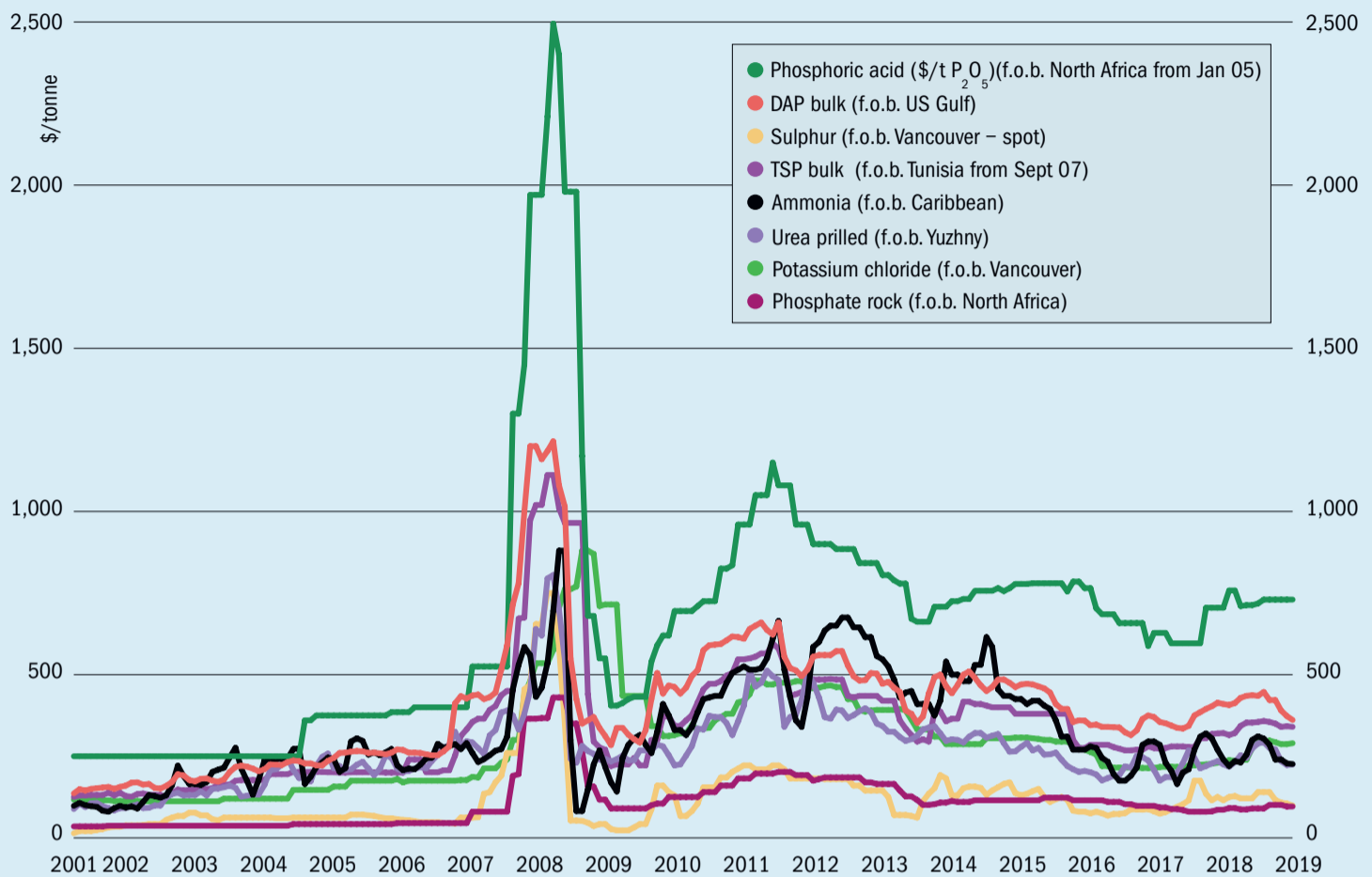
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Market insight

Historical price trends \$/tonne



Source: BCInsight

Market insight courtesy of Argus Media

PRICE TRENDS

Urea: Prices bottomed out in the first half of March, before stabilising in the lead-up to market-wide increases. The \$20/t increase in US prices, on the back of limited NOLA barge availability, acted as an important driver early on in March. Robust Indian demand, totalling 300,000-350,000 tonnes, pushed the market into deficit for April, after extensive purchasing accounted for most of Middle East, Egypt and FSU availability. This naturally supported urea prices as buyers searching for prompt cargoes were forced to pay a premium due to the tight availability.

Phosphate: The international market continued to soften in March/April. This was linked to slower demand and the end of domestic seasons in key supply regions, namely the US, Australia and China. Mosaic's phosphate rock mine outage in Brazil provided an opportunity for more MAP shipments from the US. The near-

term import line-up for Brazilian MAP was therefore correspondingly heavy. In April, strong DAP demand from India offered some price support East of Suez, but was insufficient to stop the downward spiral, let alone reverse it. Traders are aggressively offering DAP at lower levels in India, as of the first week of May.

Potash: This year will be a significant one for potash prices, marking a change in direction following a two and a half year upward trend. Crop futures prices and drought are both weighing on potash demand and values. In Indonesia and Malaysia, for example, prices have stalled on crude palm oil (CPO) futures and high stock levels. Suppliers managed to resist price drops during March/April, ahead of annual contract negotiations, but were unable to secure any increases. Although potash prices have risen almost continuously since summer 2016 – to heights not seen since 2015 – Argus sees the current price lull as a key turning point in the market. ■

MARKET OUTLOOK

- **Urea:** The short-term outlook for urea is firm. Traders – attempting to satisfy the sudden spike in demand from India – are still looking for product globally, bidding up Black Sea and Baltic prices, and even considering diverting some formula cargoes from other destinations. The market West of Suez is less positive, however, with US prices dropping about \$25/st early in May as logistical issues forced some liquidation sales. Nevertheless, Argus' trade balance shows the market to be in equilibrium in May and June. Urea prices overall should therefore remain firm over the next couple of months, although increases greater than \$5-10/t are unlikely.
- **Phosphate:** Argus' trade balance for DAP suggests the worst period for producers may be over. While a significant upside is unlikely, the DAP and MAP markets do look more balanced in coming months. Seasonal fill programmes will see Brazil,

Market price summary \$/tonne – End-April 2019

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phos Acid
f.o.b. Caribbean	223-228	-	f.o.b. E. Europe 112-140	f.o.b. US Gulf	371-377	-	-
f.o.b. Yuzhny	242-250	224-230	-	f.o.b. N. Africa	389-420	330-345	720-740
f.o.b. Middle East	245-255	247-272**	-	cfr India	389-392	-	728*
Potash	KCl Standard	K ₂ SO ₄	Sulphuric Acid		Sulphur		
f.o.b. Vancouver	262-318	-	cfr US Gulf	90-110	f.o.b. Vancouver	98-100	-
f.o.b. Middle East	272-331	-	-	-	f.o.b. Arab Gulf	100-108	-
f.o.b. Western Europe	-	500-520	-	-	f.o.b. N. Africa	93-110	-
f.o.b. Baltic	260-330	-	-	-	cfr India	110-127+	-

Prices are on a bulk, spot basis, unless otherwise stated. (* = contract ** = granular). Phosphoric acid is in terms of \$/t P₂O₅ for merchant-grade (54% P₂O₅) product. Sulphur prices are for dry material. (+ Quotes for product ex-Arab Gulf). n.a. = not available. Copyright BCInsight

Argentina, India, Pakistan, Bangladesh and the US all swing into buying mode in May/June. Intermittent demand from India is providing some Chinese f.o.b. price support. But, in our view, there is little chance of a significant upside to prices East of Suez before the second half of 2019. While the market does look more balanced than it was in the first quarter, the overall trend remains soft due to sufficient near-term spot availability.

- **Potash:** Recent developments – such as mining water flow issues, cuts in output and weather-related production problems – are not enough to offset sluggish demand and rising supply. Suppliers will at best realise modest gains in Brazil in the coming month as its demand ramps up. Important supply-side developments are happening, with a number of long-awaited greenfield potash mines now producing and selling MOP on the international spot

market. The ramp-up of K+S's Bethune mine in Canada, together with 1.4 million tonnes of combined output from EuroChem's two new mines in Russia, will contribute to a total of 3.3 million tonnes of greenfield capacity in 2019.

Note: Our usual commentary on price trends and the market outlook for ammonia and sulphur will resume in our July/August issue.

CHANGE YOUR MIND ABOUT PHOSPHATE

TECHNOLOGY | INDUSTRIAL SERVICES | OPERATION

NORTH AMERICA

IPNI ceases operations

The International Plant Nutrition Institute (IPNI) ceased operations in April and will close its Atlanta, Georgia, headquarters and regional offices at the end of June.

The future of IPNI Canada, however, is secure. It will continue to operate from its office in Saskatoon, Saskatchewan – with the Foundation for Agronomic Research continuing to act as the umbrella organisation for the 4R Research Fund.

A statement on IPNI's website confirmed: "The agronomic programs of IPNI ceased operations on April 1, 2019. This website will remain online until the end of 2019, but no further updates will be made." The statement directed any questions about IPNI's past work and projects to the International Fertilizer Association (IFA), The Fertilizer Institute (TFI), or Fertilizer Canada.

Although the ending of IPNI's operations and its office closures are being officially described as an "organisational restructuring", a senior insider told *Fertilizer International* of their shock and disappointment at the news.

IPNI was set up in 2007 as a not-for-profit, science-based organisation dedicated to the responsible management of plant nutrition for the benefit of humanity. Until six months ago, IPNI was active across the globe. Its work included agronomic programmes in Africa, Australia and New Zealand, Brazil, China, Eastern Europe, Central Asia and the Middle East, Latin and Central America, North America, South and Southeast Asia. The Institute's work was sponsored by member companies, including CF Industries, K+S, Mosaic, Nutrien, OCP, PhosAgro, Simplot, Shell Sulphur Solutions and Yara.

The decision to wind-up IPNI in its present form was made at a special meeting of its members and board of directors on

the 14th December last year. An accompanying press release described this as: "A major organisational restructure which will include the transfer of key scientific assets and programs to TFI, Fertilizer Canada and IFA."

By absorbing IPNI, the three industry bodies will receive "enhanced support for initiatives in 4R nutrient stewardship [and] regional agronomic extension", the press release added.

"IPNI has long lent scientific expertise to the fertilizer industry's efforts to address environmental and food production challenges. The fertilizer industry remains committed to helping farmers improve fertilizer management and to monitoring the performance with which our products are used," commented Tony Will, the chair of IPNI's board, and the president and CEO of CF Industries.

A senior IPNI source confirmed to *Fertilizer International* that: "IPNI, as we know it, is in the process of wrapping up. As you can imagine we were shocked and greatly disappointed at this turn of events. We are in the midst of closing our programmes and discussing the transition of some of our scientific resources with TFI, Fertilizer Canada and IFA.

More positively, the IPNI source added: "I believe IPNI has made many positive contributions to the global fertilizer industry and agriculture in general and am hopeful the legacy will inspire others to continue the work we have been engaged in."

IPNI's long-standing president, Terry Roberts, has been managing the closure of its offices and programmes and the transfer of the Institute's assets over the last six months. He was personally thanked by Tony Will: "The fertilizer industry is very grateful for the accomplishments and dedication of Terry Roberts and his team over many years."

JDCPhosphate becomes Novaphos

Florida-based JDCPhosphate has changed its name to Novaphos Inc as part of its drive towards full commercialisation.

The name change also applies to the company's innovative phosphate production technology – formerly known as the Improved Hard Process (IHP). This will also be known as Novaphos in future.

Novaphos produces high-quality superphosphoric acid (SPA) from low-quality phosphate rock via a thermal process route. Unlike conventional phosphoric acid production – which generates large volumes of hard-to-dispose-of phosphogypsum waste – Novaphos co-produces a commercially valuable construction and road building aggregate called *J-Rox*.

The company has successfully improved the efficiency and reliability of its technology during the first three months of 2019. Novaphos can now achieve phosphate yields of 80 percent. SPA quality also continues to improve, with impurities now

down to around the two percent level, with strong potential for further improvements.

Novaphos is currently running its Fort Meade demonstration plant using low-quality phosphate rock tailings as a feedstock. These contain just 14 percent phosphate (P₂O₅) on average, alongside high levels of silica and other impurities such as magnesium oxide.

"The latest improvements to the Novaphos technology are very significant," said Ron Cambre, Novaphos board member and former CEO of Newmont Mining. "Based on my long career in mineral processing, including phosphates, I am excited to see the technology poised to start addressing the fundamental needs of the phosphate sector while minimizing toxic waste."

The company says it has started a dialogue with major phosphate producers and engineering companies to fully commercialise Novaphos technology.

"Our new name is intended to signify Novaphos' readiness to move into the next phase of its business," added Timothy Cot-

ton, CEO of Novaphos. "We will work with industry partners to commercialise our technology for making phosphate products that are vital to global food production."

Mosaic cuts phosphate production

The Mosaic Company has reduced its phosphates production for the spring season by 300,000 tonnes.

The decision was made in early March in response to US market developments and a fall in the New Orleans (NOLA) price for diammonium phosphate (DAP).

The production cutback reflected "continued weather concerns across key US growing regions, along with higher than normal carryover inventory levels from the fall", Mosaic said in a statement, adding: "Protecting margins at this seasonably slow time of the year is important for the company and its customers."

The cutback in production will be achieved through changes in maintenance schedules and operations at Mosaic's US phosphate plants in Florida and Louisiana.

NETHERLANDS

ICL opens phosphate recycling unit

ICL has opened an innovative phosphate recycling unit at its Amsterdam fertilizers production complex in the Netherlands.

In an industry first, the new unit allows ICL to incorporate recovered phosphate from secondary sources in the industrial scale production of phosphate-based fertilizers.

The unit, which uses large-scale, alternative phosphate sources such as sewage sludge ashes and bone meal ashes, was formally opened by officials from the City of Amsterdam and the province of North Holland on 7th March.

ICL described the unit as a “circular innovation” and an example of the company’s strong commitment to sustainability.

“By using phosphate from alternative sources, we provide society with an innovative circular solution and also prepare ourselves for a future where phosphate rock will become an increasingly scarce source. This installation will allow ICL to continue with the production of fertilizers that help feed the world for many years to come in a sustainable way,” ICL said in a statement.

The company made clear that the unit was just the start of its plans: “Our ambition is to further increase the use of phosphate coming from alternative sources in the coming years, with ICL as one of the international frontrunners in phosphate recycling.”

RUSSIA

New phosphate plant for PhosAgro

PhosAgro has launched a project to build a new phosphate fertilizer complex at its Metachem site at Volkhov near St Petersburg.

The centrepiece of the project is a new fertilizer production line capable of manufacturing water-soluble diammonium phosphate (DAP). This will be constructed alongside a finished product warehouse, an 800,000 t/a capacity sulphuric acid plant and storage for liquid ammonia. An overhaul of Metachem’s existing phosphoric acid plant will also increase its output to 500,000 t/a.

Andrei Guryev, PhosAgro’s CEO, said: “This project is one of the key elements of PhosAgro’s strategy to 2025. In essence, this is an entire new factory that will increase PhosAgro’s total phosphate rock processing capacity [at the site] by one million tonnes per year [up from 300,000 thousand tonnes] – as well as increasing

the production of high margin phosphate-based fertilizers due to Metachem’s logistical advantages.”

The integration of fertilizer production with a new 25 MW power plant, which uses the latest water vapour generation technology, will significantly reduce the site’s energy consumption per tonne of product.

The project will require an investment of around \$360 million with commissioning expected in 2023.

Stamicarbon signs urea plant contract with ShchekinoAzot

Netherlands-based Stamicarbon has signed a urea plant contract with Russian producer ShchekinoAzot.

The contract covers technology licensing, the process design package (PDP) and the supply of proprietary equipment for a new urea melt and granulation plant at Pervomayskiy in Russia’s Tula region.

The 2,000 t/d capacity plant will use Stamicarbon’s *Pool Reactor Design* and *Flash Design*. The plant’s *Safurex*[®] high-pressure stripper and pool reactor will also be equipped with a radar-level measurement system.

The granulation plant at the site will use Stamicarbon’s *Optimized Granulation Design* and *MicroMist*[™] *Venturi Scrubber* technology.

UNITED KINGDOM

Sirius launches Stage 2 financing

Sirius Minerals has launched a comprehensive finance package to fund the second stage of its UK-based Woodsmith Mine polyhalite project.

The funding package combines four different types of financing:

- A \$400 million (£310 million) new share placement (a ‘firm placing’ and ‘placing’) and open offer at a price of between 15-18 pence per ordinary share
- A new guaranteed convertible bond worth \$644 million, of which \$400 million approximately will be fully underwritten
- \$500 million of senior secured guaranteed bonds (‘initial bonds’)
- A committed and secured ‘revolving’ credit facility of up to \$2.5 billion.

The new share offer and convertible bonds were launched by Sirius on 30th April to coincide with the announcement.

Chris Fraser, the managing director and CEO of Sirius Minerals, said: “We are pleased to announce... a comprehensive markets-led solution for our funding

requirements which will enable Sirius Minerals to complete the development of its mine and unlock what we believe to be the world’s largest known high-grade polyhalite deposit. The funding package will bring together equity, convertible bonds, high yield debt, and a \$2.5bn revolving credit facility in a multi-stage, flexible structure that balances the availability of capital with the needs of the project. [This] provides a clear pathway to a fully financed project in the months ahead, while enabling us to progress construction at full speed.”

Sirius confirmed on 1st May that the share offer had successfully raised proceeds of approximately \$425 million (£327 million), and that \$400 million of guaranteed convertible bonds had also been successfully placed.

KENYA

UN adopts sustainable nitrogen management resolution

The latest UN Environment Assembly (UNEA-4) has adopted a landmark resolution on sustainable nitrogen management.

The resolution, agreed by the Assembly in Nairobi in March, wants the negative impacts of reactive nitrogen to be tackled through a coordinated, coherent and evidence-based approach to global policy.

The International Fertilizer Association (IFA) responded positively to the resolution. “This resolution rightly points to the importance of plant nutrition for global food security,” commented IFA’s director general, Charlotte Hebebrand. “We must continue and further strengthen our efforts to improve nutrient uptake by crops and minimize nutrient losses.”

“IFA welcomes this timely proposal to better assess and quantify both negative and positive impacts of nitrogen, and to create a framework to explore and consider options for improved international coordination,” added Rakesh Kapur, IFA’s chairman and the managing director of IFFCO.

The Nairobi Assembly was attended by an IFA delegation led by Tip O’Neill, the CEO of IRM and the convener of IFA’s UN Outreach Group. IFA said its attendance confirmed the fertilizer industry’s commitment to reducing the environmental footprint of fertilizers, while helping to close agricultural yield gaps and improve food security.

IFA already contributes to the International Nitrogen Management System (INMS), also backed by UN Environment. This System will improve understanding of

the global nitrogen cycle and measure the positive and negative effects of nitrogen. The INMS should allow a more coherent and evidence-based approach to policy when completed in 2021.

Delivering on the new UN resolution will require a step change in nutrient use efficiency (NUE). The average NUE globally is around 45-50 percent currently, and ideally needs to be brought within the 50-90 percent range, according to the EU Nitrogen Expert Panel. Some cropping systems in West Europe, Brazil, the US and Japan – with an NUE of around 70 percent – already meet this goal. But NUE is still too high in other regions, such as Sub-Saharan Africa, where nutrients are not being replenished following harvests, leading to nutrient mining.

AUSTRALIA

WorleyParsons completes Jacobs ECR purchase

WorleyParsons Limited has completed its \$3.2 billion acquisition of the Energy, Chemicals and Resources (ECR) division of Jacobs Engineering Group.

The completion of the purchase was confirmed in late April and follows the binding agreement to acquire Jacobs ECR previously announced last October.

The newly-merged business will be a “pre-eminent global provider of professional project and asset services in energy, chemicals and resources employing 57,600 people across 51 countries”, WorleyParsons said in a statement.

WorleyParsons is being rebranded ‘Worley’ as part of the merger arrangements. The company’s name will also be changed to Worley Limited, subject to approval at its AGM in October.

WorleyParsons’ CEO Andrew Wood said: “This merger is about more than capacity and capability. It’s about opportunity. The opportunity to become the partner of choice for our customers, the employer of choice for our people and to deliver enhanced returns for our shareholders.”

As announced in February, Worley will now operate as four distinct business units: Advisian; Energy and Chemical Services; Mining, Minerals & Metals Services; and Major Projects and Integrated Solutions.

The merger is expected to deliver cost savings (synergies) of around AUD 130 million within two years (at a cost of AUD 160 million). A more detailed update on the merger and changes at the company is expected at Worley’s Investor Day on 5th June.

Incitec Pivot to close SSP plant

Incitec Pivot is to close its Portland, Victoria, single superphosphate (SSP) plant in May, following a strategic review.

The closure will consolidate the company’s SSP production at the Geelong, Victoria, SSP plant, around 300 km to the east. Geelong’s maximum SSP output (350,000 t/a) is almost double that of the Portland plant (180,000 t/a).

The decision to close the Portland SSP plant is the outcome of a strategic review which began in 2014. This sought to optimise and rationalise the company’s SSP production assets, at a time when Incitec Pivot was facing both domestic overcapacity for SSP and competitively priced imports.

SSP production at both Portland and Geelong relies on externally-supplied sulphuric acid and imported phosphate rock. Incitec Pivot sources phosphate rock from international suppliers, while sulphuric acid is sourced domestically from Nyrstar’s zinc smelter in Tasmania. The company’s requirement for both raw materials is expected to fall as a result of Portland’s closure.

Incitec Pivot has confirmed that Portland’s distribution centre will continue to operate as normal, despite the closure of its SSP plant.

NORWAY

Yara turns smartphones into nitrogen sensors

A new innovation from Yara International will allow farmers to measure crop nitrogen requirements using their smartphones. The company launched the new precision farming tool, known as *Yaralrix*, in March

Nitrogen analysis has traditionally required expensive equipment beyond the reach of most growers. Yara’s aim in introducing the new tool is to make precision agriculture accessible to all farmers.

Yaralrix includes a free-to-download app available for both Android and Apple’s iOS. The app uses the smartphone’s camera to determine the nitrogen demand of different crops in the early stages of growth. For measuring nitrogen demand during later growth stages, the app requires an additional *N-Tester* hardware device. This is available as either a smartphone clip-on, or as a separate Bluetooth-enabled device.

“Every field is different. By enabling farmers to simply use their smartphones for precision farming, *Yaralrix* is a game-changer that can ultimately provide millions of farm-

ers with new insight about their crops,” commented Stefan Fürnsinn, Yara’s senior vice president for digital farming.

He added: “We are now taking the first steps with the launch of *Yaralrix* across Europe. With access to precise data about the nutritional needs of crops, we can produce more food and reduce the environmental impact of farming at the same time.”

Yaralrix works by measuring chlorophyll levels using a smartphone camera combined with one of two hardware devices. This enables precise measurements of the nitrogen needs of crops – making it easier for the farmer to apply the correct amount of fertilizer.

The app – without any additional hardware – can determine the nitrogen needs of winter wheat, oilseed rape, maize and barley during early growth stages. After making its measurement, the app provides an instant recommendation about how much fertilizer the crops need. This recommendation uses algorithms and the accumulated knowledge of more than 20 years of field research.

The app can be supplemented with the *N-Tester Clip*. This add-on device clips over the smartphone camera, transforming it into a nitrogen sensor for precise nitrogen recommendations at later growth stages. Farmers will initially receive a beta version of the *N-Tester Clip* prior to its formal market launch.

Farmers also have the choice of purchasing the *N-Tester BT* device for *Yaralrix*. This connects to smartphones via Bluetooth to provide nitrogen recommendations for crops in later growth stages. *N-Tester BT* is suitable for winter and spring barley, winter rye and winter triticale, as well as the previously mentioned crop types. It also saves historical data, improving the ability of farmers to make correct nitrogen recommendations.

EGYPT

tkIS wins fertilizer complex contract from NCIC

Germany’s thyssenkrupp Industrial Solutions (tkIS) has won a contract to build a new nitrogen fertilizer complex for Egypt’s Nasr Company for Intermediate Chemicals (NCIC).

The two companies signed the engineering, procurement and construction (EPC) contract in Cairo in March. The major order is said to be valued in the “mid-three digit million euro range”.

The new complex will be built in Ain El Sokhna, around 100 km southeast of Cairo, close to NCIC’s existing phosphate

and compound fertilizer complex. It will produce up to 440,000 t/a of ammonia, 380,000 t/a of urea and 300,000 t/a of calcium ammonium nitrate (CAN).

The new Ain El Sokhna complex is part of a plan by NCIC to expand its current product portfolio to include high-quality nitrogen fertilizers – and manufacture these for both domestic consumption and the export market. The complex will be completed and enter production in 2022 under current plans.

“We have a particularly successful partnership with Egypt stretching back more than 160 years which offers great potential for the future. Our longstanding experience in plant construction, our strong local presence and close collaboration with our customers form the basis for our success and strong market position in the region,” said Marcel Fasswald, the CEO of tkIS.

“To date, we have planned and built 16 of the 17 existing nitrogen fertilizer plants in the country and are delighted that another state-of-the-art plant will now be added,” said Ralf Richmann, CEO of the company’s fertilizer & syngas technologies business unit.

thyssenkrupp will deliver the project as part of a consortium with the Egyptian company Petrojet.

MOROCCO

OCP awards acid plant contracts to Intecsa and Outotec

Intecsa Industrial, part of ACS Group, has been awarded two sulphuric acid plants contracts totalling €255 million by OCP Group.

The contracts involve the construction of two new 5,000 t/d sulphuric acid plants at OCP’s vast Jorf Lasfar site. The sulphuric acid produced will be used to manufacture

phosphate fertilizers. Both acid plants will also generate energy for the Jorf Lasfar site.

The two contracts, announced on 5th March, cover basic engineering, detailed engineering, equipment and material supply, construction and implementation of the plants. The timetable for completion of work on the two plants is estimated at 26 months and 32 months, respectively.

On 13th March, Outotec separately announced the signing of an €80 million engineering, procurement and construction (EPC) contract with OCP Group for a sulphuric acid plant.

The new acid plant will be based on Outotec’s sulphur burning system. It will incorporate proprietary technologies such as the *HEROS* heat recovery system, as well as a converter, absorption towers and an acid distribution system made of Edmeston SX stainless steel alloy.

“Outotec’s sulfuric acid technology has proven to be one of the leading technologies for decades. We are honoured that OCP has selected our design for their new plant. With our leading technologies providing benefits such as safety, high reliability and enhanced heat recovery we are happy to help OCP reach their sustainability targets,” says Kalle Härkki, head of Outotec’s metals, energy & water business.

NIGERIA

OCP firms-up ammonia plant plan

Plans by Morocco’s OCP Group to build a one million tonne capacity ammonia plant in Nigeria are progressing.

The \$1.5 billion project should be finalised with Nigerian authorities by the end of 2019, Karim Lotfi Senhaji, CEO of the Group’s OCP

Africa subsidiary, told *Reuters* in March.

OCP signed a memorandum of understanding for the project with Nigeria’s Sovereign Investment Authority in June last year.

OCP Africa’s CEO also confirmed plans to build a \$3.7 billion chemical plant in Ethiopia. This will have an initial capacity of 2.5 million tonnes, and should enter production by 2023/2024.

These investments are part of OCP’s strategy to boost phosphate-based fertilizer use and production in Africa. The company believes there is potential to boost Africa’s phosphate consumption five-fold from current levels

“We encourage having this [production] done as close as possible to the farmers or the area of consumption. We don’t aim to produce everything in Morocco,” Lotfi Senhaji told *Reuters*.

Dangote signs gas supply agreement

Dangote Fertilizer Limited has entered into a long-term natural gas supply agreement for its under-construction Lekki fertilizer plant.

The agreement with Chevron’s Nigerian subsidiary guarantees the gas supply for the nearly complete large-scale fertilizer project. Dangote Group’s massive nitrogen complex, located at Lekki near Lagos, consists of two ammonia-urea trains with a combined annual production capacity of three million tonnes for urea.

Speaking at the signing ceremony, Devakumar Edwin, an executive director at Dangote, said the Group was looking forward to enjoying a long-term relationship with Chevron Nigeria Ltd, and to finding other joint opportunities in the oil and gas sector.

Dangote expects to commission the new fertilizer plant in June. ■



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People

Mayo Schmidt is the new chair of Nutrien. He officially succeeded the previous chair, **Derek Pannell**, at Nutrien's annual meeting on 9th May. Mr Schmidt has held significant agri-business leadership roles, both in Saskatchewan and globally, over his distinguished 32-year career. He has also been a director of Nutrien and its predecessors for the past six years.

Derek Pannell and two other incumbent directors, **Jerry Grandey** and **Anne McLellan**, all retired from the board at the May annual meeting, reducing the size of Nutrien's board to 12 directors.

"Derek, Jerry, and Anne have been valuable members of the board of directors and we want to express our sincere thanks for their significant contributions to our success," said Chuck Magro, Nutrien's president & CEO. "The board of directors and the management team are excited to work with Mayo as board chair. His experience, leadership and proven track record will be important as Nutrien advances its vision and strategic plans."

Mayo Schmidt replied: "It has been a pleasure serving with Derek and Anne for the past six years and with Jerry since the start of Nutrien. They are departing Nutrien having helped to make it the world's largest provider of crop inputs and with an enviable balance sheet. It is a great privilege and honour for me to be named chair of Nutrien with an opportunity to lead the board as our business continues to grow and create value for shareholders."



David Trafford.

David Trafford is CRU Group's new CEO. He was promoted into the role, having previously been the CEO of CRU Consulting since joining the Group in 2015. David is an international natural resources executive with over 30 years' experience in the mining, metals and investment banking sectors. He was instrumental in the successful transformation and global expansion of CRU Consulting, substantially increasing sales during his time as leader of the business unit.

Robert Perlman, CRU's executive chairman, said: "David brings real breadth of experience in the commodities that we specialise in, and understands the nature of roles at every level of the business. I am delighted to see him appointed this year, as we celebrate our 50th anniversary."

David Trafford replied: "It is an honour and a privilege to be asked to run CRU Group, a business with an unparalleled her-

itage and reputation in commodity research, built over 50 years by dedicated professionals and supported by loyal customers."

Joe Reece has joined the board of Compass Minerals as a new independent director. Joe has more than 30 years of capital markets and investment banking experience, and is expected to enhance the board's market and sector knowledge.

"We are pleased to welcome Joe and his experience to our Board," said Dick Grant, board chairman and interim CEO of Compass Minerals. "We believe his background fulfils needs identified by our nominating committee last year and will add value in our ongoing consideration of strategies to increase shareholder value."

Mr Reece is currently CEO of Helena Capital, a merchant bank he founded in 2015. He was previously the executive vice chairman, and head of the Investment Bank for the Americas, of UBS Securities from 2017 to 2018. Prior to this, Joe worked at Credit Suisse between 1997 and 2015, eventually serving as global head of Equity Capital Markets and global head of Basic Materials and Infrastructure. He was also an attorney for 10 years, including stints at the Securities and Exchange Commission and law firm Skadden.

Mr Reece holds a BSc, MBA and Juris Doctor from University of Akron, as well as a Master of Laws from Georgetown University Law Center. He currently serves as independent director on three other boards, including Del Frisco's Restaurant Group. ■

Calendar 2019

JUNE

4-5

IFS 2019 Technical Conference, BRUSSELS, Belgium
Contact: Steve Hallam, International Fertiliser Society, Tel: +44 (0)1206 851 819
Email: secretary@fertiliser-society.org

7-8

43rd AIChE Annual Clearwater Conference 2017, CLEARWATER, Florida
Contact: Perry Alonso, AIChE Central Florida Section
Email: vice-chair@aiCHE-cf.org

11-13

IFA 87th Annual Conference, MONTREAL, Canada
Contact: IFA Conference Service, Tel: +33 1 53 93 05 00
Email: ifa@fertilizer.org

SEPTEMBER

22-24

TFI World Fertilizer Conference, CHICAGO, Illinois, USA
Contact: Valerie Sutton
Fax: (202)-962-0577
Email: vsutton@tfi.org

24-26

10th GPCA Fertilizer Convention, MUSCAT, Oman
Contact: Ammara Shahiryar
Tel: +9714 4510666, Ext. 102
Email: ammara@gpca.org.ae

OCTOBER

1-3

Africa Fertilizer Agribusiness Conference 2019, CAPE TOWN, South Africa
Contact: CRU Events
Chancery House, 53-64 Chancery Lane, London WC2A 1QS, UK
Tel: +44 (0)20 7903 2260
Email: conferences@crugroup.com

NOVEMBER

4-7

CRU Sulphur and Sulphuric Acid 2019 Conference, HOUSTON, Texas, USA
Contact: CRU Events
Tel: +44 20 7903 2448
Email: conferences@crugroup.com

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THEN&NOW

AGI Fertilizer Systems

Fertilizer International is 50 this year. The continuing success of the magazine is built on mutually beneficial partnerships forged over five decades. So, in celebrating our 50th anniversary this year, we will also be profiling a much-appreciated commercial supporter in each issue. This month it is the turn of Marshall, Illinois-headquartered **AGI Fertilizer Systems**, a valued long-term advertiser. The company is even older than *Fertilizer International*, having celebrated its 50th anniversary in 2018.

Company profile

AGI Fertilizer Systems, formerly **Yargus Manufacturing**, established in 1968, proudly produce a wide range of premium bulk blending and material handling equipment that are shipped worldwide for agricultural and industrial uses. 2018 marked the 50-year anniversary of the Yargus brand. The Layco-Yargus story is a true testament to the American Dream. Hard work, grit and imagination. These words best describe how this family-owned company went from a small business making truck bumpers and rebuilding conveyors for local fertilizer plants to become an international leader in the development and manufacture of material handling solutions.

“The 50-year journey for me has been remarkable,” says Larry Yargus, former owner of Yargus Manufacturing. “I have been truly blessed.” Not everyone has the opportunity to work with multiple generations of their family. It is uncommon these days for children to return home to work in a smalltown rural family business. Yet all three of the Yargus girls came back home to help build the business and the brand – making this family’s business story truly unique.



Larry Yargus receiving the ARA's Jack Eberspacher Lifetime Achievement Award surrounded by family, including his wife and daughters Kate, Meg and Anne.

Larry's lifetime achievement

In December 2018, the United States Ag Retailer Association (ARA) honoured Larry Yargus with the Jack Eberspacher Lifetime Achievement Award. This award, presented at the Association's Annual Conference and Expo in Boca Raton, Florida, is the ARA's highest individual honour. It recognises career-spanning achievements and major contributions to the agriculture retail industry. For family, friends and colleagues, there could not have been a better way to celebrate Larry's outstanding contribution to a company that – having started from such humble beginnings – has achieved so much. ■



1979

Yargus built their first open top blender (pictured). Things really started changing for the company, with US-wide interest in buying their products. Yargus went to their first national show in Dallas, Texas. It was such a big deal, the entire Yargus family attended.

1980-1985

Yargus built over 1,000 open top blenders and shipped these across the United States. In 1983, Yargus got its first shot at international sales. Glenn Todd from northern England saw a Yargus ad, visited Marshall, Illinois, and ended up buying the company's first blender for export.

1992

Larry Yargus became the sole owner of the company, reincorporating Layco and renaming the business Yargus Manufacturing. Larry started marketing the Layco product line and brand internationally. He also started developing the tapered vertical blender and rotary drum blender demanded by the market.

MID 1990s

Yargus became more aggressive in international markets, attending more trade shows and advertising internationally. The company expanded its North American sales to Europe, South America and Australia, establishing agents in Argentina, Mexico and Australia. The UK fertilizer business loved Yargus open top blenders and sales continued through the 1990s.

1998

Yargus, always the trailblazer, sold its first plant in Africa. The Nigerian government bought three plants that were installed in three states. This marked the start of its thriving African business.

2002

Anne Yargus Sheehy, Larry's oldest daughter, came back home and took over international business development.

2002-2019

Yargus installed equipment in over 60 countries around the world, including installations all over Australia and in nearly every Central and South American country. The Yargus footprint in Africa also expanded to 10 African countries. The company's strong international sales team and in-country agent/distributor presence has driven this growth.

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PICTURE THIS...

Made in Canada

Canada is the world's third largest producer of primary (NPK) plant nutrients, a position achieved thanks to the pre-eminent might of its potash industry and its strength in nitrogen manufacturing. The country's fertilizer industry is highly export oriented, but also serves a large and sophisticated domestic agricultural market. Some 95 percent of potash and 40 percent of nitrogen products are exported. In fact, Canadian fertilizers are traded with over 75 countries and represent some two percent of the nation's total exports. Importantly, Canada is ranked as the number one potash producer globally, with 10 operations in Saskatchewan providing massive production capacity in excess of 35 million tonnes (KCl). K+S's new Bethune mine also produced 1.4 million tonnes of marketable potash in 2018, its first full year of operation. Canada exported more than 10 million tonnes of potash in 2016, making it by far the world's largest exporter – the US, Brazil and China being the main export destinations. Potash exports are a major revenue earner for the country, yielding \$4.7 billion in 2016. Canada's nitrogen manufacturing industry, particularly for ammonia and urea, is another strength – the

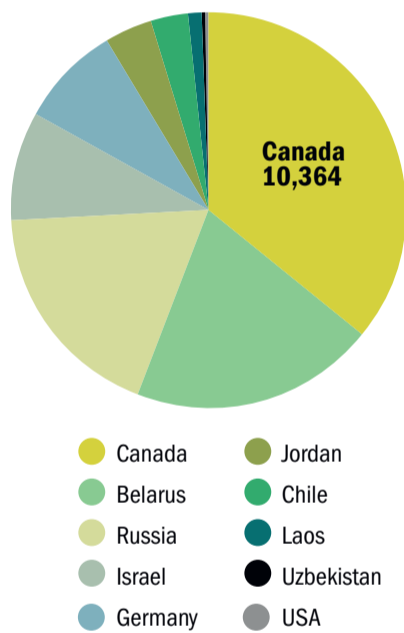
country being ranked eighth as a nitrogen-producing nation globally. Canadian ammonia is exported in large volumes to the neighbouring US market. Indeed, the scale of this growing cross border trade has positioned Canada as the world's fifth largest ammonia-exporting country. Canada's urea industry is world-scale too, with seven plants providing a total production capacity of just over four million tonnes.

Fertilizer production (mining, processing and manufacture) in Canada is on the rise and generates \$17 billion in economic activity and \$9.2 billion in GDP. The fertilizer industry's total contribution to Canada's economy and GDP rises to \$23.6 billion and \$12.7 billion, respectively, once transport, storage, wholesale and retail activities are included. The industry also employs the equivalent of nearly 77,000 full time workers, and pays out \$5.1 billion in wages each year.

Fertilizer consumption in Canada has been steadily rising for several decades to support increased crop yields. The country's mature agricultural market is the seventh largest consumer of fertilizers globally.

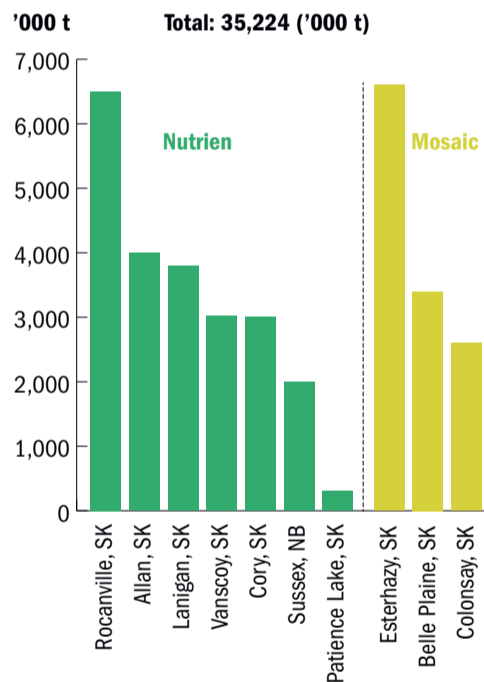
Sources: Fertilizer Canada/Nutrien/IFA

WORLD POTASH EXPORTS

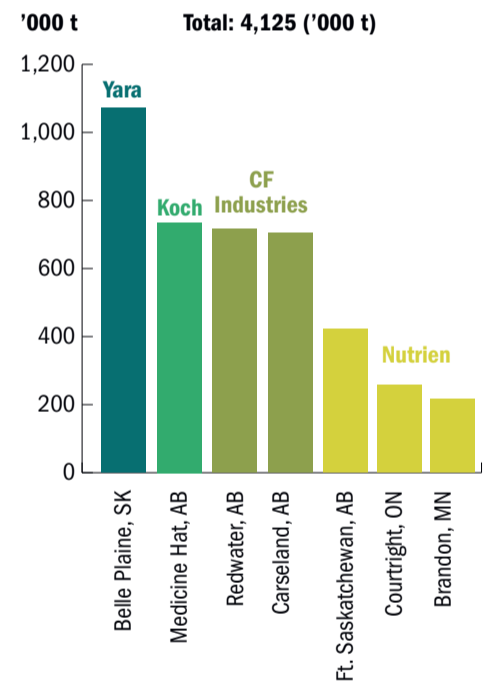


World total exports: 28,778 ('000 t)

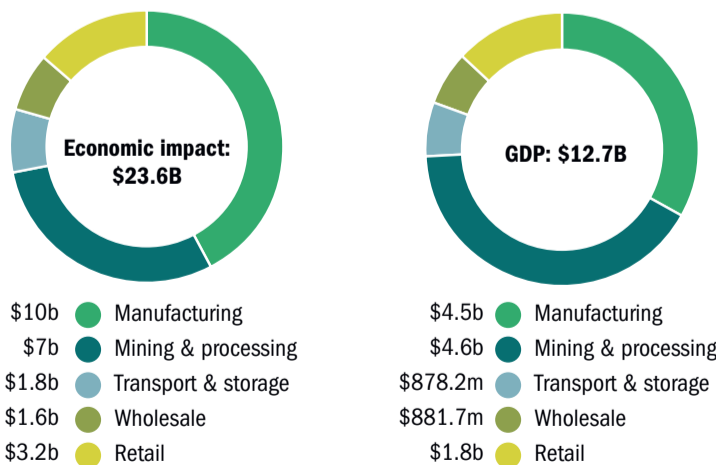
POTASH MINES BY CAPACITY



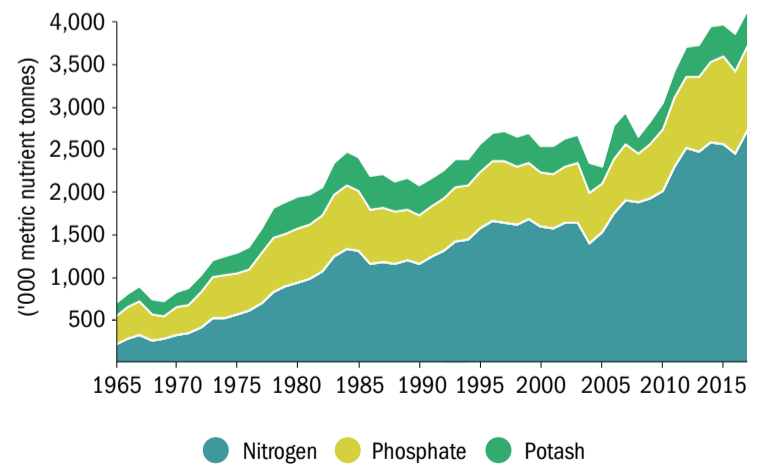
UREA PLANTS BY CAPACITY



FERTILIZER INDUSTRY IMPACT ON ECONOMY & GDP



FERTILIZER CONSUMPTION, 1965-2017



Fertilizer Canada: well-positioned to compete

Its commitment to domestic supply investments, trade negotiations, and safe and sustainable production has positioned Canada at the forefront of the fertilizer industry internationally. Canada's fertilizer industry is well-positioned to compete globally, as **Garth Whyte**, the president and CEO of Fertilizer Canada, explains.

Competitiveness, growth and investment

The future of the Canadian fertilizer industry remains strong due to our focus on improving – not just maintaining – competitiveness, growth and investment.

Canada is the world's leader in potash production. The country exports fertilizers to 75 countries worldwide – representing two per cent of all Canadian exports. The strength of Canada's fertilizer industry comes from being the holder of the world's largest reserves of potash and the capacity this provides, combined with its ability to manufacture high-quality products. It also draws on our nitrogen manufacturing market share. As a consequence, the Canadian fertilizer sector contributes \$23.6 billion in economic activity to national GDP and provides nearly 77,000 jobs.

Looking beyond our manufacturing might, the Canadian fertilizer industry is also steadfastly committed to the safe, secure and sustainable use of fertilizer products – with our member companies united in making this a common goal. In doing so, our industry has created a business environment that, by enhancing our reputation domestically and internationally, improves our ability to compete globally.

Having our voice heard

The Canadian fertilizer industry has enjoyed success working and communicating with government at both provincial and federal levels. This has helped ensure there is mutual agreement about the importance

of creating a competitive operating environment for the fertilizer industry – and a recognition of how our industry supports farmers, the agricultural sector and the wider national economy.

Fertilizer Canada – with its focus on maintaining the industry's freedom to operate without needless regulations – continues to work with governments on legislation that encourages trade and maintains an effective transportation system. It also ensures Canadian environmental policies and programmes reflect fertilizer industry priorities.

Our constructive engagement with governments across Canada means the fertilizer industry is seen as a positive participant. Indeed, Fertilizer Canada enjoys a highly positive working relationships with federal and provincial governments and other key stakeholders – as was revealed by a recent perception survey. Encouragingly, some 93 percent of industry and government stakeholders hold a favourable opinion of the Canadian fertilizer industry. While fifty four percent agreed that their opinion of the industry has become more favourable over the past three years.

Secure, safe and sustainable

The Canadian fertilizer industry's world-class safety, security and sustainability programmes have also enabled our industry to thrive. We have become a global leader in developing and implementing a number of innovative measures. These have improved both our competitiveness and enhanced our social license to operate.

One example of innovation is the three Codes of Practice created by Fertilizer

Canada. These offer standardised best practices for handlers and users of ammonium nitrate, calcium ammonium nitrate and anhydrous ammonia. We have made compliance with these Codes, via an independent, third-party audit, mandatory for all Fertilizer Canada members.

By providing access to resources and training via our eLearning platform, the Canadian fertilizer industry is improving the safety and security of its products with thousands of users.

Sustainability is also a priority and the Canadian fertilizer industry leads the world in fertilizer product stewardship. Canada is at the forefront in adoption of 4Rs Nutrient Stewardship (Right Source @ Right Rate, Right Time, Right Place®) which is recognised, both nationally and internationally, as the standard for sustainable nutrient management.

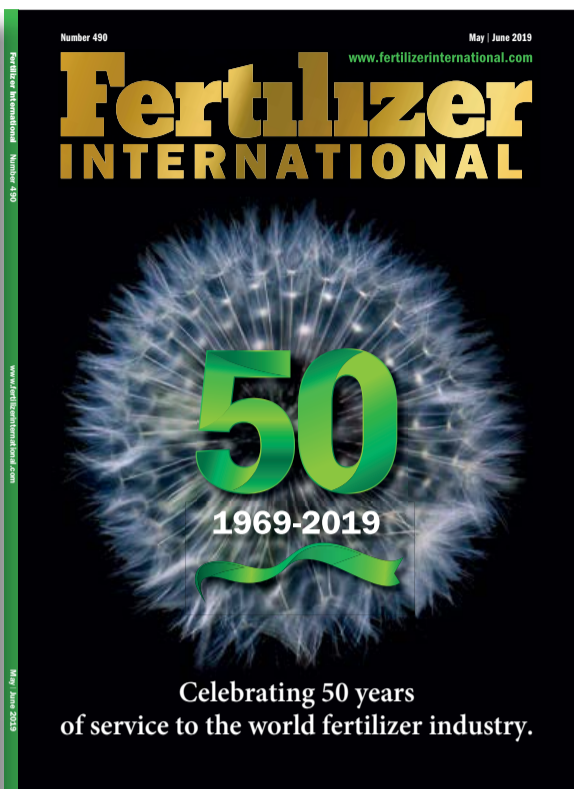
Fertilizer Canada has formal agreements in six Canadian provinces to implement 4R Nutrient Stewardship as a key measure. Three of those provinces (Saskatchewan, Manitoba and Ontario) have also included 4R Nutrient Stewardship in their provincial climate plans.

The Canadian fertilizer industry has also been successful in promoting the international adoption of 4R Nutrient Stewardship. It is now officially recognised by the UN's Food and Agriculture Organisation and the International Joint Commission, for example.

Furthermore, Fertilizer Canada and its partners, the Cooperative Development Foundation of Canada, Global Affairs Canada and IPNI Canada, recently announced the \$17-million 4R Solution project. This will bring 4R Nutrient Stewardship to 80,000 smallholder farmers in Ghana, Ethiopia and Senegal.

In future, the Canadian fertilizer industry will continue to innovate and take a global lead on product security, safety and sustainability. The sector will also seek to maintain its highly positive working relationships with all its stakeholders. In doing so, Fertilizer Canada and its members will ensure that government policies continue to attract additional business investment, grow the economy and recruit and maintain skilled employees. ■

Fertilizer International will reach its half-century in July. In this anniversary article, we highlight how the magazine and the fertilizer industry have changed, decade by decade, over the last 50 years.



Fertilizer International at 50

Fertilizer International is 50 this year. The title began life as an eight-page magazine first published in July 1969 by The British Sulphur Corporation out of their Upper Brook Street offices in London's Mayfair district.

Auspiciously, *Fertilizer International* first rolled-off the press at the time of the 1969 moon landing, during the very month that Neil Armstrong and Buzz Aldrin successfully touched down in the Sea of Tranquility in Apollo 11's lunar module.

It was a year of other notable firsts. Robin Knox-Johnston became the first person to sail solo non-stop around the world. And the first episode of Monty Python's Flying Circus was aired on the BBC. 1969 was also the year of Woodstock, the original rock festival. Richard Nixon was inaugurated US president too.

1969 didn't just mark the end of a decade either. Elsewhere in London that year, less than three miles from Mayfair, the final Beatles album, *Abbey Road*, was being recorded in St John's Wood.

The last year of the 1960s was also a volatile time. A quarter of a million people marched on Washington to protest against the Vietnam War. In the UK, it was also a year that was dominated by the start of the 'Troubles' in Northern Ireland.

Yet it was also a time of technological

innovation and change with the maiden flight in March of the world's first and only supersonic airliner, Concorde.

Half a century ago

In 1969, British Sulphur was still being run by its long-time managing director, John Lancaster, under the chairmanship of Major-General Godfrey Edward Wildman-Lushington, CBE. The Corporation was certainly well-connected and run with a military swagger in those days. Wildman-Lushington had previously commanded the Royal Marines towards the end of World War II, before becoming aide-de-camp to King George VI.

Lancaster and Wildman-Lushington's partnership dated back to 1953 when John joined the Major-General at the Sulphur Exploration Syndicate. Remarkably, almost all of today's UK-based fertilizer consultancies can trace their roots back to this post-war progenitor.

The syndicate's first *Quarterly Bulletin* in 1953 also launched what was to become, under British Sulphur, the first privately-owned publishing house and information company specialising in fertilizers and fertilizer raw materials.

Although British Sulphur Corporation's first publication, now familiar as *Sulphur*,

appeared in 1953, it was not until 1959 that the second journal, *Nitrogen*, was published, followed by *Phosphorus & Potassium* in 1962. The finance for this expansion into wider fertilizer industry research and publishing came from Fisons Ltd, during its brief 1958-1963 period of ownership. By April 1963, however, British Sulphur Corporation had severed ties with Fisons, operating once again as an independent private company, up until the merger with CRU in 1985.

Fertilizer International didn't appear from nowhere. It was preceded between 1966 and 1969 by 36 issues of British Sulphur's monthly *World of NPKs* periodical, which it later incorporated. British Sulphur's *Phosphorus and Potassium*, first published in May 1962, still survives today as our *Phosphates and Potash Insight* section.

Astutely, *Fertilizer International* filled a clear gap in the market by combining a valuable news and information service with commentary and analysis. From the very start, the magazine was designed to be broad-ranging, covering the whole of the industry from production technology to crop nutrition. Its remit and scope included the major nutrients, nitrogen, phosphorus and potassium, and their respective producers, as well as fertilizer industry raw materials, particularly sulphur and ammonia.



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TECHNOLOGY

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■ Penetrates Deeper For More Consistent Results

PENXCEL technology delivers active ingredients deeper into solid fertilizer granules more consistently. This innovative formulation allows the use of active ingredients previously deemed “impossible to be coated” on fertilizer. It also works well in liquid fertilizer providing an advantage over powders that stubbornly float on the surface and blow off granules in a cloud of dust.

■ Blends Faster Even In Challenging Cold Weather

Products using PENXCEL technology have low viscosity, so handling is easy. They pump or pour quickly, even in freezing cold temperatures, accelerating blending up to 25% faster than industry standard formulations. Saving time is critical during application season. PENXCEL provides superior performance in high-volume, high-speed mixers. The result is consistent fertilizer products that flow freely and perform in the field.

■ Excels In The Field, Excels In Safety

Field trials have demonstrated superior performance for PENXCEL technology, which has been attributed to more consistent coverage and deeper penetration of the active ingredients. Lab tests show that PENXCEL Technology is safer than the industry standard formulations. The key ingredient’s safety profile, as proven by its use in human medicine, is evident in the results.

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1960s

1969, Issue 1: Six issues of *Fertilizer International* were published monthly between July and December 1969. The magazine was put together by a team of six, including the editor-in-chief, Daphne Mermikedes, and our very first editor, Ivan Elek. Those first six issues varied in length from eight to 12 pages. Its short length, broadsheet format and the emphasis on industry news gave the title the appearance of a newspaper rather than a magazine.

British Sulphur's latest foray into publishing certainly managed to pack a lot of information into the limited space available. Individual sections were devoted to shipments and sales (international markets), country-by-country production and consumption ('news of the world'), company news, and the new types of equipment being used at production plants and for packaging, handling and storage. The latest in production technology and agronomic research was covered in an abstracts section. A table of the latest market tenders, mostly offered by Asian governments, was also provided.

1960s: Price recession in a growing market

The last years of the 1960s reveal a world fertilizer market that, although expanding strongly, was in a supply-driven phase with sliding prices (*Fertilizer International* 1, p4). World fertilizer consumption had risen by a robust six percent in 1968/69, with growth in the world's largest consuming country, the US, slightly lower at four percent.

Time magazine celebrates the moon landing, 20 July 1969. The 'Fab Four' began playing together as *The Beatles* in 1962. Concorde makes it's first flight on 9 April 1969.



Despite healthy demand growth, it had been an unsatisfactory year for producers of fertilizers and fertilizer raw materials due to an overall annual price decline of about four percent. The price recession was more pronounced for potash and phosphate products, less so for nitrogen products such as urea and ammonium sulphate. But it was sulphur, following five years of rising prices, that was most badly affected. Sulphur prices, in a "spectacular change" fell by just under one-fifth between the autumn of 1968 and the summer of 1969.

Excess supply was partly to blame, according to *Fertilizer International's* notebook column: "The continued slide in the prices of fertilizers and their raw materials, the corollary of intense competition, reflects the excess of available production capacity over effective demand."

The price slide of the late 1960s was hitting profitability too: "In most sectors of the fertilizer industry, the expansion of capacity has not been accompanied by significant cost reductions, and the deterioration of market prices has depressed many operations to the limits of profitability and in some instances below it," commented *Fertilizer International*.

Today's fertilizer producers can only dream of demand growth running at six percent per annum. But these were different times. The answer to the industry's malaise at the end of 1960s, suggested *Fertilizer International*, was to focus on making improvements in transportation and distribution, due to the scope for achieving cost savings and increasing profits downstream of production.



The Intel 4004 was the first commercially-available microprocessor, released in 1971. Ray Tomlinson sent the first ever email (to himself) in 1971 on the ARPANET.



1970s

1979, Issue 120: A decade on, the look of *Fertilizer International* was largely unchanged. It was still being published monthly as a 12-16 page broadsheet – the front page news stories still giving the title the look of a newspaper. Ivan and Daphne were by now directors of British Sulphur with John Lancaster installed as both chairman and managing director. But FI did have a new editor, Peter Shaddick, and a publisher, the estimable John French. Among its six contributors was a certain Clive Yearsley, a very well-known industry figure today, who later went on to found the consultancy Profercy.

1970s: Soviet trade emergence

With the eventual thaw in the Cold War still a decade away, the growth in international trade with the Soviet Union, especially in the ammonia and potash markets, was causing a stir in the late 1970s. Although the USSR's fertilizer production was close to 100 million tonnes at the time (*Fertilizer International* 116, p1), the bloc largely operated as a closed and self-contained market. That all changed in 1978, a remarkable year for the Soviet fertilizer industry, due to the impact on world trade of three landmark developments:

- An agreement with Morocco to import 5-10 million tonnes of phosphate rock
- The first export shipments of ammonia from Ventspils, the newly-built Baltic terminal in Latvia
- First import shipments of super phosphoric acid received at Ventspils.

Occidental Petroleum Corp and the USSR had in fact signed a massive and historic

PHOTOS: BEATLES IMAGE: LIBRARY OF CONGRESS, PRINTS & PHOTO DIVISION; TIME MAGAZINE COVER: TIME.COM; CONCORDE IMAGE: ANDRÉ CROS, WIKIMEDIA, CREATIVE COMMONS

PHOTO: INTEL PROCESSOR: THOMAS NGUYEN/WIKIMEDIA COMMONS

1980s

20-year trade deal in the spring of 1973. This agreed to the large-scale exchange of Soviet ammonia, urea and potash in return for the supply of Western super phosphoric acid. But it was not until five years later, in 1978, that the first exchange of shipments began (*Fertilizer International* 120, p22).

The arrival of the USSR on the international market came at an interesting moment. The talk in early 1979 was all about the possible return to price levels last seen in the 'fertilizer crisis' of 5-6 years previously. In March 1979, ammonia prices in Europe hit \$150/t cfr with commentators comparing the latest boom with that of 1973 (*Fertilizer International* 117, p1). That year saw ammonia prices climb from \$40/t to \$150/t f.o.b., before eventually reaching \$400/t in mid-1974. Price expectations for 1979 were, however, tempered by the anticipated arrival of "huge Soviet exports".

The USSR exported at least 740,000 tonnes of ammonia in 1978, up from 200,000 tonnes in 1977 (*Fertilizer International* 116, p1). These increases were mainly down to 'compensation deals' with two Western companies, Occidental in the US and Montedison in Italy. Soviet ammonia exports were due to accelerate further and more than double in 1979. Deliveries to Occidental alone were scheduled to increase to 950,000 tonnes. Other long-term deals in 1979 would take total Soviet ammonia exports to more than 1.5 million tonnes for the year. Additionally, the USSR would also continue to act as a spot supplier of ammonia in Europe and the Mediterranean.

Remarkably, the Soviet Union in the late 1970s was also supplying more potash to some Southeast Asian countries than Canada (*Fertilizer International* 116, p4). The USSR contributed 16,000 tonnes to total Indonesian potash imports of 70,000 tonnes in 1978, for example. The European cartel was Indonesia's largest potash supplier, delivering 32,000 tonnes through its own Singapore bagging terminal. While East Germany (GDR) and Canada each supplied Indonesia with 12,000 tonnes and 10,000 tonnes of potash, respectively.

The USSR clearly recognised the growth potential of the Southeast Asian potash market as far back as the late 1970s. An exclusive long-term supply agreement between Soyuzpromexport and Indonesia's Fertexim guaranteed that Soviet potash supply to Indonesia almost doubled to 30,000 tonnes in 1979. ■



Microsoft Windows 1.0 was released on 20 November 1985. Developed in the 1970s, CDs became commercially available in 1982. The Berlin wall fell on 9 November 1989.



1989, Issue 270: By this time, *Fertilizer International* had a new owner, CRU Publishing, and was being produced out of London offices at 31 Mount Pleasant. The magazine had shifted to full colour and its issue size had also expanded to fifty plus pages. Mark Evans, my immediate predecessor was now installed as editor, a position he would hold until his retirement more than 25 years later in June 2015.

1980s: Market reliant on Chinese imports

Today, the mammoth scale of China's nitrogen and phosphate production capacity is a given. And the behaviour of its major urea and phosphate exporters has long been accepted as a key determinant of international trade flows and prices. But this was not always the case. In fact, the opposite was true: rather than being a mighty exporter, China was once a major import destination for phosphate and nitrogen fertilizers.

Indeed, going back 30 years, our February 1989 issue (*Fertilizer International* 270, p32) asked whether China's goal of fertilizer self-sufficiency by the year 2000 was realistic and ever going to be attainable. At the time, imported fertilizers accounted for around 20-25 percent of China's fertilizer consumption.

"As China has become an indispensable market to the world's leading fertilizer exporters, any shift in China's buying patterns during the 1990s would have

major implications," the article notes. Such fears were very real ones. A wholesale curb on Chinese fertilizer imports in 1986, for example, had a catastrophic effect on world fertilizer market prices.

The article reflected widespread Western scepticism about the economics of China's fertilizer self-sufficiency plans, saying: "It is debatable whether the construction of high-analysis fertilizer plants is compatible with low prices on the [Chinese] home market," arguing that: "Regulating any [difference] between home demand and supply via imports makes more economic sense than investing in under-utilised, badly located and costly fertilizer projects."

With the benefit of hindsight, such views appear quaintly paternalistic and misguided. A fixed belief in the status quo was also plainly in the self-interest of Western producers and exporters. However, it is equally important to remember that, in the 1980s, China's economic ascendancy and its present day global pre-eminence were by no means certain. The Chinese state's ruthless efficiency in pursuit of its industrial and economic goals – and how staggering successful this policy would prove – only became clear much later.

The article did prove accurate in other respects. More presciently, it predicted that China's dependence on imported phosphates would start to taper off in the early 1990s as a plethora of Chinese-Western joint venture projects in Hubei and Yunnan came to fruition. ■

1990s

1999, Issue 370: By now, *Fertilizer International* was being published bimonthly, emerging six times a year as it does today. The internet age had arrived by the end of the millennium and with it came a new section: website reviews. Designed to ease our readers into the digital age, these rated company websites on their content, ease of use and visual appeal. Overall scores ranged from 'outstanding' to a forgiving 'could do better'!

1990s: Cyclically low prices

The magazine is becoming much more recognisable as well. Two long-lasting staples – our historical price trends graph and the market price summary table – are present and correct, for example. The market price tables (*Fertilizer International* 370, p14) reveal some remarkable price disparities between end-April 1999 and end-April 2019:

- Ammonia f.o.b. Caribbean, \$93-95/t then vs \$223-228/t now



Spooof front page of *The Sun* newspaper reporting the invention of the worldwide web by Tim Berners Lee fooled many on Twitter. A 'Y2K' warning sticker, a worldwide digital apocalypse that never happened.

These price differences exaggerate true changes in value, having not been adjusted for inflation over the intervening 20 years. (One dollar in 1994 would be worth \$1.53 in today's prices, for example.) What is clear, though, is that fertilizer and fertilizer raw material prices were cyclically low and, starting from this baseline, did steadily appreciate year-on-year throughout most of the first decade of the new millennium. This was a trend that eventually culminated in the commodity price spike of 2008.

- Urea f.o.b. Middle East, \$80-83/t then vs \$245-255/t now
- Potash f.o.b. Vancouver, \$115-130/t then vs \$262-318/t now
- DAP f.o.b. US Gulf, \$192-195/t then vs \$371-377/t now
- Phosphoric acid f.o.b. North Africa, \$325-385/t then vs \$720-740/t now
- Sulphur f.o.b. Vancouver, \$30-31/t then vs \$98-100/t now.

2000s

2009, Issue 430: By 2009, current owners BCInsight had acquired *Fertilizer International* and its two sister titles *Sulphur* and *Nitrogen+Syngas* from CRU. The magazine was also being produced from its current Black Prince Road offices, off London's Southbank.

2000s: Boom, bust and recovery

The fertilizer industry in the early years of the millennium was enjoying an unprecedented period of prosperity that accompanied the sustained upturn in prices which began in 2004/05 (*Fertilizer International* 431, p7). That halcyon period was to end in 2008 when the world economy suffered its greatest shock of the entire post-1945 period. Consequently, the fertilizer industry, in common with other commodity markets, suffered a cataclysmic reversal in fortunes over the 18-month period between the start of 2007 and mid-2009 (*Fertilizer International* 430, p40). The high hopes, ambitions and marked optimism that initially characterised this period, engendered by sharply rising prices, bullish demand and strong profit levels, were ultimately dashed as boom turned to bust.

As with many rollercoaster rides, it all started so positively. Fertilizer prices in



The Economist reports on the global economic crash of 2008.

general had been on a gentle and benign upward trajectory for several years previously. But an unprecedented combination of strong demand, rising crop prices, high farm profits and access to credit spurred a price rally that accelerated fast as 2007 moved into 2008.

By mid-2008, prices had risen vertiginously to unprecedented levels, dizzying

heights not seen before or since. DAP (f.o.b. US Gulf) hit \$1,200/t, potash (f.o.b. Vancouver) peaked at just under \$900/t, while urea (f.o.b. Yuzhny) reached \$800/t. On the raw materials side, ammonia (f.o.b. Caribbean), sulphur (f.o.b. Vancouver) and phosphate rock (f.o.b. US Gulf) saw highs of \$900/t, \$750/t and \$425/t, respectively. Unbelievably, phosphoric acid (f.o.b. North Africa) was even being traded at \$2,500/t at one point. Investor confidence in the industry was equally high and, at the height of the boom, some company valuations peaked at five times their January 2007 levels.

Such elevated prices were always going to be unaffordable over the longer-term and, unsurprisingly, the price bubble proved to be both short-lived and unsustainable. The inevitable downturn, that came as 2008 ended and 2009 began, was swift and brutal. As the global economy faltered, the market quickly shifted into a period of weak and uncertain demand as cash-strapped farmers stopped buying inputs. Prices predictably plummeted as sharply as they had risen, leaving retailers caught holding over-valued stock, the unfortunate middlemen in a product-choked supply chain.

The resulting downturn hit nitrogen and phosphate producers particularly hard. Fertilizer producer profits tumbled in the

2019 AND BEYOND

final quarter of 2008 as prices headed sharply downwards, while a collapse in sales led to widespread production shut-downs. Incredibly, about 50 percent of global phosphate production capacity was idled at one point. Many nitrogen plants in Western and Central Europe were also switched off at the end of 2008 in reaction to stalling demand.

Flickers of optimism and the early shoots of recovery did begin to return to the market from mid-2009 onwards. This came from a belief among producers and investors that the underlying fundamentals that had spurred the 18-month long price rally remained largely in place. For crops, prices remained relatively high and stock levels relatively low, for example, compared to their long term averages. There was also a view that any hiatus in fertilizer applications, and the resulting mining of soil nutrients, would create pent-up demand. In the end, the fertilizer sector did survive 2007/08 mostly intact, with the profits of the boom largely cancelling out the losses of the bust, to eventually emerge in a resilient if chastened mood. ■

2019, Issue 490: This article hopefully highlights some of the key changes, both good and bad, that have convulsed the fertilizer industry over the past half-century. My experience – since taking over the editorship from my long-standing predecessor Mark Evans in 2015 – is that industry change, if anything, is accelerating.

Fertilizer producers are no longer localised commodity producers with domestic assets concentrated in a single country. Many, through mergers and acquisitions, have become more integrated, owning the international production and distribution assets – and even retail outlets – needed to secure cost and logistical advantages in their key end-markets.

An inexorable longer-term shift from 'volume to value' is also underway in the fertilizer market, with producers moving into lower volume but higher value speciality fertilizer production. Indeed, the very term 'fertilizer producer' is fast becoming a misleadingly narrow misnomer. Most

companies now offer fertilizer inputs as part of a much wider and more comprehensive package of goods and services to farmers. Digital farming and precision agriculture are also now widely-recognised as being integral to future growth and success.

Would Ivan and Daphne, our very first editor and editor-in-chief, still recognise the 2019 version of *Fertilizer International*? I'd like to think they would. Half a century later we still provide – as they did in that very first issue – an informative mix of company and project news, market analysis and articles on fertilizer technology.

The continuing success of the magazine depends not only on our own expertise and acumen. It also relies on the mutually beneficial partnerships forged with the many companies and individuals who have supported us over five decades.

So, in celebrating the 50th anniversary of *Fertilizer International* this year, we'd also like to say thank you – to all our readers, contributors and advertisers, then and now. As one thing is certain, we wouldn't be here without you. ■

Simon Inglethorpe, Editor



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Fertilizer financial scorecard

PHOTO: NIKADA/ISTOCKPHOTO.COM

We compare and contrast the 2018 financial performance of the major listed fertilizer producers, following the publication of fourth-quarter results.

Nutrien: very productive first year

Canada's Nutrien is the world's largest crop nutrient company with a market capitalisation of around \$32 billion (Figure 1). This fertilizer industry giant produces and distributes over 25 million tonnes of potash, nitrogen and phosphate products for agricultural, industrial and feed customers globally. The company's agriculture retail business also serves over 500,000 growers worldwide through a network of international outlets.

Nutrien's much improved 2018 company results exemplified the overall upswing in the financial fortunes of the fertilizer majors. Revenues last year increased by eight percent to \$19.6 billion (Figure 2), while earnings rose 32 percent to \$3.9 billion (Figure 3).

Nutrien's strong revenue and earnings growth reflected across-the-board improvements in the performance of its potash and nitrogen operations and agricultural retail business. Results were also lifted by wider market conditions in 2018 – and improving fertilizer market prices in particular.

Chuck Magro, Nutrien's president and CEO, described 2018 as a "very productive first year" for the company. This was despite poor weather affecting the spring and fall application seasons in North America, and uncertainties created by the US-China trade dispute.

Magro said: "Nutrien delivered excellent operational and strategic results in 2018. Earnings [adjusted EBITDA] totalled \$3.9 billion in 2018, which was 32 percent above 2017. We delivered stronger margins and volumes on wholesale fertilizer

Fig. 1: Market capitalisation of selected producers, 1 April 2019

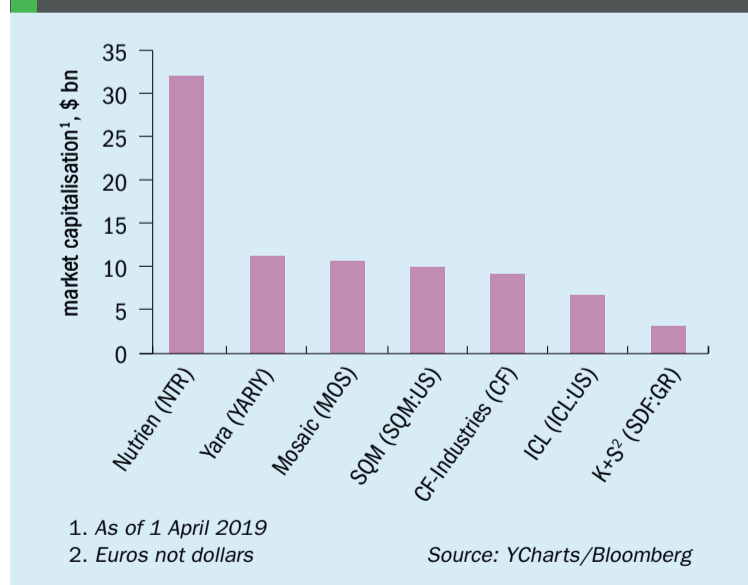


Fig. 2: Revenues of major fertilizer producers, 2017-2018



Fig. 3: Earnings of major fertilizer producers, 2017-2018

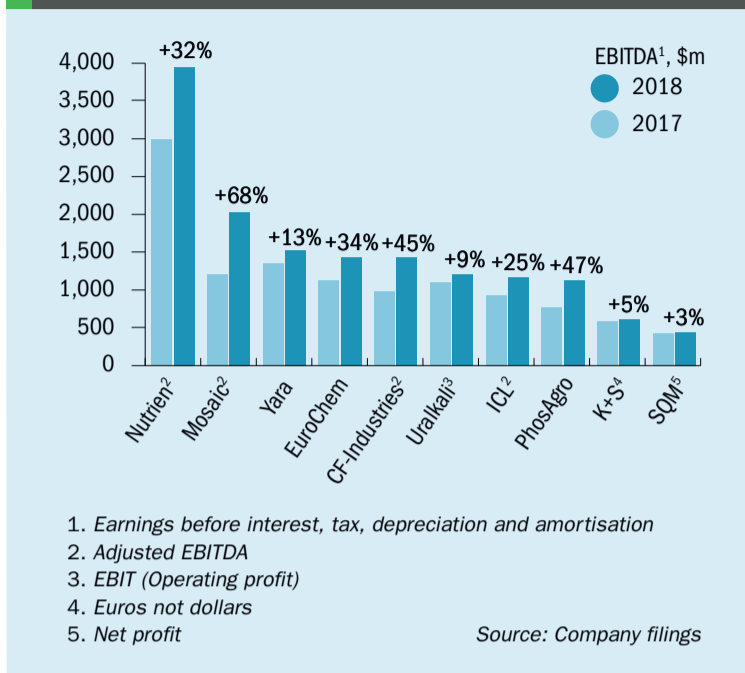
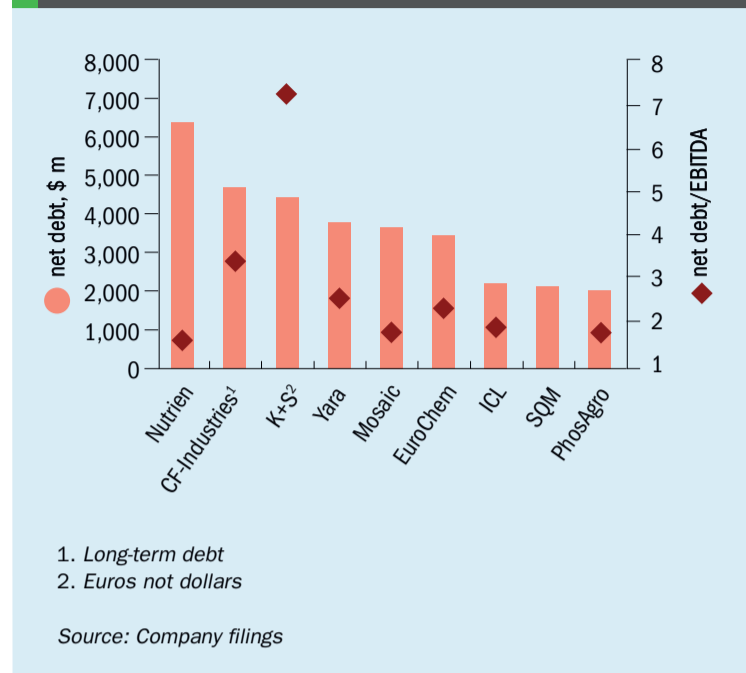


Fig. 4: Net debt of major fertilizer producers, end 2018



sales and achieved record retail earnings – despite some challenges in grower economics and weather conditions.

“Earnings from our potash and nitrogen business units rose significantly due to higher prices, increased volumes and lower costs. We received \$5.3 billion in net proceeds from the sale of equity investments. Our [fourth-quarter] results demonstrate the resilience in our earnings and cash flow, given this was one of the wettest fall seasons in the US in over 100 years.”

With a massive 22.6 million tonnes of potash production capacity, potash sales remain a core part of Nutrien’s business. Potash earnings (adjusted EBITDA) increased by a robust 48 percent in 2018 compared to the previous year. The year ended particularly strongly with fourth-quarter potash earnings up 59 percent year-on-year – boosted by higher selling prices, record sales volumes and lower cost of goods sold per tonne.

Nutrien’s nitrogen earnings (EBITDA) were similarly solid, up by 43 percent in 2018 compared to the previous year. Fourth-quarter earnings were again buoyant for nitrogen, being 63 percent higher than the same period in 2017, mainly due to higher prices across all products.

Nutrien’s full-year retail earnings (EBITDA), in contrast, improved by a modest five percent year-on-year. These were dented by a 11 percent downward hit in the fourth-quarter, compared to 2017, a consequence of the weather-affected fall application season in the US.

Enviably, Nutrien also benefited from massive divestment proceeds and a large increase in cash flow last year. Proceeds of the sale of SQM shares and other divestments totalled \$5.3 billion in 2018. Free cash flow also rose to \$2.0 billion for the year, a 53 percent increase on 2017.

Looking ahead, Magro said: “For 2019, we expect strong crop input demand in the first half of the year due to the limited application window in the fall of 2018, a recent improvement in crop prices and higher corn acres in the US. We expect crop nutrient fundamentals will remain strong in 2019, and we are well positioned to benefit as the world’s largest producer.”

Mosaic: earning rise by two-thirds

The Mosaic Company also prospered in 2018. Full-year revenues at the Florida-headquartered potash and phosphate producer rose 29 percent to \$9.6 billion (Figure 2).

2018 earnings (adjusted EBITDA) grew by an even more impressive 68 percent over 2017 to reach \$2.0 billion (Figure 3). Full-year operating earnings of \$928 million, up from \$466 million the year previously, were driven by higher margins across the business, and were also aided by higher sales volumes, both for potash and at the company’s Mosaic Fertilizantes business in Brazil.

2018 highlights at Mosaic included:

- Record potash and phosphates production and record sales of its *MicroEssentials* speciality phosphates product

- Receiving the final permit to mine the Ona phosphate reserves, extending the company’s phosphate mining in Florida for decades
- The commissioning of the first production hoist at the K3 mine as part of the expansion of the Esterhazy potash complex in Saskatchewan.

Fourth-quarter phosphates revenues of \$926 million were slightly down from the \$1.0 billion seen last year, with a phosphates sales volume decline of 25 percent partially offset by higher average selling prices. Lower sales volumes reflected both lower production volumes, due to Mosaic’s idling of its Plant City unit, and negative impacts of weather on the North America fall application season.

Phosphate gross margins for 2018’s last quarter improved to \$81/t, up from \$53/t the year before, primarily driven by higher selling prices and more premium product sales of *MicroEssentials*. Mosaic’s North American operations produced 2.1 million tonnes of finished phosphates in 2018’s fourth-quarter, compared to 2.3 million tonnes in 2017.

Mosaic’s potash revenues totalled \$592 million in the fourth quarter, up from \$496 million last year. The improvement was driven by higher average selling prices and higher sales volumes.

Potash gross margins improved to \$88/t, compared \$51/t in the fourth-quarter of 2017, thanks to higher selling prices in large part. Potash production for the fourth-quarter was 2.6 million tonnes, some 99 percent of operational capacity, up from 87 percent the year before.

“Mosaic delivered strong fourth quarter results to complete a year of significant accomplishments and operational excellence,” said Joc O’Rourke, Mosaic’s president and CEO. “We are capturing the full benefit of improved market conditions, and we expect our strong business and financial performance to continue in 2019.”

Looking ahead, O’Rourke said: “We are optimistic for 2019. Accelerated synergy capture in Brazil, the transformation of our phosphates business, the successful ramping up of our Esterhazy K3 mine and improved market conditions put Mosaic in position to create significant value – now and in the years ahead.”

CF Industries: operating exceptionally well

Illinois-headquartered nitrogen producer CF Industries was another of 2018’s strong performers. Full-year revenues rose seven percent to \$4.4 billion (Figure 2), while 2018 earnings (adjusted EBITDA) of \$1.4 billion were up 45 percent on 2017 (Figure 3).

The company reported net earnings of \$290 million, and also returned \$780 million to shareholders in 2018 – \$500 million in share repurchases supplemented by \$280 million in dividend payments.

The North American nitrogen producer – similar to its potash- and phosphate-producing counterparts – benefitted from higher average product prices in 2018. Its raw material costs were also lower.

“We delivered strong results in 2018, as higher global nitrogen prices and lower natural gas costs drove a 45 percent increase in adjusted EBITDA compared to 2017,” said Tony Will, CF’s president and CEO. “With strong nitrogen demand anticipated in North America during the first half of 2019, our in-region production and extensive transportation and distribution network position us well to build on our 2018 performance.

“Longer-term, our outlook remains positive: we are positioned at the low end of the global cost curve due to our access to low-cost North American natural gas, we continue to operate exceptionally well and we expect the global nitrogen supply and demand balance to continue to tighten.”

Yara: double-digit earnings growth

Norwegian-headquartered Yara International is the fertilizer sector’s second-largest listed company with a market

capitalisation of around \$11.3 billion (Figure 1). Indeed, Yara describes itself as the industry’s only truly global player, having production assets on six continents, operations in more than 60 countries, and making sales to about 160 nations. The company is a world-leading nitrates and NPK producer, with a growing phosphates portfolio.

While improving results did not match the upswing of some of its rivals, Yara still saw double-digit growth in both its revenues and earnings in 2018. Full-year revenues rose by 15 percent to \$13.5 billion (Figure 2), while 2018 earnings (EBITDA) grew to 1.5 billion, up 13 percent year-on-year (Figure 3).

Yara also increased its production, deliveries and margins in 2018. The margin improvements were mainly driven by higher urea production margins at Yara’s Belle Plaine plant in Canada and higher phosphate upgrading margins at the company’s NPK plants. Yara’s production of ammonia and finished fertilizers increased by 11 percent and eight percent, respectively, in 2018. Fertilizer deliveries of 28.5 million tonnes in 2018, up four percent on 2017, mainly reflected company acquisitions in India and Brazil.

Yara’s 2018 net income did, however, decline by more than two-thirds year-on-year to \$159 million. This reflected depreciation on new investments in production capacity, which generated only limited income in 2018, as well as a currency translation loss. Operating income for 2018 was also down 12 percent at \$402 million.

Svein Tore Holsether, Yara’s president and CEO, said: “After a period of growth and significant investments, our main focus is currently on optimal integration and operation of these new assets. Yara’s earnings must improve in order to generate satisfactory returns for its shareholders and achieving this is a top priority for us. We are also significantly reducing our capital expenditure, which peaked at \$2.2 billion in 2018, while committed investments for 2019 and 2020 are 1.3 and one billion US dollars, respectively.”

Yara highlighted the health of market conditions and demand for fertilizer and industrial nitrogen products in 2018. Although urea prices increased in 2018, they remain supply-driven, in Yara’s view, with capacity growth exceeding consumption trends. Yara remains relatively immune from the commodity urea market, however, as more than 60 percent of its

finished fertilizers are premium products such as nitrates and NPKs.

“We have seen increased gas prices in 2018, which mean higher costs for us,” commented Svein Tore Holsether. “At the same time, nitrogen prices have been at a relatively low level – although improving towards the end of the year. This has had a negative effect on revenues, but we have managed to compensate by increasing our sales of higher margin premium products.”

He added: “We ended 2018 with the best fourth-quarter earnings (excluding special items) in four years, with earnings per share up 22 percent year-on-year.”

K+S: earnings rise despite headwinds

Germany’s K+S Group is the world’s fifth largest potash producer with a market capitalisation of around €3.2 billion (Figure 1). The company’s full-year revenues increased by a respectable 11 percent year-on-year to €4.0 billion in 2018 (Figure 2), while earnings (EBITDA) grew by five percent to €606 million (Figure 3).

Earnings were negatively affected by production losses at the company’s Werra plant, a direct result of Germany’s prolonged heatwave and severe drought last year. “Despite this headwind, we still achieved an increase in our operating earnings,” commented Burkhard Lohr, the chairman of K+S. “I see many positive signals for 2019 and am optimistic as a result. Our earnings [EBITDA] should increase significantly compared with the previous year.”

Revenues and earnings at K+S were boosted by larger sales volumes in 2018 – particularly from the company’s new Bethune mine in Canada – and higher market prices for potassium and magnesium products. These two factors helped to counteract the €110 million in lost earnings from weather-related production standstills at the Werra plant.

In contrast, K+S Group’s Bethune potash plant – currently in the ramp-up phase – met its 2018 potassium chloride production target of 1.4 million tonnes. In an encouraging sign for future profitability, the new mine also began to generate positive earnings for K+S for the first time last year.

EuroChem: strong sales performance

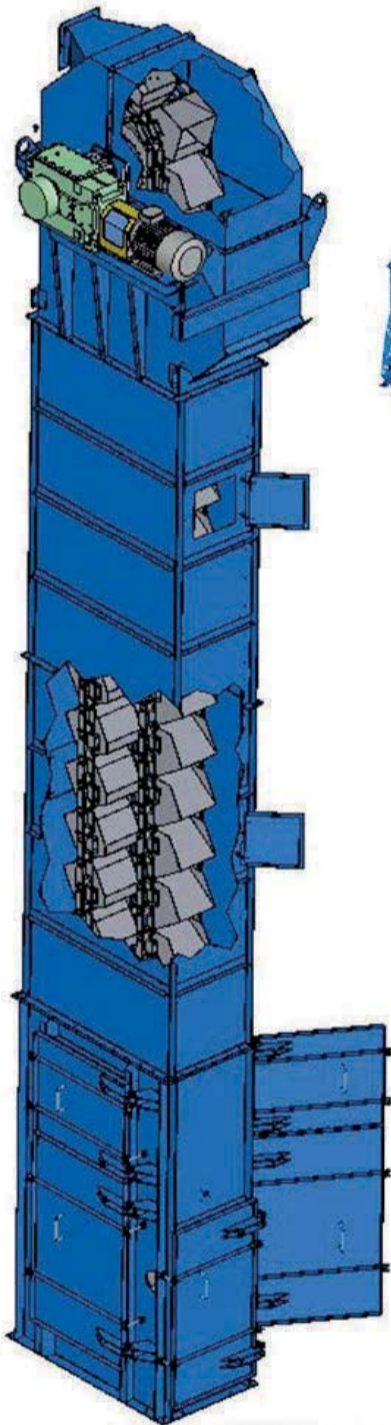
Stronger product pricing and an improvement in its sales mix in 2018 lifted Swiss-headquartered EuroChem Group’s full-year revenues to \$5.6 billion, a 15 percent rise



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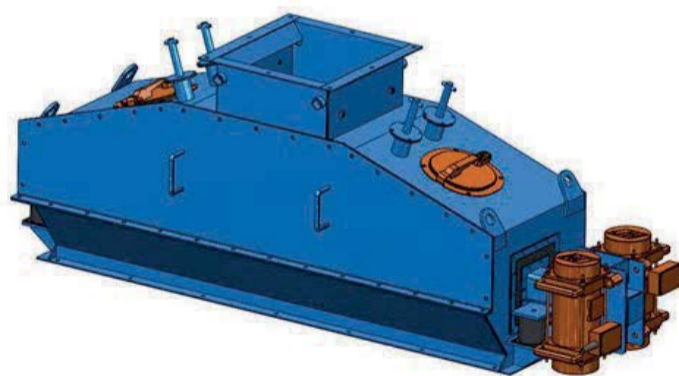
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PHOTO: PHOSAGRO

Machine handling of high-quality fertilizers by PhosAgro.

on the previous year (Figure 2). A strong fourth-quarter performance also helped to push up EuroChem's earnings (EBITDA) by 34 percent year-on-year to \$1.5 billion (Figure 3).

Earnings growth was partly driven by market price improvements for the Group's main fertilizer products. Changes to the rouble/dollar exchange rate – many of EuroChem's production assets are Russian-based – were another contributory factor due to their positive effect on EuroChem's rouble-denominated costs.

EuroChem's operating cash flow of \$982 million for 2018 was down by some \$67 million (six percent) on the previous year, principally due to a fourth-quarter decline. Higher net working capital and inventory investments also contributed to the fall.

"We have delivered a very strong sales performance, rounding off a terrific year," said Kuzma Marchuk, EuroChem's acting CEO. "This leaves us well-positioned to ramp up our new potash and ammonia projects – and we expect continued growth in 2019."

PhosAgro: an outstanding year

Russia's PhosAgro is one of the world's leading integrated phosphate fertilizer producers with a market capitalisation of around £3.8 billion. The company declared 2018 an "outstanding year" in terms of operational and financial performance.

The company's full-year revenues for 2018 grew by about 29 percent year-on-year to RUB 233.4 billion (\$3.5 billion,

Figure 2), while earnings (EBITDA) were up 47 percent for the year at RUB 74.9 billion (\$1.1 billion, Figure 3). The company's 2018 adjusted net income almost doubled RUB 41.7 billion (\$666 million).

Fourth-quarter revenue growth of 30 percent to RUB 59.4 billion (\$893 million) was mainly driven by the higher realised price in US dollars for phosphate and nitrogen products, combined with the effects of the rouble's depreciation against the dollar.

Summing up 2018, Andrey Guryev, PhosAgro's CEO, said: "The company increased production volumes last year, with the production of fertilizers and feed phosphates growing by more than seven percent year-on-year to nine million tonnes. We also produced a record 10 million tonnes of phosphate rock."

Buoyant market prices for finished phosphates such as diammonium phosphate (DAP) have also benefited producers, PhosAgro noted. 2018 DAP prices (f.o.b. Tampa) averaged \$419/t for the year, for example, having peaked at \$439/t in September, a rise of almost 40 percent on the start of 2017.

Guryev also highlighted the importance of the domestic market to the company: "PhosAgro retained its position as the leading supplier of all types of fertilizers to the rapidly-growing Russian market, where we sell more than to any other country. Combined with third-party products, we sold nearly three million tonnes of fertilizers in our priority market."

PhosAgro's operational performance has also benefitted from recent production

capacity investments and upgrades: "The modernisation of beneficiation plant #3 helped us achieve an unprecedented 92 percent phosphorous recovery rate from our apatite-nepheline ore, while the new ammonia plant enabled us to boost self-sufficiency in this crucial feedstock to 90 percent," commented Guryev. "As a result, we increased production of our fertilizers... by eight percent year-on-year to nine million tonnes [in 2018]."

ICL: strong finish to an extraordinary 2018

Israel's ICL Group is a leading specialty chemicals and fertilizer producer with a market capitalisation of around \$6.8 billion (Figure 1). The Group reported an annual rise in revenues of around nine percent to \$5.5 billion for 2018 (Figure 2), while full-year earnings (adjusted EBITDA) grew by 25 percent year-on-year to \$1.2 billion (Figure 3).

Adjusted operating income for 2018 increased by 42 percent to \$750 million (excluding divestments). This was supported by higher selling prices across all of ICL's businesses. Annual net income also more than tripled last year – relative to 2017 – while 2018 adjusted net income, increased by around 50 percent year-on-year (excluding divestments).

Strong fourth-quarter results "capped an extraordinary year for the company", commented Raviv Zoller, ICL Group's CEO.

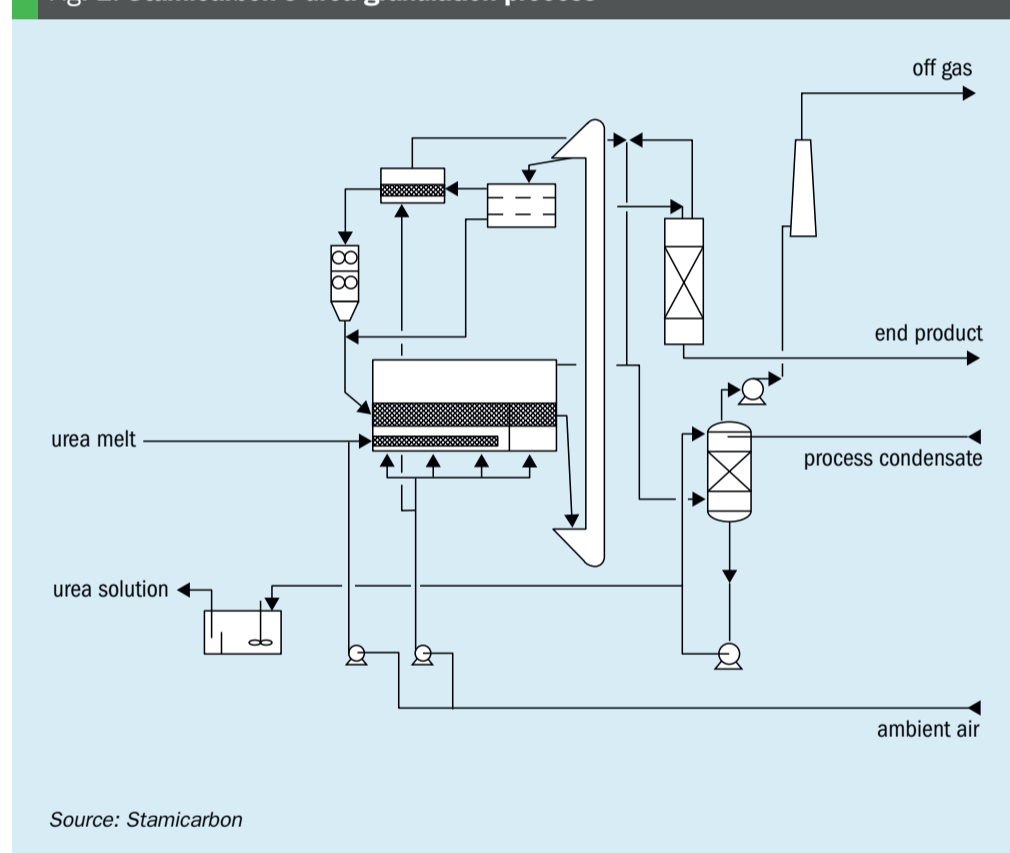
"Our industrial products division set an all-time record for annual profit this year, benefiting from record bromine prices and higher sales volumes of several products, while our Potash division achieved record production at our Dead Sea unit," said Zoller. "We significantly improved the performance of our potash operations in Spain and our YPH JV in China, both of which shifted to profitability, as we continued to focus on cost controls, prudent capital investments and environmental responsibility."

ICL's chairman, Johanan Locker, added, "2018 represented an important turning point for ICL. We started implementing our new strategy... while expanding our specialty businesses and promoting our Innovative Ag Solutions offerings. I am confident that ICL will continue to be a flagship of Israeli industry with a strong global footprint as one of the world's major fertilizers and specialty chemicals companies." ■

Stamicarbon's new UAS technology

Stamicarbon has developed a new granulation process for the production of urea ammonium sulphate (UAS). This is able to produce UAS granules containing up to 50 weight percent ammonium sulphate.

Fig. 1: Stamicarbon's urea granulation process



Soils need sulphur

Sulphur is recognised as the fourth major plant nutrient, after nitrogen, phosphorus and potassium. Yet large areas of agricultural land are no longer being replenished with sufficient sulphur. This is a direct result of flue gas desulphurisation, the use of cleaner fossil fuels, an increased reliance on chemical rather than organic fertilizers, and the shift to sulphur-free, higher-analysis phosphate fertilizers. At the same time, the removal of sulphur from soils – and consequently the demand for sulphur as

a crop nutrient – has actually increased because of more intensive cultivation and higher yielding crops. As a result, soil sulphur deficiency is becoming ever more widespread – with fertilizer producers and farmers becoming much more aware of the value and importance of sulphur as a major plant nutrient.

Ammonium sulphate

Sulphur can be applied to soils in two forms:

- Sulphate – this can be directly taken up by plants but can also be lost due to leaching

- Elemental sulphur – this is not lost to leaching but only becomes plant-available after microbial oxidation to sulphate.

Sulphate is generally a better alternative to elemental sulphur for prompt availability.

Ammonium sulphate – besides being a sulphur source – is also a reasonably efficient nitrogen fertilizer, although it does contain less than half the nitrogen content of urea. Ammonium sulphate currently accounts for about 50 percent of the total sulphur applied as fertilizer. Single superphosphate (SSP) is the next most important sulphur source. Other sulphur fertilizers, such as potassium sulphate (SOP), elemental sulphur and liquid thiosulphate products, have a much smaller market share at present.

UAS granulation process development

Stamicarbon, the innovation and license company of Maire Tecnimont Group, has prioritised the development of urea ammonium sulphate (UAS) as a sulphur source. Ammonium sulphate, in contrast to elemental sulphur, is a non-flammable, non-explosive substance, and is not susceptible to the build-up of static electricity. Plant operational factors, such as off-gas removal and the cleaning of off-gas ducting, also favour ammonium sulphate over elemental sulphur, in Stamicarbon's view.

The starting point for UAS process development was Stamicarbon's standard urea granulation process, featuring an extended granulator design and solid flow cooler (Figure 1).

To gain additional knowledge, a number of topics were researched and studied during the development of the new UAS

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granulation process. In particular, the following thermodynamic properties of the water-urea-ammonium sulphate system needed to be thoroughly scoped and examined:

- The solubility, crystallisation temperature and heat of crystallisation of UAS solutions and UAS suspensions over a range of different compositions
- The specific heats of UAS solutions, suspensions and solids.

More practically, the spraying characteristics of a UAS solution/suspension through Stamicarbon's patented nozzles and other factors also needed investigating, including:

- Handling of the off-gas (containing both urea and AS) from the granulator
- De-aeration of the UAS-melt prior to granulation
- Handling, storage and shipping conditions.

The extra knowledge and fresh insights gained led to the development of the new UAS process (Figure 2).

Main features

The main features of Stamicarbon's new UAS granulation process are:

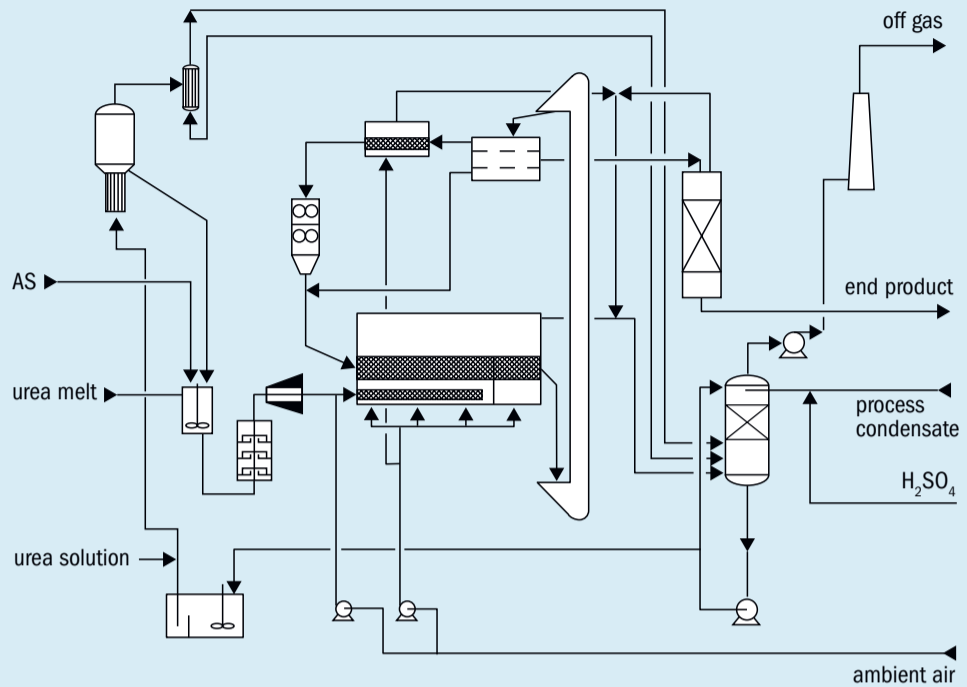
- The system is fed with urea melt, urea solution and solid ammonium sulphate
- The granulation process is suitable for production of UAS with ammonium sulphate contents ranging from zero up to 50 weight percent (wt-%)
- This allows standard urea granules to be produced as well as UAS
- The UAS granules have the same particle size (range) as standard urea granules.

UAS process differences

The main differences between the new UAS granulation process and Stamicarbon's standard urea granulation process are:

- Ammonium sulphate is dosed as a solid stream to the process
- Upstream of the granulator is a dispersal system in which urea melt and the solid ammonium sulphate are mixed and wet-milled to the desired particle size
- The ammonium sulphate dissolves completely in the urea at concentrations of up to 10 percent of total weight
- At higher ammonium sulphate concentrations, part of the ammonium sulphate remains undissolved and is fed to the granulator as a suspension in the UAS melt.

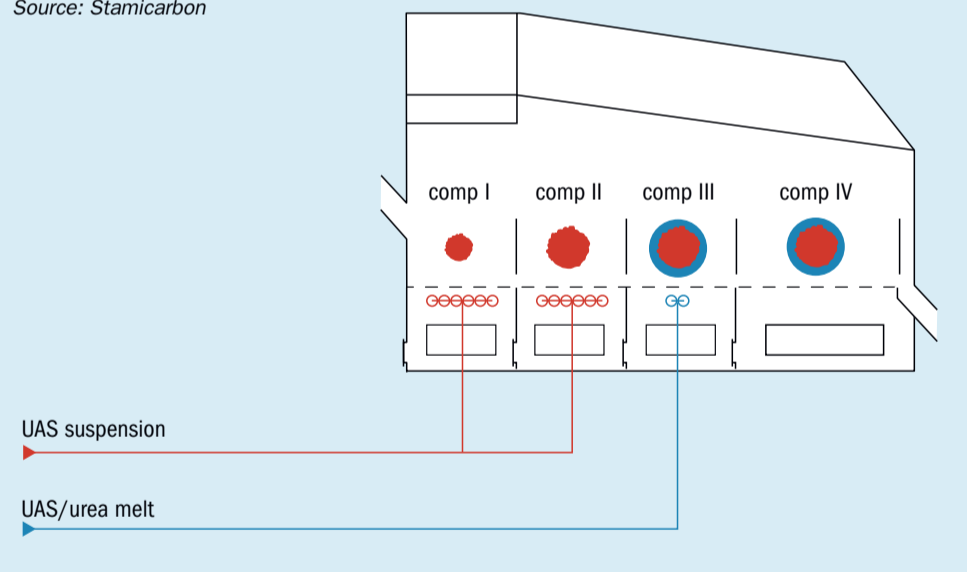
Fig. 2: Stamicarbon's UAS granulation process



Source: Stamicarbon

Fig. 3: Separate compartments for the UAS suspension and UAS/urea melt within the granulator

Source: Stamicarbon



For products where the desired ammonium sulphate concentration is above maximum solubility, the UAS suspension is fed to compartments I and II of the granulator (Figure 3). Granules produced from this UAS suspension have a rough surface. This could potentially increase dust formation due to attrition in downstream handling, and result in inferior flow properties. However, to correct the roughness, granules are given a smooth surface by feeding solid-free UAS melt to compartment III of the granulator.

Process description

UAS granulation requires a separate evaporation section to concentrate effluent from the scrubber. This is necessary because scrubber effluent cannot be recycled to the melt plant's urea evaporation section – as the presence of ammonium sulphate is a corrosion risk for synthesis equipment.

The ratio of ammonium sulphate to urea (AS:U) in the off-gas from the granulator will be equal to the ammonium sulphate to urea ratio in the UAS melt. This is true

as long as the concentration of ammonium sulphate in the UAS melt is kept below 10 weight percent, its maximum solubility.

However, when ammonium sulphate concentration in the UAS melt exceeds its maximum solubility – and is partly present as a suspension – then the AS:U ratio in the granulator off-gas will be significantly higher than the AS:U ratio in the granulator's UAS melt feed. This is because a proportion of the ammonium sulphate particles in the melt are incompletely wetted and become entrained with fluidization air to the scrubber. Consequently, the AS:U ratio in the scrubber's effluent will also be proportionately higher – because ammonium sulphate dissolve readily in wash water during the cleaning of granulator off-gas in the water-scrubber.

In the evaporation section, the UAS solution from the scrubber is concentrated in two stages to form a UAS melt. There is a risk that ammonium sulphate will partly crystallise and form deposits that foul the evaporation equipment. This could happen, as explained above, when the AS concentration in the evaporation section is above the maximum solubility of AS in the urea melt (10 wt%). To prevent this happening, the scrubber-effluent is mixed with fresh urea solution from the urea melt-plant. This mixing is regulated to ensure that the ammonium sulphate concentration in the outlet of the second evaporator is below its maximum solubility in urea melt (10 wt-%).

For standard urea granulation, bed temperature ranges from about 103 to 110°C. The UAS plant, in contrast, is designed to allow granulator bed temperature to be controlled in a range from about 95 to 110°C at full plant load. This is necessary because of the significantly lower crystallisation temperature of UAS melts, in comparison with a pure urea melt. (UAS melt containing 10 weight percent of dissolved ammonium sulphate, for example, has a crystallisation temperature of approximately 120°C, versus a temperature of 132°C for a urea melt.)

The ammonia washed from the off-gases generated by the granulator and granulate coolers is captured and converted to ammonium sulphate. This means ammonia is used efficiently in the UAS-process, being incorporated in the UAS end-product.

Ammonium sulphate is fed to the UAS process in solid form, preferably as a granular free-flowing product with a small

Table 1: Typical UAS end-product composition and properties: 31.5 weight percent ammonium sulphate content

Total nitrogen, wt-%	38.35
Total sulphur, wt-%	7.5
Biuret-increase, wt-%	0.1
Water, wt-%	0.25
Formaldehyde, wt-%	0.3
Free ammonia, ppm-wt	50
Temperature, °C	40
Crushing strength (granule of 3.15 mm), kgf	> 3.0
Fraction of product between 2 and 4 mm	≥ 0.9
Fraction of product < 1 mm	< 0.01
Average granule size, mm	3.0

Source: Stamicarbon

Table 2: Typical expected emission levels

	Standard technique	Best available technique
Urea dust	25 mg/Nm ³	< 5 mg/Nm ³
AS dust	25 mg/Nm ³	< 5 mg/Nm ³

Source: Stamicarbon

Stamicarbon has prioritised the development of urea ammonium sulphate (UAS) as a sulphur source.

particle size ($d_{50} = \sim 1$ mm). In theory, ammonium sulphate from any source can be used – including waste ammonium sulphate from caprolactam production or from coke ovens, for example.

Product properties

UAS granules are produced by fluid-bed granulation in a similar way to the standard urea granulation process – including screening, crushing of oversize granules and recycling of undersize and crushed oversize to the fluid-bed granulator. The average particle size and particle size distribution of the UAS granules are therefore similar to those of standard urea granules. The shape and surface of the UAS granules – after smoothing in the third compartment of the fluid-bed granulator – are also similar to those of stand-

ard urea granules. The composition and properties of a typical UAS end-product are shown in Table 1.

Emissions

Both urea and ammonium sulphate are easily and effectively removed from vented off-gases. This is because all the off-gases from granulation equipment are directed to the scrubber, and urea as well as ammonium sulphate are very soluble in water and UAS solutions. Depending on local regulatory requirements, a number of scrubbing technologies are available to reduce dust (urea and ammonium sulphate) emission levels to the 5-30 mg/Nm³ range (Table 2).

Status of first UAS project

Stamicarbon designed its first commercial UAS plant for EuroChem's Novomoskovk Azot site in Russia. This is Russia's first urea-UAS plant, with a capacity of 400 t/d for urea and 600 t/d for UAS. The plant was formally opened in December 2018 and the first UAS granules have been produced. ■



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Product substitution

POLY4's unique multi-nutrient content enables a wide range of options for substitution of existing fertilizer products containing one or more of the same nutrients: potassium, sulphur, magnesium and calcium.

Premium performance

An extensive global crop science programme evaluated crop responses to POLY4. Trials have demonstrated a high yield response to POLY4's macro and micro nutrients in a wide range of broad-acre and high-value crops. POLY4 improves crop quality and health while enhancing the strength and structure of soils. With increasing focus on nutrient use efficiency and improvement of arable soil quality, POLY4 will attract a premium.

Unmet market demand

POLY4 satisfies current unmet demand for low-chloride sources of potassium: 32% of total potassium consumption is used on chloride-sensitive crops while, due to cost and limited availability, only 9% of this demand is currently met. In addition to potassium, POLY4 offers low-chloride sulphur, magnesium and calcium.

Added value - NPK blending

As a multi-nutrient feedstock, POLY4 has the potential to reduce the number of fertilizer inputs, improve the nutrient content and reduce the blending cost of NPKs. POLY4 is ideal for NPK blending, where all the nutrients are utilised, and it can be used in a dry blend and complex NPK.

As it becomes one of the largest producers of multi-nutrient fertilizer, Sirius Minerals will target the adoption of the best agricultural practices across the world making a positive contribution to global food security.

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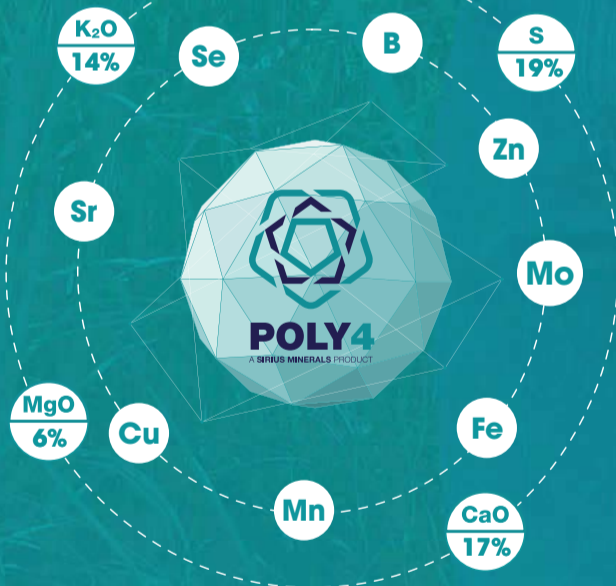


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POLY4 offers unique qualities:

Multi-nutrient profile



- Source of macro and micro nutrients
- Fully soluble
- Improved nutrient recovery
- Sustained nutrient delivery profile
- Improved fertilizer use efficiency

Sustainability

- Low chloride
- Suitable for organic farming
- pH neutral
- No requirement for chemical processing
- Low carbon footprint



Advanced heat recovery

The latest heat recovery systems from Outotec, Chemetics and Clark Solutions are driving energy efficiency, reliability and safety improvements at sulphuric acid plants.

Outotec's HEROS™ heat recovery system

Outotec recently introduced improvements to its safe and robust HEROS™ heat recovery system. The new concept – which is designed to enhance the acceptance and reliability of heat recovery systems in the sulphuric acid industry – has been successfully proven. An installation of the enhanced HEROS™ system at one particular metallurgical sulphuric acid plant has demonstrated its reliability over a number of years – and done so under a variety of different operating scenarios, such as gas flow and SO₂ fluctuations induced by the upstream smelter operation.

HEROS™ has two key elements: a venturi absorber combined with a dedicated acid circulation system (*Fertilizer International* 478, p30). These are installed at sulphuric acid plants upstream of the intermediate absorption tower (Figure 1). HEROS™ works by transforming heat generated within the system into low-pressure steam using a specially designed boiler.

HEROS™ heat recovery systems can be easily retrofitted at existing sulphuric acid plants. The systems are designed to be shutdown while the intermediate absorption tower remains in full operation. Advantageously, HEROS™ has ability to convert a large percentage of low-level heat into valuable steam, while at the same time dra-

stically reducing cooling water consumption. The system can produce up to 0.46 tonnes of additional low-pressure steam per tonne of sulphuric acid, depending on the plant configuration.

HEROS™ was first introduced in 1989. The system was always designed with high safety standards in mind and for ease of operation. The concept has been refined over the years, further increasing operational efficiency and safety. These system improvements culminated in recent HEROS™ installations at metallurgical plants in Turkey and Asia, as well as at sulphur-burning plants in Egypt.

Metallurgical acid plant reference case

Outotec recently shared the operational experiences gained from a pioneering retrofit project for an enhanced HEROS™ system (*Sulphur* 373, p46). This was integrated into an existing modern metallurgical sulphuric acid plant complex with only limited space for installation.

The installed HEROS™ system, which has been in continuous operation since early 2014, includes a venturi tower, fully clad with an acid-resistant brick lining, as well as different levels of process and automation control. The system captures most of the excess heat from the intermediate absorp-

tion stage, producing low-pressure steam to satisfy on-site industrial demands. The installation has successfully allowed the acid plant to operate continuously, a key requirement of the customer, without disturbing the metallurgical production process.

Chemetics Energy Solutions (CES)

Extracting more of the energy released during the production of sulphuric acid is increasingly important to create additional revenue for plant operators. Chemetics has developed a family of process add-on systems that recover additional energy without causing a reduction in plant availability. Marketed as Chemetics Energy Solutions (CES), they provide various process options, including add-ons for low-pressure steam production, hot water production, and the preheating of boiler feed water upstream of the deaerator.

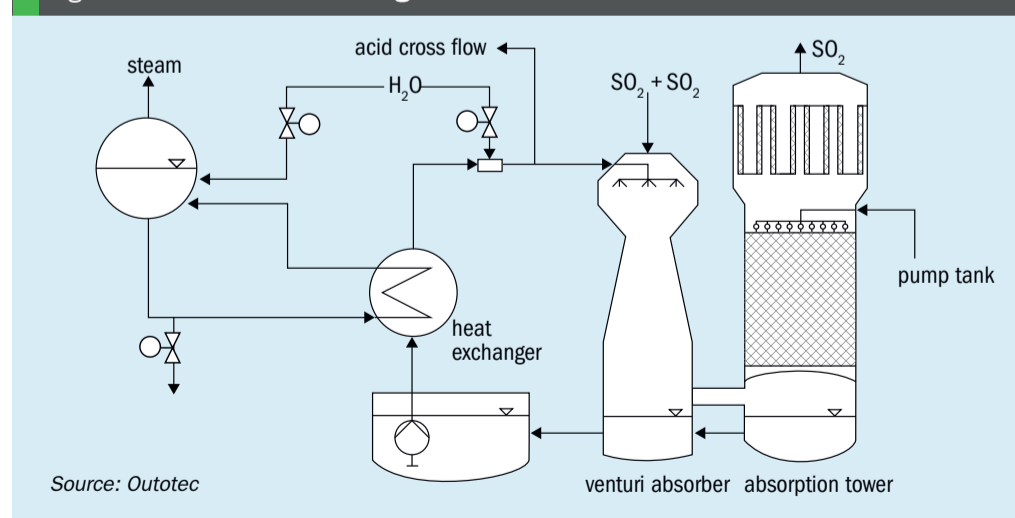
The benefits of producing low-pressure steam are relatively well known within the sulphuric acid industry. Less well known, however, is a new and interesting application that uses hot water in sea water desalination. This novel application is well-suited to locations where fresh water is not readily available (*Sulphur* 373, p50).

CES-HWS™

Chemetics offers a proprietary hot water system (CES-HWS™) as a process add-on for sulphuric acid plants. CES-HWS™ is used to produce hot water from the acid in absorber circuits. The process incorporates anodically protected acid coolers. These are specially designed to withstand high hot water temperatures.

Chemetics, as the inventor and the world's leading fabricator of anodically protected stainless steel acid coolers, is capable of designing coolers that can produce hot water at temperatures up to 95°C while still maintaining effective passivation of metallic surfaces. If required, even higher temperatures can be reached – up to approximately 105-110°C – by using SARA-MET® coolers instead.

Fig. 1: Outotec HEROS™ configuration



Source: Outotec

Fig. 2: Integration of a sulphuric acid plant with an MED unit

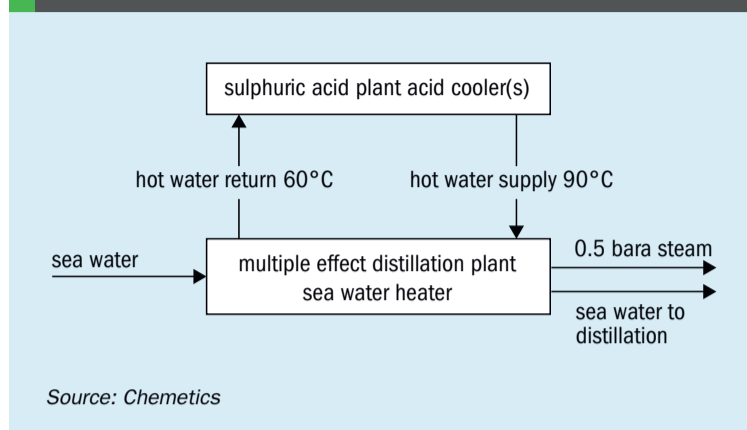
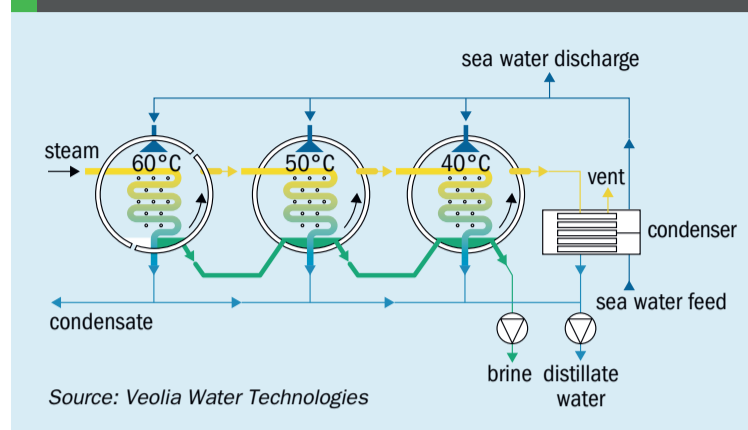


Fig. 3: Typical 3-stage MED system



The amount of energy that can be economically recovered by *CES-HWS*[™] depends on the plant configuration. All the absorption energy can be recovered if a single pump tank provides acid to all towers. If multiple pump tanks are used, then it is typically only justified economically to recover energy from the intermediate tower.

For *CES-HWS*[™] installations to be of benefit, it is also necessary to have a hot water use (e.g. for process heating) and a user located within a reasonable distance. Equally importantly, the user must be able to cool the water to approximately 60°C before returning it to the acid plant. This is because the temperature of the returned water needs to be low enough to cool the absorber acid to 75°C or less before it enters the acid towers. The installation of trim coolers can become necessary, in situations where the hot water user is not able to utilise all the energy, or if there are periods when the hot water user is not available. Trim coolers use cooling water, seawater or air to allow the acid plant to operate normally.

CES-DSW[™]

Chemetics also offers a desalinated sea water system (*CES-DSW*[™]) as another process add-on. This system – similar to the *CES-HWS*[™] – also generates hot water in the acid plant, although its configuration is different (Figure 2).

In *CES-DSW*[™], hot water is used in a closed loop to produce desalinated water from sea water or brackish water using multiple effect distillation (MED). Hot water generated at 90-95°C flows from the acid plant to the MED unit where it is used in the sea water heaters to create low-pressure (0.5 bara) flash steam (Figure 2). This flash steam, in turn, provides the energy source for the multiple effect distillation process. The use of a closed loop

ensures that the circulating hot water does not have a direct path to the desalinated water produced.

The MED unit, as the name implies, uses multiple evaporation stages. Sea water is evaporated in the first stage using the flash steam generated in the sea water heaters. The steam produced is then condensed to form desalinated water.

Vapour generated in the first stage goes on to be used in the next stage operating at slightly lower pressure (Figure 3). The entire system operates under vacuum. This helps eliminate the scaling and corrosion of surfaces in contact with sea water by keeping temperatures low.

The combination of a sulphuric acid plant together with a multiple desalination unit is a very economical way to produce desalinated water in areas where fresh water is not readily available. MED units can produce up to 10 kilos of desalinated water from each kilo of steam provided by the sea water heaters. Compared to sea water reverse osmosis (SWRO), multiple effect distillation provides better quality water (lower TDS), has fewer operational issues and lower production costs.

Operation of MED systems is very easy and requires minimal operator attention. Chemetics installed a *CES-DSW*[™] system in Australia in 2004. The performance of this system has exceeded expectations for more than a decade now, and continues to produce high-quality desalinated water.

Clark Solutions' SAFEHR[®] heat recovery technology

Clark Solutions offers *SAFEHR*[®] heat recovery technology as a new approach to sulphuric acid production. The technology is designed to make heat recovery safer and more efficient by addressing concerns about equipment corrosion and damage,

plant shutdowns and the risk of hydrogen explosions (*Sulphur* 373, p53).

Hydrogen generation is a particular issue of concern. Iron corrosion by sulphuric acid generates hydrogen, with the rate of formation increasing at higher acid operating temperatures. Hydrogen can damage equipment by several mechanisms – including solid solution hardening and hydrogen embrittlement and blistering. It can also accumulate at high points in the plant and ignite, causing explosions.

In normal operation, with corrosion within standard rates (<1 mil/year), the generation of hydrogen is minimal. But corrosiveness increases as strong acid is diluted, with hydrogen generation rising accordingly.

It is therefore important to avoid the formation of weak acid – to avoid hydrogen formation and its deleterious consequences – while not losing the benefits of heat recovery. With this concept in mind, Clark Solutions has developed and patented *SAFEHR*[®] heat recovery technology.

SAFEHR[®] technology uses CS fluids, a family of proprietary inert liquids. These function as intermediate media transferring heat between the hot acid and boiler feed water. *SAFEHR*[®] operates as a closed loop system in which hot acid is cooled by the CS fluid which, in turn, heats the boiler feed water (Figure 4).

The unique properties of CS fluids make them ideal as intermediate media in *SAFEHR*[®] systems:

- **Inert to acid and water:** the fluids are totally inert to both acid (in any concentrations) and water.
- **Non-corrosive:** they can be used with virtually any materials without any corrosion risk, being compatible with strong acids, water and organics fluids.
- **Non-toxic:** the fluids are FDA-approved and require no special handling and storage measures.

Fig. 4: **SAFEHR®** closed loop for high temperature conditions

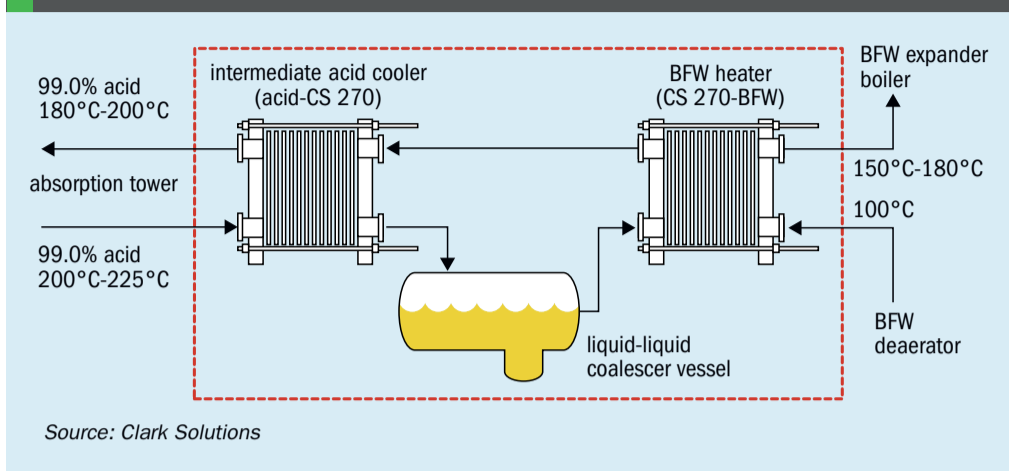


Fig. 5: **SAFEHR®** closed loop for conventional operating conditions

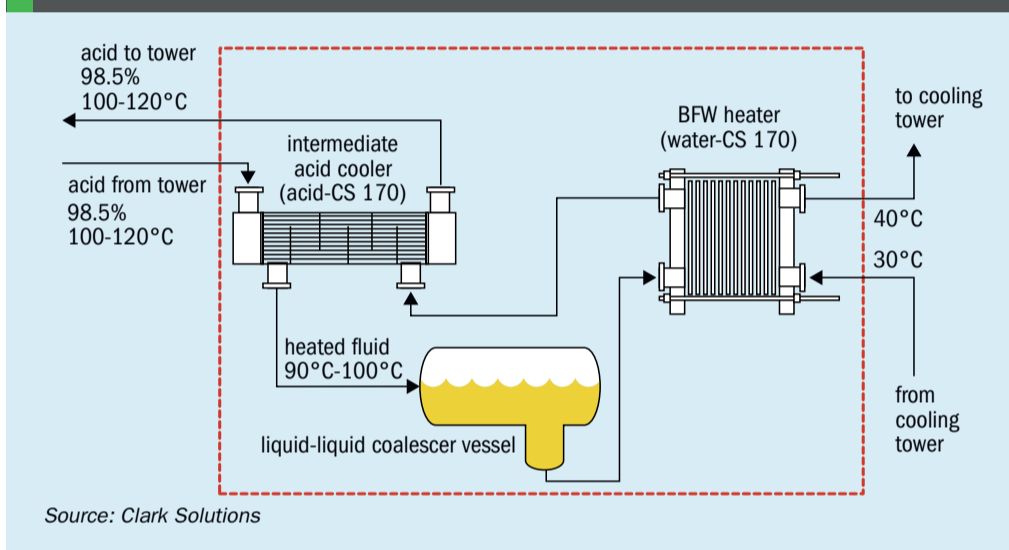
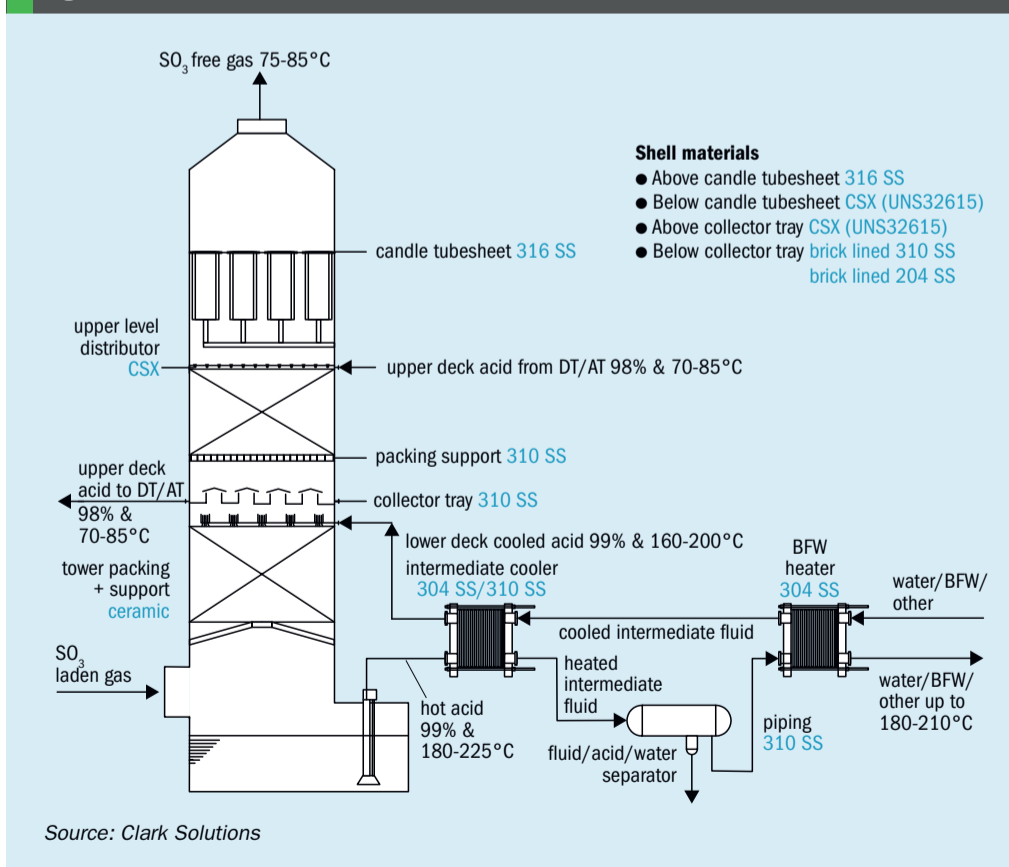


Fig. 6: **SAFEHR®** schematic



- **Non-flammable:** they will not catch fire, even when an ignition source is put in contact with hot fluid.
- **Non-oxidant:** the fluids will not oxidise in the presence of oxygen or atmospheric air, so they can be used and stored in non-blanketed environments.
- **High boiling points:** boiling points vary between 200-300°C, depending on the fluid and the application selected.
- **Density mid-way between water and acid:** fluid densities (1.3-1.5 g/cm³) at operating temperatures are between that of water (880-980 g/cm³) and strong acid (1.6-1.8 g/cm³), keeping the phases separated even in leakage situations.
- **Low vapour pressures:** fluids have minimal evaporation losses, usually less than 20 mm w.c.
- **Odour:** fluids are odourless and require no mask or other respiratory devices while being handled.

SAFEHR® heat recovery technology can be applied at sulphuric acid plants in a number of ways. The concept can be used in existing plants as an intermediate cycle in the acid cooling circuit (Figure 5). Existing heat recovery systems can also benefit from a skid mounted **SAFEHR®** system as a replacement to the strong acid to boiler feed water exchanger.

SAFEHR® can also be implemented as a complete system. This configures a two-stage absorbing tower and integrated pump booth with an acid pump and the **SAFEHR®** system. (Figure 6). Such systems are generally designed to use 99.0-99.5 percent sulphuric acid as an absorbing media, as this allows the use of less expensive 310S stainless steel materials. However, nothing prevents the system from being built for 98.0-98.5 percent acid using Alloy 33 or CSX stainless steel (UNS32615) instead.

In conclusion, **SAFEHR®** is an innovative new approach to acid production. It functions without any substantial energy losses, while adding a great deal of safety to the process and reducing corrosion risks. Indeed, **SAFEHR®** systems can actually improve steam quality, depending on the configuration, a particular advantage for those plants generating electricity.

Author's note

The innovative **MAX3™** sulphuric acid plant technology offered by MECS was covered in-depth by *Fertilizer International* in our 2018 May/June issue (*Fertilizer International* 484, p48). This holistic solution to plant design incorporates MECS proprietary heat recovery system (**HRS™**) and its **SolvR®** regenerative SO₂ scrubbing technology.

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phosphates & potash

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Our ideas make profitable plants



World class phosphoric acid technology

We offer advanced solutions for:

- phosphoric acid production
- phosphoric acid concentration
- fluorine recovery
- gas scrubbing
- phosphoric acid purification
- gypsum purification
- uranium recovery

Our services include:

- process design
- plant surveys and revamping
- effluent surveys
- process training
- phosphate rock tests

With more than

50 years' experience, Prayon Technologies has developed a unique expertise in designing phosphoric acid plants. Our mission is to optimise your plant performance and increase its profitability.



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Standing more than 380 feet above the prairie landscape, the K3 headframe is currently the largest structure in Saskatchewan.

PHOTO: MOSAIC/HUZAR VISUALS



The world's largest potash mine

Mosaic is making a strategic investment in a long-term project to transform its Esterhazy production site into the largest and most competitive potash mine in the world. We profile Mosaic's \$2 billion plus K3 expansion project as it seeks to increase Esterhazy's production capacity from 5.3 million to greater than 7.0 million tonnes by 2024.

In 2007, the Mosaic Company embarked on an ambitious multi-billion-dollar expansion programme. The prime focus was its four mines in Saskatchewan, Canada – Belle Plaine, Colon-say, and Esterhazy K1 & K2. The overall aim was to increase production by adding about three million tonnes of finished product to the company's total annual nameplate potash capacity. Esterhazy is the largest of Mosaic's three Saskatchewan mine sites, with a combined potash production capacity of approximately 5.3 million tonnes per annum (t/a), with Mosaic planning to increase the plant's combined mill capacity to 7.0 million t/a.

Largest global potash mining complex

Esterhazy is the world's largest potash mining complex. It is located near Esterhazy, Saskatchewan, a prosperous industrial and agricultural community just west of the Saskatchewan-Manitoba border. The site, which has been in operation since

1961, consists of the K1 and K2 potash mines together with the respective K1 and K2 mills which they supply. The Esterhazy complex produces a range of muriate of potash (MOP) products, including crystal, ag white, granular, and standard. The end-users for these products are primarily agricultural, supplemented by some industrial customers.

"Our Esterhazy operations will transform into the largest and one of the most competitive underground potash mines in the world – capable of moving 21 million short tons of potash ore per year, which is transformed into approximately seven million tons of product, from one of the best ore deposits," comments Gerry Couture, Mosaic's senior advisor, strategic capital.

Mosaic selected Hatch early on as their engineering partner for the Esterhazy expansion projects. The large-scale expansion plans for Esterhazy involve increasing plant capacity at the K1 and K2 sites and building a new underground mine at K3. Upon completion, the ambitious K3

development will create one of the largest underground potash mines in the world. The objective is to install a massive 21 million t/a of hoisting capacity at Esterhazy's operations – which in turn will enable production of finished potash products on a much greater scale. The underground mine at K3, once at full capacity (scheduled for 2024), will eventually replace the older K1 and K2 mines.

"Hatch is proud to be part of this world-class project that will enable Mosaic to continue to provide fertilizer to grow food more effectively for many more decades to come," comments Mike Fedoroff, Hatch's global director, potash.

Embarking on a ten-year journey

The journey to establish the largest potash complex in the world began with the expansion of the K1 and K2 mills, and the original project goal of increasing their capacity to 7.0 million t/a. Mosaic engaged Hatch as their full engineering, procurement, and construction management (EPCM) services partner, following Hatch's successful completion of the scoping, prefeasibility, and feasibility studies.

Hatch, working in close partnership with the Mosaic team, was responsible for ensuring that the expansion projects were executed with minimal or no negative impacts on existing operations. As Randy McMeekin, Global Director of Engineering, explains, "In a brownfield project such

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as this, careful design, planning, and an engaged team with extensive experience working in an operating facility are critical to success.”

The K1 expansion project increased the capacity of the existing crushing and screening area of the plant. Hatch’s scope of work included:

- The addition of a new primary screen
- The upgrade of the run-of-mine conveyor
- Adding one more bay to the buildings in the area
- The addition of conveyors and dust collection capacity, bin modifications, and other supporting services.

For the expansion at K2, the scope of work included:

- The addition of a third independent circuit to the mill wet side
- Corresponding additions and upgrades to the mill dry side equipment, including the addition of a fourth compaction circuit
- A circuit containing multiple compactors, a building to house it, and interconnections to the current mill.

The building design also needed to incorporate allowances for existing equipment and the equipment space to support future expansion.

By 2013, the K1 and K2 expansion projects had been completed below budget, with minimal negative impact to operations and an excellent safety record. At K1, production capacity increased from 2.5 million t/a to 2.7 million t/a. While the K2 expansion increased capacity from 2.6 million t/a to 3.3 million t/a, with plans for an additional increase to 4.4 million t/a by 2020. Successful advances were also made in process automation and new production controls. Impressively, on completion, the K1 and K2 projects ramped-up rapidly and quickly exceeded design capacities during their proving runs.

Digging deep and towering above

The next phase of the Esterhazy expansion is the construction of K3, a massive, new state-of-the-art mine. This highly ambitious engineering project involved sinking twin shafts to a depth of just over 3,280 feet, and slip-forming a headframe with a design height of over 380 feet. Hatch has participated in the K3 mine project from its initiation in 2008, starting with scoping-level studies all the way through to project development. Indeed, Hatch will continue to partner with Mosaic until the



Galloway and potash layer at Esterhazy.

PHOTO: HATCH/MOSAIC

“Managing a project of this complexity and magnitude is no easy task. There is no doubt that the best people in the industry are leading this project.”

Joc O’Rourke,
President and CEO, Mosaic

K3 mine is fully commissioned and operational, expected in 2024.

Hatch’s Mike Fedoroff comments, “Supporting Mosaic on K3 presented a unique and rewarding opportunity. It has allowed us to work closely and in an integrated way with our long-term client and harness our global expertise to tackle tough challenges with innovative solutions.”

The Mosaic Company approved the first stage of the new underground mine development at K3 in 2009. This gave the go-ahead for the detailed design and construction management of two production shafts, headframes, and hoisting systems.

The North K3 headframe, the tallest structure in the province, houses and operates the massive hoists and skips that will transport potash to the surface from more than half a mile underground – by no means a simple feat.

For years, Mosaic has used state-of-the-art technology, such as 3D seismic and exploration drilling, to study the geology of the proposed mine. The region is notable for its geological complexity and high water pressures present at depth. These geological conditions make shaft construction challenging, as does the potential effects on both workers and equipment of the highly concentrated brine that is ever-present underground.

Hatch and Mosaic addressed these challenges by using unique shaft-linings techniques for the two 20-foot diameter shafts during their sinking through water-bearing formations. To accomplish this, both shafts were frozen to hold back the water while the permanent liner was installed. “To control water inflow from the Blairmore formation, we used unique technology to freeze the ground surrounding the shafts to a depth of 1,600 feet,” explains Scott Williamson, Hatch’s shaft manager. “The shaft is lined with concrete and steel in various configurations based on the geology encountered.” The permanent shaft liner construction consisted of support concrete, as well as a composite steel liner to prevent water ingress, where required.

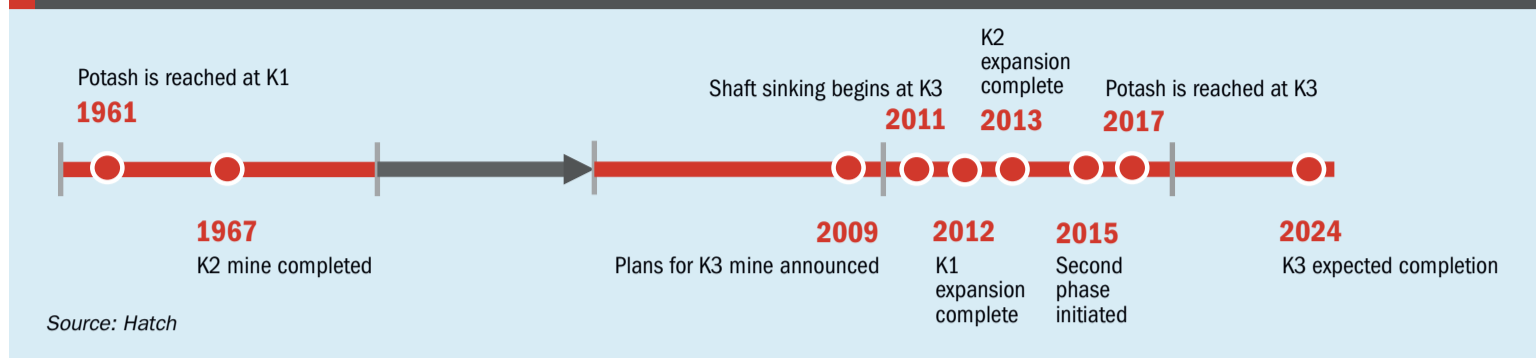
K3 has two shafts – a production and a service shaft. The production shaft has two skips with a 60-ton payload and an auxiliary cage. Whereas the service shaft has two production skips with a 50-ton payload and a service cage.

Following shaft sinking, the next hurdle was the slip-forming and mechanical fit-out of the North headframe. This structure towers more than 380 feet above the prairies and houses two massive hoists – the Koepe and Blair. The Koepe hoist will move potash to the surface from underground, while the Blair hoist will carry a cage for people and equipment. Hatch’s globally-responsive team of experts from Canada, Australia, and South Africa – working closely with Mosaic – designed the overall hoisting systems. These use leading-edge technology, state-of-the-art automation, and unique hoists.

Construction at K3 – comprising foundations, an electrical substation, ground freezing, shaft sinking and hoists – was completed in two stages. The first construction stage included:

- Site preparations
- Sinking and lining of the two shafts
- Hoist equipment and systems in the North shaft
- Egress hoist and headframe, bottom steel, surface facilities
- Preliminary mine development.

Fig. 1: Esterhazy expansion project: key milestones



The second construction stage involved:

- Replacing the temporary sinking headframe in the South with a production headframe and hoisting system
- Completing the underground development
- Debottlenecking the K2 mill to achieve the final desired capacity of the Esterhazy complex.

Shaft construction was performed using an unusual working platform – a five-level, shaft-sinking Galloway. An excavator suspended from the Galloway removes blasted muck to large buckets, which are then hoisted to the surface. Also, to reduce underground construction time, the steelwork of the shaft load-in-station was modularised. To reduce shaft hoisting times and assembly times underground, innovative work practices were also used to lower the large quantity of heavy mobile equipment and bulk material handling systems.

“The team applied innovative thinking and smart design concepts, particularly for the steel modularisation work,” says Hatch’s Scott Williamson. “By adapting the design to allow modularisation to be fully utilised, the team created a shorter construction schedule, provided for safer construction, and lowered the overall cost.”

Major milestones achieved

Years of careful planning were finally realised in February 2017. This was the date when the team celebrated a crucial K3 project milestone – reaching potash at a depth of 3,350 feet (Figure 1). At the later official celebration, held in May 2017, Joc O’Rourke, Mosaic’s president and CEO said, “K3 is the foundation of Mosaic’s future for potash production in Saskatchewan. We have a long and proud legacy here. For more than fifty years, we’ve managed to overcome great chal-

lenges and find success underground in Esterhazy. We’re ready for the next fifty and beyond.”

John Bianchini, CEO of Hatch, added, “We are incredibly proud to be part of Mosaic’s expansion to the K3 mine. A project of this size, scale, and complexity requires exceptional planning, strong teamwork, and above all, a deep and personal commitment to building a better world through positive change. Delivering this milestone is something we can all be proud of and I commend our integrated team for delivering it.”

The remainder of 2017 saw the realisation of several other significant K3 project objectives. In May, the team broke through the connection drift between the North and South shafts, located some 450 feet apart. The resulting flow-through ventilation was important as it allowed the operation of the diesel-run equipment required for underground development. This achievement was followed shortly after by the completion of the North shaft potash-level station. The completion of the South shaft potash station, including the equipment assembly bay and electrical substation excavation, was subsequently completed in July. And, in October, another significant milestone was reached – the lights were turned on underground and a new, fully-assembled drum miner chassis, weighing 60 tons, was lowered into the mine.

Hatch and Mosaic have also achieved significant commissioning and operational milestones for K3 over the last 12 months. Commissioning of the hoisting systems began in May 2018, and the system became operational later that year. The massive K3 mine is now active with production being ramped up. Looking ahead, the South headframe and equipment are at the design stage currently and their construction will start later this year to replace the temporary headframe. ■

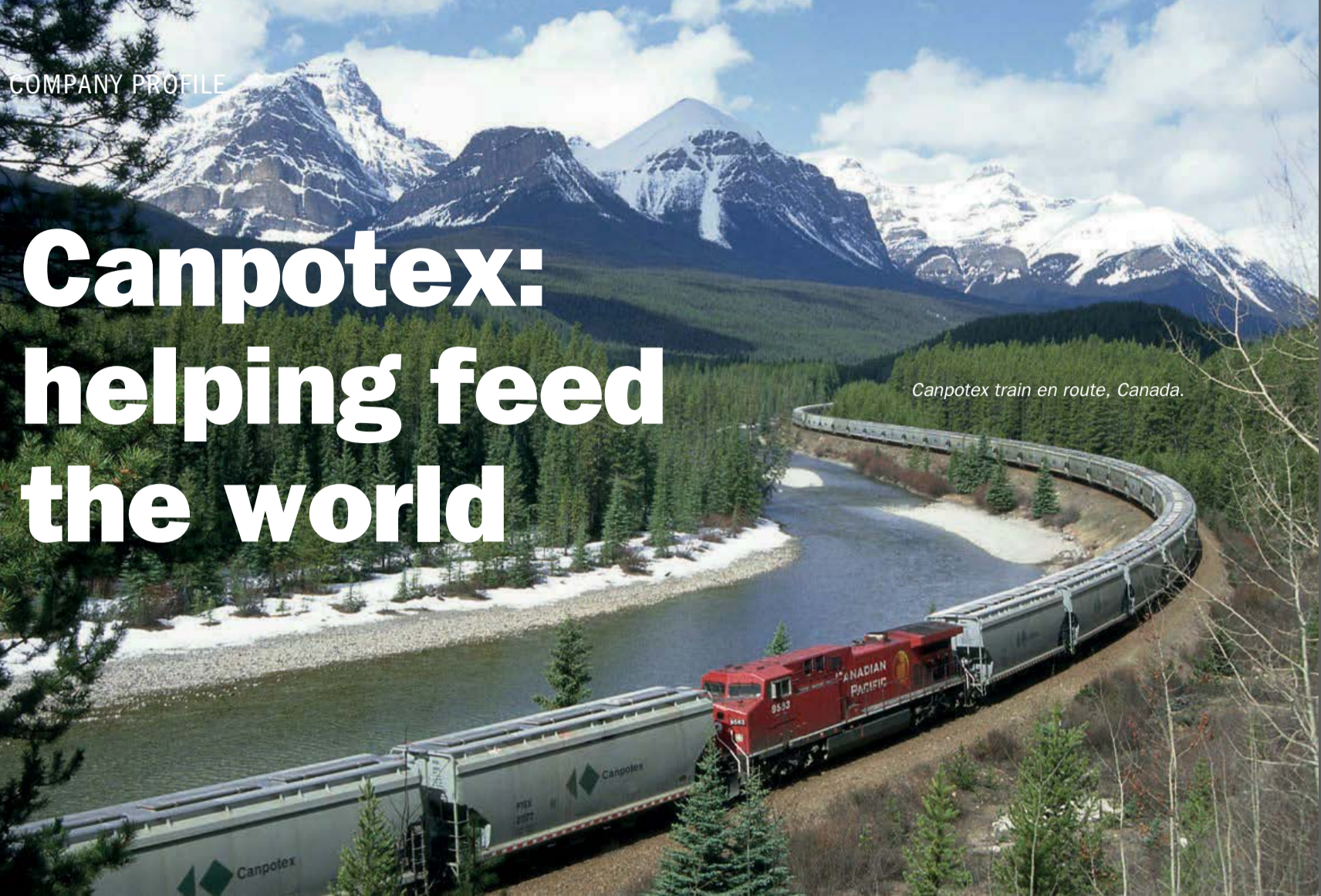
The Esterhazy expansion in numbers*

Depth of shaft	3,350 feet
Height of headframe	374 feet
North headframe and shaft	3,944 feet
Distance between shafts	450 feet
Investment	\$2 billion approximately
Target mine production	21 million t/a
Increased hoisting capacity	2.1 million t/a
Increased plant capacity	5.3 to 7.1 million t/a
Increased capacity at K1	2.5 to 2.7 million t/a
Increased capacity at K2	2.6 to 3.3 million t/a
Total length of surface conveyors	22 kilometres
Amount of steel	4,181 tonnes approximately
On-site construction contractors	300 per year Up to 600 at peak construction
People hours	5.2 million
Man-years worked since 2009	6,001

*2017 figures

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Canpotex: helping feed the world



Canpotex train en route, Canada.

PHOTO: CANPOTEX

Taking millions of tonnes of potash from the middle of a landlocked Canadian province, moving it 6,000 kilometres across prairies and through mountains to both the Atlantic and Pacific coasts, and finally shipping it to customers all around the world by ocean is a Herculean task – and a tremendous feat of skill and effort. Yet this is exactly what Canpotex has been doing, year in, year out, for decades.

Canpotex is one of the world’s largest potash exporters. Based in Saskatoon, Saskatchewan, the Canadian export company is responsible for marketing and delivering potash overseas on behalf of its two shareholders – Mosaic and Nutrien – who mine this Saskatchewan product.

Sophisticated supply

Each year, approximately 13 million tonnes of Canadian potash is destined for approximately 120 customers in 40 overseas markets around the world. To accomplish this, Canpotex has developed a sophisticated and highly-efficient supply chain, comprising of:

- Two major port terminals on the west coast of North America: Neptune Bulk Terminals in Vancouver, British Columbia, and Portland Bulk Terminals in Portland, Oregon;

- An east coast port terminal in Saint John, New Brunswick;
- Use of a Great Lakes access point in Thunder Bay, Ontario, providing access to the St. Lawrence Seaway;
- Potash storage capacity of over 650,000 tonnes to maximise delivery efficiency;
- A fleet of over 5,000 specialised and purpose-built rail cars that reduce rail congestion by transporting greater quantities of potash than traditional rail cars;
- A state-of-the-art rail car maintenance facility in Saskatchewan to ensure railcars meet high quality, safety and efficiency standards;
- Managing approximately 270 ocean vessel voyages each year, making over 700 port calls annually;
- On any given day, Canpotex is managing 50 or more vessels carrying Canadian potash to its overseas customers.

This sophisticated supply chain is matched by an equally sophisticated logistics operation controlled from Canpotex’s head office in Saskatoon.

Knowing the market

Canpotex not only moves potash, it also sells it. As well as running a marketing team at its Saskatoon head office, the company also serves its diverse and widespread customer base through an established network of international marketing offices. These are located in Singapore, Tokyo, Shanghai and Sao Paulo, its newest office which opened in 2018. Canpotex’s expert marketing team is highly-knowledgeable, with decades of industry and direct customer sales experience.

Canpotex works closely with farmers, getting to know its markets from the ground up – spending time with farmers in their fields to better understand the type

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and amount of potash that is best suited to their crops. As each customer and each crop is unique, Canpotex's dedicated marketing team will discuss the importance of balanced fertilization with farmers.

Feeding the world

These efforts reflect the importance Canpotex places on contributing to global food security.

Saskatchewan is home to the world's richest potash deposits, and the amount of potash farmers use is directly related to the amount of food that the world consumes. Put simply, Saskatchewan potash plays an important role in helping to improve crop yields and feeding the world.

The world needs to grow 70 percent more food by 2050, according to the Food and Agriculture Organization of the United Nations. With the world's population at over seven billion currently and rising, and a growing middle class in China and India, the potash shipped

by Canpotex has become a vital contributor to global food supply and security.

Put simply,

Saskatchewan potash plays an important role in helping to improve crop yields and feeding the world.

Potash, for example, is a key fertilizer that has helped to improve the nutrient status of Brazil's potassium-deficient soils. In Brazil, Canadian potash has played a critical role in improving the yields of major crops such as soybean, sugarcane, corn and coffee.

Promoting balanced fertilization

Canpotex, as a responsible company, has for many years supported education programs as part of its services to customers. The company works alongside farmers, teaching them about balanced fertilizer application, best practices, and how to maximise the farming benefits that potash offers.

Since 1983, Canpotex has invested upwards of \$50 million on education programs in more than 25 countries. Canpotex has focused these programs in regions where balanced fertilization is relatively low. Programs run over the past four decades have included region-specific training sessions, demonstration plots, field days, and farmer days. These have all helped demonstrate the benefits of balanced fertilization.

Helping child hunger at home

Canpotex's commitment to food security is also evident in its hometown of Saskatoon. Canpotex has concentrated on improving food access of the most vulnerable people, children, by supporting several local programs working to alleviate child hunger. Programs sponsored by the company range from providing milk to children whose families rely on food banks, to weekend food packages for school children who may otherwise go hungry. Canpotex employees at all levels of the organisation also actively volunteer in their local community.

Canpotex is a highly committed contributor to global food security, whether shipping potash around the globe, or working to address child hunger at a local level. ■





Dry granulation of fertilizers

Our technology has been recognized around the world for dry granulation of MOP/SOP and NPKs. Our services cover pilot plant tests, basic engineering, equipment supply, start-up supervision, and commissioning. Typical flake capacities are in the range of 10–130 t/h or more.

We have received orders for more than 90 fertilizer compactors of latest Köppern technology since the year 2000. The total installed flake capacity of these plants is exceeding 77,000,000 tpa.

[Köppern – Quality made in Germany.](http://www.koepfern.de)

- State of the art technology
- Process technology know-how
- High plant availability
- Quick roller replacement

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K plus specialities

With a potash market share of about nine percent, K+S is the world's fifth-largest producer of potash products. The company's speciality fertilizer portfolio offers a wide spectrum of plant nutrient formulations. These chloride-free and water-soluble products provide yield-enhancing magnesium, sulphur, sodium and micronutrients – alongside or without potassium.

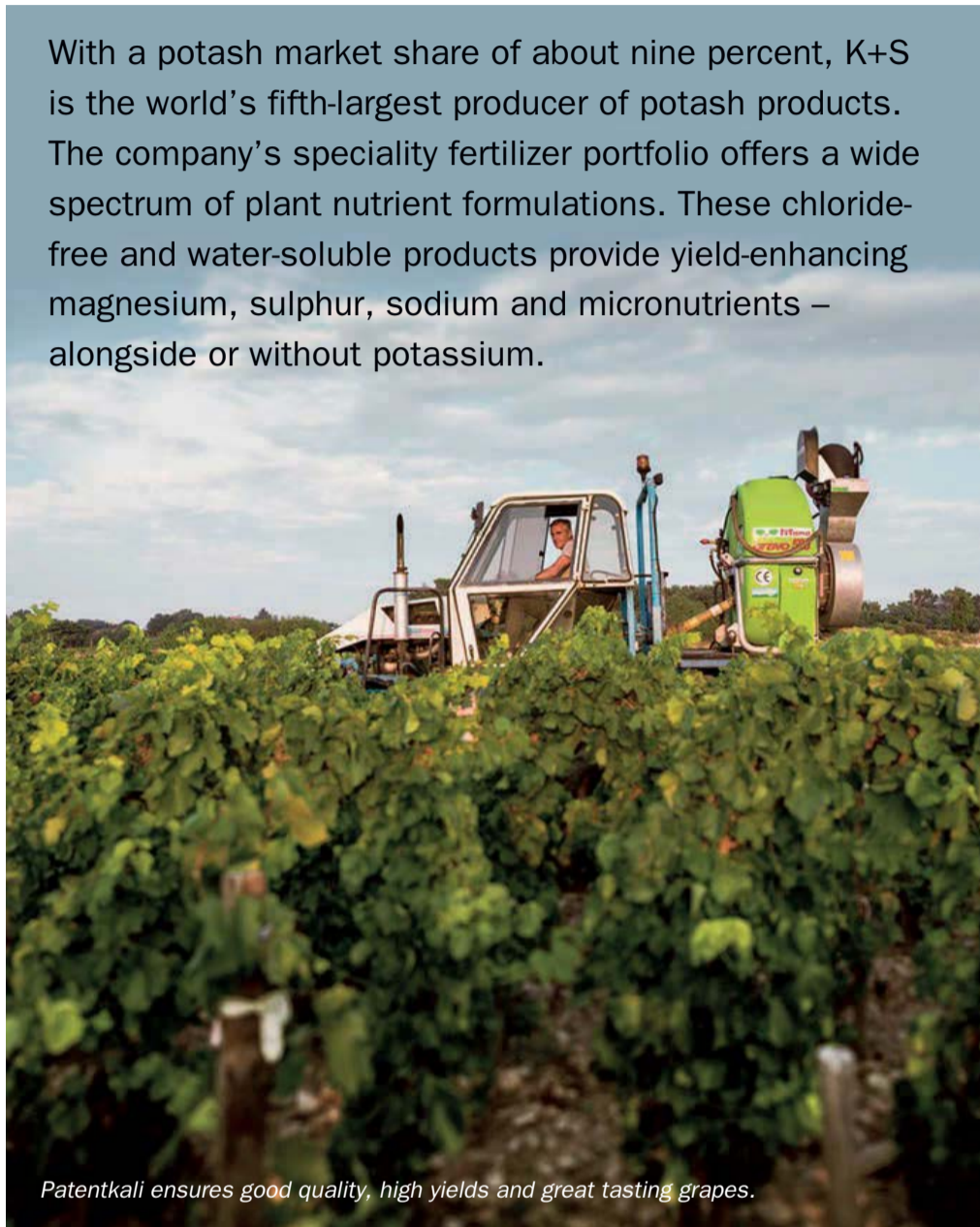


PHOTO: K+S

Patentkali ensures good quality, high yields and great tasting grapes.

Not just potassium chloride

Germany's K+S is the world's fifth-largest and Western Europe's largest producer of potash products. Uniquely, the company mines potash on two continents, having access to 1.1 billion tonnes of potash ore reserves in Germany supplemented by ore reserves totalling 0.2 billion tonnes in Canada.

K+S has increased its share of the world potash market to about nine percent, following the opening of the company's new Bethune solution mine in Saskatchewan, Canada. In 2018, the company mined 34.7 million tonnes of crude potash ore in Germany supplemented by more than 1.4

million tonnes of marketable potash end-product from its Canadian mine.

K+S currently has the capacity to produce up to nine million tonnes of potash and magnesium products each year. In several deposits in Germany, crude salt is mined underground by conventional drilling and blasting. Large shovel loaders convey the ore to crushing plants. From there, the crushed ore is transported onwards by conveyor to the extraction shaft. Once brought to the surface, the ore is processed to obtain potassium chloride (KCl), magnesium sulphate ($MgSO_4$), kieserite ($MgSO_4 \cdot H_2O$), epsom salt ($MgSO_4 \cdot 7 H_2O$), potassium sulphate (K_2SO_4) and rock salt (NaCl).

The deposits in Germany contain varying amounts of magnesium and sulphur (9-24% $MgSO_4$ equivalent) and potash (11-25% KCl). Depending on its quality, K+S partly treats crushed ore using electrostatic separation (the *ESTA* process) in combination with two other processes, thermal dissolution and froth flotation.

Potassium chloride (MOP, muriate of potash) is the standard source of potassium for field crops, such as cereals, corn, rice and soybeans, and is applied in one of several ways:

- Directly on fields in granular form
- In a bulk blend with other straight fertilizers
- As a compound NPK fertilizer manufactured from fine-grained 'standard' MOP.

Although MOP remains its bestselling fertilizer, accounting for some 57 percent of agricultural revenues, speciality products have become an increasingly important part of K+S's fertilizer portfolio.

A wide water-soluble, chloride-free portfolio

K+S markets a wide range of speciality fertilizer products. These include products for soil application:

- *KALISOP*[®]
- *Korn-Kali*[®]
- *Patentkali*[®]
- *ESTA*[®] *Kieserit*
- *Magnesia-Kainit*[®]

These are supplemented by products for liquid and foliar application:

- *EPSO Top*[®]
- *EPSO Microtop*[®]
- *EPSO Combipot*[®]
- *soluMOP*[®]
- *soluSOP*[®] 52
- *hortiSUL*[®]

All the above speciality products are water-soluble and differ from standard MOP as they are:

- Chloride-free or low in chloride
- Formulations containing magnesium, sulphur, sodium and micronutrients.

These products are used for crops which have a greater need for magnesium and sulphur, such as rapeseed or potatoes, as

well as for chloride-sensitive crops, such as citrus fruit, grapevines and vegetables.

K+S generated revenues of €727.4 million from the sale of fertilizer specialities in 2018, a two percent rise on the previous year (€710.5 million). Lower product availability from the Werra plant in Germany last year was offset by higher prices. Sales volumes in Europe remained unchanged at around 2.0 million tonnes, while overseas sales were down slightly year-on-year at 0.6 million tonnes.

K+S generates half of its agricultural product revenues from customers in Europe, benefitting logistically from the proximity of its European production sites. South America, particularly Brazil, and Asia are also key sales regions for K+S.

The range of speciality fertilizer products offered by K+S are reviewed below.

KALISOP®

KALISOP® is a sulphate of potash (SOP, K_2SO_4) product that offers a highly-concentrated, plant-available supply of water-soluble sulphur and potassium. It is classified as an organic fertilizer and is virtually chloride-free – making it ideal for chloride-sensitive crops. The low salt index of *KALISOP®* also means it is particularly suitable for high-value cash crops grown in intensive cropping systems.

Most fruit and vegetable crops are chloride-sensitive, being particularly susceptible to high chloride levels during germination and early growth stages. Notable chloride-sensitive crops include: tobacco, soft fruits, stone fruits, grapevines, beans, potatoes, cucumbers, melons, onions, lettuce, glasshouse crops, conifers, flowers and ornamentals.

KALISOP® has the following beneficial effects when applied to fruits and vegetables:

- Improves colour intensity, increases sugar and acid content and intensifies aroma, making marketable fruits more attractive to the customer
- Increases firmness – improving storage life, transportability, and suitability for processing and preservation.

KALISOP® is offered in granulated form and as a fine powder. Its chloride content ranges from 0.5 percent to a maximum of

1.5 percent. *KALISOP® Premium* is a round granulated product. It is ideal for blending because of the roundness and stability of its granules. Its round shape also makes accurate spreading up to 48 metre bout widths possible.

ESTA® Kieserit

ESTA® Kieserit is a magnesium sulphate-based fertilizer containing water-soluble magnesium and sulphur in plant-available form. It is also classed as an organic fertilizer and is an effective magnesium and sulphur source for all crops and all soil types. *ESTA® Kieserit* is suitable for use in agriculture, horticulture, special crops, plantations and forestry. It is recommended for amelioration of soils with poor magnesium status and is typically applied after harvest or prior to sowing.

ESTA® Kieserite is available as either a granulated or fine product. For annual crops, *ESTA® Kieserite* is applied as a basal dressing in autumn or late winter. Early spring application as a basal or top dressing is recommended on sandy soils and/or under high rainfall conditions.

Sub-surface fertilization, alongside nitrogen and phosphate fertilizers, has proved to be effective for maize.

The granular variant, *ESTA® Kieserit gran.*, has excellent spreading properties due to its particle size distribution and granule hardness. It can be applied accurately

and efficiently with all modern fertilizer spreaders. The best application time for perennial crops is prior to the main growth period.

Patentkali®

Patentkali® is a speciality potassium fertilizer with a high magnesium and sulphur content. It is classed as an organic fertilizer. Nutrients are present in sulphate form and are fully water-soluble. Importantly, *Patentkali®* is able to alleviate sulphur deficiency quickly, having an immediately plant-available sulphur (SO_3) content of 42.5 percent.

Patentkali® is unaffected by pH and is therefore suitable for all soil types. It also has excellent spreading properties due to its uniform particle size distribution. *Pat-*

entkali® can be safely applied until shortly before the drilling or planting date. On light soils, it should be applied in the spring so as to avoid potential nutrient losses over the winter.

Patentkali® is particularly well-suited to chloride-sensitive agricultural, horticultural and forestry crops due to its low chloride content (3% Cl maximum). It is highly suitable for application to potatoes, vegetables, fruits, grapes and sunflowers.

Korn-Kali®

Korn-Kali® is a potash and magnesium fertilizer that combines potassium chloride (40% K_2O), kieserite (magnesium sulphate, 6% MgO) and sodium chloride (4% Na_2O). *Korn-Kali®* also provides adequate sulphur supply for most crops due to its high sulphate content (12.5% SO_3). All these nutrients are fully water-soluble, and therefore directly available to plants, independent of soil pH. *Korn-Kali®* also has excellent spreading properties during field application due to its uniform particle size distribution.

Korn-Kali® is an ideal potassium fertilizer for chloride-tolerant crops which also have a requirement for the other nutrients supplied – such as sulphur for oil crops and magnesium and sodium for sugar beet. Suitable crop types include cereals, oilseed rape, sugar beet, forage/grain maize, forage crops.

Korn-Kali® is ideally applied during the autumn. In crop rotation systems, it is generally applied to those crops with the highest nutrient demand (sugar beet, oilseed rape, maize, for example) or those with a specific demand for sulphur, magnesium and sodium.

Magnesia-Kainit®

Magnesia-Kainit® is a kieserite-containing crude potash salt marketed by K+S as a cost effective organic fertilizer for grassland and forage crops. It contains potash, magnesium, sodium, sulphur and chloride.

Magnesia-Kainit® significantly improves the palatability of pastureland due to its high sodium content. By increasing magnesium and sodium accumulation of the fodder, *Magnesia Kainit®* contributes to good animal health, growth and fertility.

Magnesia-Kainit® has a nutrient ratio that makes it highly suitable for grazing pasture. It should ideally be applied in early spring before vegetative growth begins. It can also be applied to young grassland and after the first grazing.

Expanding the speciality fertilizer business is a key pillar of K+S's future growth strategy.

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EPSO product range

K+S offers its water-soluble, organic-approved *EPSO* magnesium sulphate fertilizer in four variants.

EPSO Top® (16% MgO and 32.5% SO₃) is a quick acting magnesium and sulphur fertilizer for foliar application. All nutrients are fully water-soluble and are present in sulphate form (MgSO₄·7H₂O). The product dissolves rapidly without a residue in water, making it well-suited to foliar spray applications and for fertigation through irrigation systems. *EPSO Top*® can be used to supplement soil applications during periods of peak demand, particularly if magnesium deficiency is observed. It is recommended for a range of crop types, including cereals, oilseed rape, sugar beet, potatoes, hops, asparagus and softwood.

EPSO Microtop® is quick acting micro-nutrient-enriched foliar fertilizer recommended for sugar beet, oilseed rape, brassica, potatoes, sunflower, maize and grapevines. It contains:

- 15% water-soluble MgO
- 31% water-soluble SO₃
- 0.9% water-soluble B
- 1% water-soluble Mn

Magnesium, sulphur, boron and manganese deficiencies in growing crops are quickly alleviated by *EPSO Microtop*® – and it is particularly suitable as a preventive application, helping to avoid deficiencies before they occur.

EPSO Combitop® is a quick-acting, micronutrient-enriched foliar fertilizer containing magnesium, sulphur, manganese and zinc. It has been specifically developed to meet the nutrient needs of cereals, maize and leafy crops with a high demand for manganese in combination with magnesium and sulphur. The product contains:

- 13% water-soluble MgO
- 34% water-soluble SO₃
- 4% water-soluble Mn
- 1% water-soluble Zn

EPSO Combitop® alleviates magnesium, sulphur, manganese and zinc deficiencies in growing crops. It is particularly suitable as a preventative application to avoid deficiencies. If applied in one or two applications, *EPSO Combitop*® meets the magnesium and sulphur demands of crops, and provides a full maintenance dressing of manganese and zinc. Autumn application to winter barley has been shown to improve winter hardiness.

EPSO Bortop®

EPSO Bortop® is the latest product developed for the K+S foliar range. It targets crops with higher to medium boron demand, such as rapeseed, sugar beet, sunflower and corn. *EPSO Bortop*® is a fast-acting and fully water-soluble fertilizer which effectively supplies plants with boron during growth. The combination of sulphur, magnesium and boron is ideal for efficient nutrient uptake in the plant. This can be further improved by split applications. *EPSO Bortop*® contains:

- 12.6 % water-soluble MgO
- 25 % water-soluble SO₃
- 4 % water-soluble B

A special feature of *EPSO Bortop*® is its positive effect on pH in spray solutions. In combined applications, *EPSO Bortop*® can lower pH by up to two units, helping to maintain the effectiveness of the mix. *EPSO Bortop*® – as with all other *EPSO* products – is registered for use in organic farming. Its significant boron content quickly alleviates boron deficiencies, improves winter hardiness and aids plant physiological processes such as starch and sugar formation, cell development.

soluMOP®

soluMOP® is a completely soluble potassium chloride fertilizer that makes an ideal potassium source for fertigation systems and for foliar application with plant protection sprays. It is suitable for all chloride-tolerant crops, including oilseed rape, cereals, corn and sugar beet. The product is fully compatible with the water-soluble *EPSO* product range and can be combined with these without difficulty.

soluMOP® can be used in both open-field crops and crops cultivated under protection using soil-based or hydroponic systems. The recommended concentration of *soluMOP*® solutions depend on plant type, variety, age, stage of development, yield expectation, growth duration, nutrient requirements, temperature and growing system – but, in general, should not exceed five percent w/v.

soluSOP® 52

soluSOP® 52 is a water-soluble (<0.1% insoluble content) and virtually chloride-free (<0.5% Cl) SOP product designed

for fertigation systems and foliar application. It provides potassium (52% K₂O) and sulphur (45% SO₃) to crops, such as vegetables and high quality fruits, in direct, plant-available form. The product is ideal for chloride-sensitive crops, and has a very low salt index (46) compared to other potassium sources.

soluSOP® 52 is suitable for open field agriculture, as well as for crops grown under protection, and is recommended for salinity prone growing conditions. It mixes well with most other soluble fertilizers, except Ca-containing products due to the risk of gypsum precipitation.

hortiSUL®

hortiSUL® is a water-soluble (<0.1% insoluble content) and virtually chloride-free (<0.5% Cl) high sulphur (45% SO₃) SOP product designed for fertigation systems – and for foliar application as a supplementary potash source. It provides potassium (52% K₂O) and sulphur in plant-available form and is classed as an organic fertilizer. The product is particularly suitable for crops with a high sulphur requirement, such as oilseed rape, sunflower, brassicas, onion and leeks. It has a very low salt index (46) compared to other potassium sources.

Looking ahead

Expanding the speciality fertilizer business and developing into high growth areas such as fertigation is a key pillar of K+S's future growth strategy out to 2030.

K+S also runs the Institute of Applied Plant Nutrition (IAPN) as a public/private partnership with the Georg August University of Göttingen. IAPN's research last year looked at ways of optimising the supply of potassium and magnesium to plants, increasing water use efficiency and promoting environmentally-friendly nitrogen use. Other research priorities at IAPN include developing:

- Sustainable solutions that optimise plant nutrition in organic agriculture
- Innovative precision agriculture methods and products to improve fertilizer use efficiency
- High-quality micronutrient-enriched products that can prevent crop deficiencies
- New and improved foliar products for the speciality fertilizer portfolio, as quick, effective supplements to soil-applied fertilizers. ■

Phosphates 2019

Around 430 delegates from 37 countries gathered at the Omni Orlando Resort, Florida, 25-27 March, for CRU's Phosphates 2019 conference.



Keynote speakers at the conference, from left to right: CRU's Chris Lawson, Nutrien's Robert Mullen and Mosaic's Bruce Bodine.

We report on the main plenary, market outlook and other selected presentations given at CRU's 12th Phosphates International Conference and Exhibition held in Orlando in March.

Chasing away market jitters

The conference opened with a keynote address from CRU's **Chris Lawson**. This promised to take delegates "around the world in 30 minutes", stopping off to look at critical phosphate market developments in China, the US and India. In particular, Chris asked whether China – and the promise of reforms, relocations and restructuring – would be enough to "chase away short-term market jitters".

"We're going to talk about some of the negative sentiment that's crept into the phosphates market over the last six months or so – giving an overview of how we got here, and some of the key things to watch out for," Lawson said. "It will come as no surprise that we're also going to talk about China quite a lot."

Taking the New Orleans (NOLA) f.o.b. price benchmark for diammonium phosphate (DAP) as an indicator, Chris pointed to the 22 percent slide in prices since their peak of more than \$460/t in October 2018. This six-month downward correction, which followed a 14-month price upswing, has taken the DAP f.o.b. NOLA price to below \$380/t for the first time since November 2017. The following sequence of supply- and demand-side factors have accompanied the price correction:

- Mosaic's closure of Plant City and consolidation in the US market
- The sulphur price spike
- The poor US fall application season
- The 15 percent year-on-year increase in China's annual DAP exports
- Production cuts from Mosaic and OCP (300,000 tonnes) and China Inc (800,000 tonnes)
- A slide in raw material prices.

In the short-term, prices are most likely close to their bottom, Lawson suggested, with production cuts in the US, Morocco,

and China helping to "stop the rot". However, the US spring application season will be key in ending the downward correction, as prices could fall again if demand in the market fails to emerge. The China DAP f.o.b. price, as of mid-March, was also close to the production cost floor – suggesting that the future direction of prices will depend on Chinese producer discipline and other factors such as sulphur pricing. The demand-side picture looks reasonably positive, however, with Brazil's phosphate imports forecast to rise this year, while India's imports look set to move only slightly lower.

In China, phosphate producers are being pushed up the cost curve. Phosphate rock mining in the country is becoming more expensive and difficult, labour costs are rising, and producers are also having to invest to comply with new environmental standards. These developments will affect the future competitiveness of China's phosphate industry. Chinese DAP production costs already fall in the middle of the global cost curve, for example, while its monoammonium phosphate (MAP) producers are clustered towards

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the upper end of the cost curve. Phosphate rock mining costs in China are also rising and likely to exceed the global average by 2020.

In response to market conditions and rising costs, Chinese producers are generally choosing to limit their production by adjusting utilisation rates. “We don’t see many closures,” commented Lawson. The country’s phosphates capacity is declining, though, if slowly. By 2023, phosphoric acid production capacity is expected to contract by 1.1 million tonnes from its 2015 peak of 22 million tonnes, for example.

Phosphate-producing provinces such as Sichuan, Yunnan, Guizhou and Hubei have also seen their production curtailed due to environmental measures imposed on mine production, water safety and phosphogypsum waste. To stay in operation, Chinese producers are responding by “going green” – with Hubei province pushing hardest in this direction. It is either relocating or making improvements to around 4.3 million tonnes of P₂O₅ production capacity.

All eyes are on India as well this year, as the country remains a vital phosphates market globally. Inventory levels were high at the start of 2019, following a 43 per cent year-on-year increase in DAP imports in 2018 – although the market remains relatively unconcerned about this stock position. More generous subsidies in an election year should also bolster Indian demand in the short-term. Phosphate rock prices in India have edged higher in recent months, while phosphoric acid prices have held firm.

On the supply side, OCP in Morocco and Ma’aden and its JV partners in Saudi Arabia dominate production capacity additions, although only modest increases to global capacity are expected over the next five years. Large-scale projects such as Ma’den’s phase three expansion and the Sonatrach/CITIC JV project in Algeria remain speculative, in CRU’s view.

Summing up, Lawson said: “We see a tightening market, with raw material prices creeping higher as well, which is generally supportive for the medium-term outlook for prices. We see a bit of dip in prices this year with a modest recovery thereafter.”

Mosaic goes global

In his keynote address, Mosaic’s **Bruce Bodine** explained how Mosaic had transformed itself from a mainly North American market player into a truly global phosphates company.



Delegates networking at the evening reception.

Due to the scale of its operations, Mosaic is a global leader in the procurement and consumption of raw materials. Mosaic’s total sulphur requirements – including its North American assets and those of Mosaic Fertilizantes in Brazil – are well over five million tonnes, for example. The company’s US and Brazilian operations also consumed more than 1.4 million tonnes of ammonia last year.

Today, North America’s share of global phosphoric acid output has dropped to just 15 percent, down from a peak of more than 45 percent in the mid-1990s. Over the same period, the region’s share of global phosphate exports (DAP/MAP/TSP) has also fallen from more than 60 percent to around 10 percent currently. This decline has been accompanied by a major consolidation of the North American phosphates industry.

“In 1990, there were 18 firms in North America running 22 phosphate production facilities. Later this year, when Nutrien’s Redwater plant closes, there will be just four firms running nine different facilities. The rationalisation and consolidation has been quite profound,” commented Bodine. Mosaic, however, remains North America’s largest phosphate company by far, possessing some 60 percent of regional phosphoric acid production capacity.

Mosaic has reacted to North America’s waning global influence by transforming itself into the only global phosphate producer, as Bodine explained: “While the largest concentration of phosphate production is right here in Florida, we’ve made investments around the world in the last several years to bolster our leading industry position.”

He went on to list these: “In Peru, our acquisition of the Vale stake in Miski Mayo joint venture moved our interest in that phosphate rock mine to 75 percent. In Brazil, we’ve been growing our distribution platform and subsequently [purchasing] a slate of phosphate and potash assets in 2018. Finally Mosaic has a 25 percent share in the Ma’aden Wa’ad Al Shamal Phosphate Company joint venture in Saudi Arabia.”

Mosaic’s Brazilian acquisitions have proved particularly astute. The company’s new Mosaic Fertilizantes subsidiary sold 9.1 million tonnes of crop nutrient products in 2018, accounting for around 24 percent of total fertilizer shipments in Brazil. The quality of these production assets and their logistical cost advantage has propelled Mosaic into a leadership position in the Brazilian market.

In North America, Mosaic has moved away from commodity monoammonium phosphate (MAP) production, shifting to the manufacture of its premium *MicroEssentials* product instead. *MicroEssentials* sales volumes increased from two million tonnes in 2014 to three million tonnes last year. This has been a profitable shift in sales for Mosaic, given that *MicroEssentials* commands a price premium of +\$50/t over MAP. Further expanding *MicroEssentials* production by investing in a Brazilian production unit is one option being weighed up by the company.

Global changes, domestic challenges

In a wide-ranging keynote address, Nutrien’s **Robert Mullen** examined some of the global agronomic changes, as well

as domestic regulatory challenges, facing the phosphates industry currently. He summarised changes in crop production in key agricultural countries such as Argentina, Brazil, Canada, the US, India and China. This revealed a general shift away from small grains towards high-yielding corn and oilseeds. This change in the global crop mix has altered phosphorus requirements and, consequently, the demand for phosphate fertilizers.

At a global level, agricultural land use and crop yields will continue to rise, Mullen concluded, driven by improved agronomic practices and improvements in plant genetics. Sub-Saharan Africa, and Central/South America, in his view, are likely to be the next regions to deliver significant agricultural productivity gains. However, he cautioned that in both regions poor market access to fertilizers and other inputs, linked to poor infrastructure and logistics, together with land ownership issues and a lack of agronomic expertise, could act to limit agricultural productivity improvements.

Mullen ended by using Lake Erie as a regulatory case study for the application and use of phosphate fertilizers. He shared some of the lessons learnt about how to reduce phosphorus loads in surface waters. Best management practice has shown that avoiding surface applications without incorporation and instead placing phosphorus below the soil surface was part of the solution. No-till systems and other approaches that keep soils in place and minimise sediment transport are also essential.

Constructive outlook for the Americas

In his phosphates outlook, Mosaic's **Andy Jung** provided an overview of global market dynamics, albeit with a focus on the Americas. "The outlook for the Americas is very constructive, despite recent headwinds," said Jung. "The region is home to most of our [Mosaic's] assets and it's also where we sell most of our product."

World demand remains robust with global phosphate deliveries (DAP/MAP/NPS/TSP) approaching 70 million tonnes in 2018. Plant nutrients also remain affordable, in Mosaic's view. USDA's March outlook for grains and oilseed stocks also gave grounds for market optimism.

Brazil remains an engine for growth in the Latin American region. NPS product shipments (*MicroEssentials*) to the country have

grown particularly strongly. Brazil's farm economics remain robust, and soybean prices in local currency make it "a good time to be a Brazilian farmer", commented Jung. Fertilizer consumption elsewhere in the region also looks solid with "a lot of fundamentally good stories on demand".

The headwinds Jung was referring to were high North American inventory levels. North America should, however, sustain phosphate shipments of around 10 million tonnes this year, in Mosaic's view, once the spring season was under way.

The phosphate market price declines of recent months have certainly hit phosphate production margins – the so-called 'DAP stripping margin'. These margins have fallen out of the "adequate and sustainable range" (\$275-300/t) – as of mid-March – but had yet to fall into what Jung called the "red channel" (\$225-250/t), a level that could result in plants being idled.

Although China's phosphate fertilizer exports grew by around one million tonnes last year, reaching around 11 million tonnes, the country's export behaviour "remains a wildcard on the supply side", concluded Jung.

New phosphate rock opportunities

CRU's **Alexander Derricott** presented the outlook for phosphate rock. Demand will remain relatively flat over the medium-term, averaging around one percent per annum between now and 2023. In terms of supply, Morocco and Saudi Arabia will dominate increases in phosphate rock mining capacity over this period, with growth being driven by integrated downstream fertilizer expansions.

Chinese rock capacity has slowed after 15 years of rapid growth. This could open up opportunities – with China possibly becoming a net importer of phosphate rock by 2023. The country is already importing. OCP notably supplied 161,000 tonnes of rock to China in 2018, for example. This looks set to be supplemented by significant rock exports to China from Peru, following an agreement signed in January. Peru already dominates US phosphate rock imports, supplying more than two million tonnes annually.

In their present form, the impact of the new cadmium limits in the EU market is likely to be minimal, according to CRU. This is because major consuming countries such as Lithuania, Norway, Belgium and Finland already source their phosphate

rock from low cadmium sources, although Poland and Bulgaria will be left exposed by the new legislation

Positive ammonia and sulphur demand growth

Anthony Garcia gave CRU's view on the outlook for phosphate fertilizer feedstocks over the next five years. The ammonia market experienced uncharacteristic price declines during the first quarter of 2019, as poor US fall season demand combined with increasing supply. The arrival of EuroChem's Kingisepp plant in Russia is expected to continue to disrupt the ammonia market in 2019, by adding an additional 0.9 million tonnes of additional ammonia supply West of Suez.

Medium-term prospects for ammonia demand growth remain positive. In the phosphates market, capacity expansions in Morocco and Saudi Arabia will offset closures in China and North America. Consequently, the combined ammonia requirement from DAP/MAP is forecast to grow by more than 300,000 tonnes out to 2023. Over the medium-term, CRU expects ammonia prices to rise by around \$75/t between 2019 and 2023. The lack of merchant capacity investment over the next three years, in particular, looks set to tighten the market.

Although China's requirements and logistical constraints inflated sulphur prices in 2018, these have been on a slide since late last year as demand has slowed. This price decline should be reasonably short-lived, however, as 2019 will mark a low point in sulphur pricing, according to CRU's medium-term outlook. Prices are anticipated to increase over the period 2020-2023 as demand growth outstrips supply.

Looking ahead, the global market is expected to remain in surplus (+0.5 million tonnes) until 2021, although the inaccessibility of stocks will keep the market more balanced than the oversupply figures suggest. Phosphate-based sulphur demand is expected to grow by around five million tonnes between now and 2023, led by the increasing requirements of producers in Morocco, China and Saudi Arabia. ■

Author's note

A set of abstracts highlighting the key technical presentations at Phosphates 2019 can be found in the conference preview in our March/April issue (*Fertilizer International* 489, p30).

Great granulation

Efficient, low maintenance screening machines are essential for the effective operation of fertilizer granulation plants. **Cliff Hollyfield**, president of J&H Equipment, draws on his acknowledged expertise and decades of experience to explain how the granulation process can be optimised and plant output increased.

J&H Equipment: world leader in vibrating wire screens

J&H Equipment, Inc. was founded in 1974 by Allen Jackson and Cliff Hollyfield, both mechanical engineering graduates of the Georgia Institute of Technology. In the decades that followed, the company has grown to become a world-leading supplier of screening equipment to fertilizer granulation plants globally.

Notably, J&H was the first company to design and manufacture rotary-driven vibrating wire screening machines. These overcame many of the shortcomings of conventional machines, such as noise, high maintenance requirements and poor efficiency.

Thousands of J&H screening machines now operate around the world. The company's wide range of plant machinery also

includes crushers, bucket elevators, lump breakers, feeders, stream splitters and modulating control diverters – all of these essential components of modern fertilizer granulation plants.

J&H offers complete screening equipment packages for the fertilizer industry. These operate as fully-controllable and integrated screening process systems. J&H chain mills also optimise the crushing of oversize fertilizer product. For the phosphate industry, a screen fines hopper fitted with an integrated modulating control valve allows precise computer-control of recycle material to the granulation process. This in turn reduces oversize, generates a closer sized final product and – most importantly of all – increases production by ensuring that the other machinery in the granulation plant is operating optimally.

Granulation plant equipment

Granulation plant feed materials differ according to the product being manufactured. For NPK granulation, for example, the feed consists of solid raw materials such as potash, triple superphosphate, urea, etc. While in diammonium phosphate (DAP) and monoammonium phosphate (MAP) granulation, anhydrous ammonia and phosphoric acid are combined in a pipe reactor (granulator).

In the latter stages of the granulation plant process, the product moves from the product screens to a cooler of some type and then finally to storage.

Key granulation plant machines, excluding the rotary granulator, dryer and cooler, are described in turn below. Please refer to Figure 1 for plant layout and the location of numbered equipment items.

Fig. 1: Schematic of a modern DAP/MAP/NPK fertilizer granulation plant

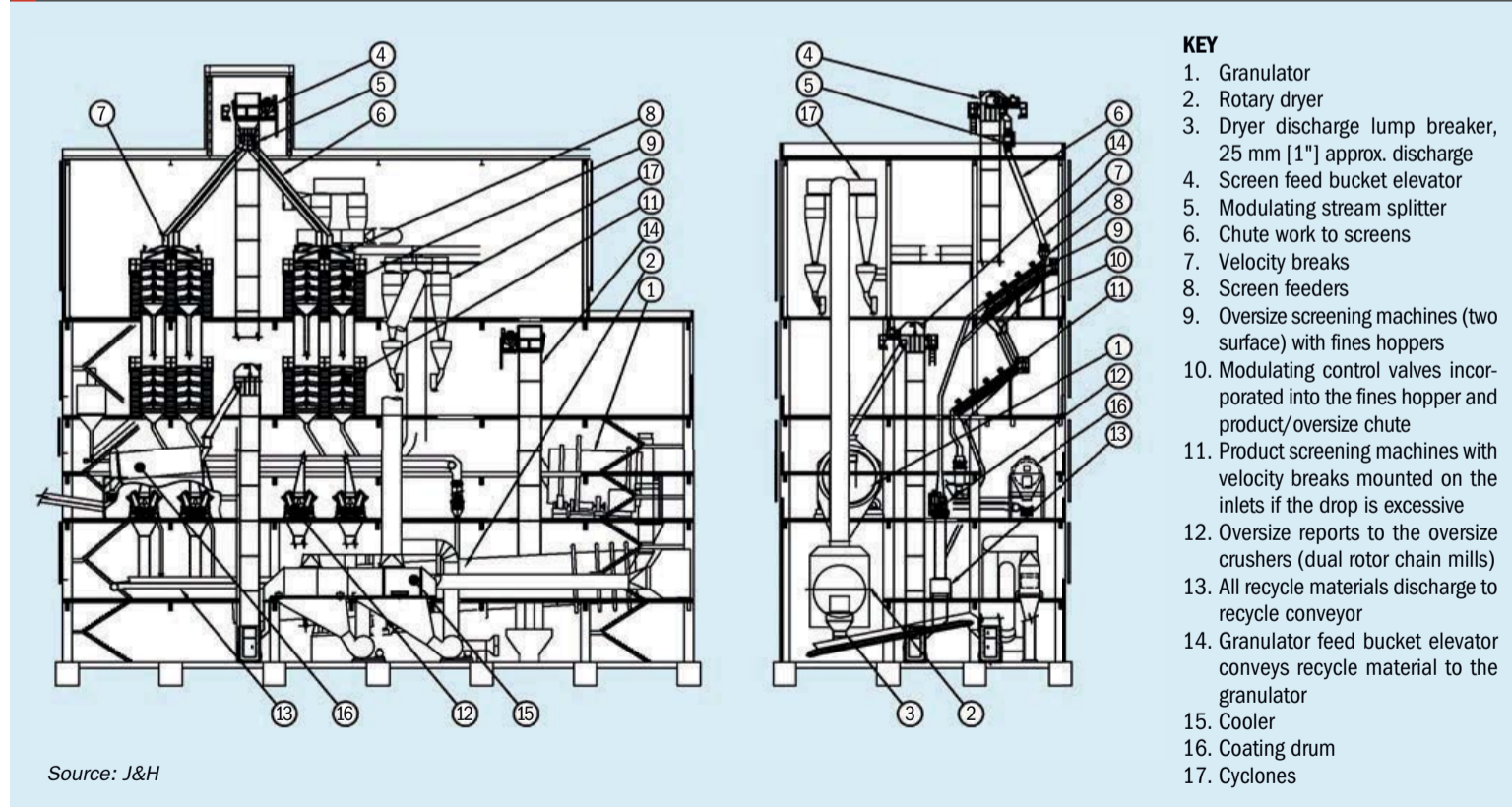


Fig. 2: Lump breaker

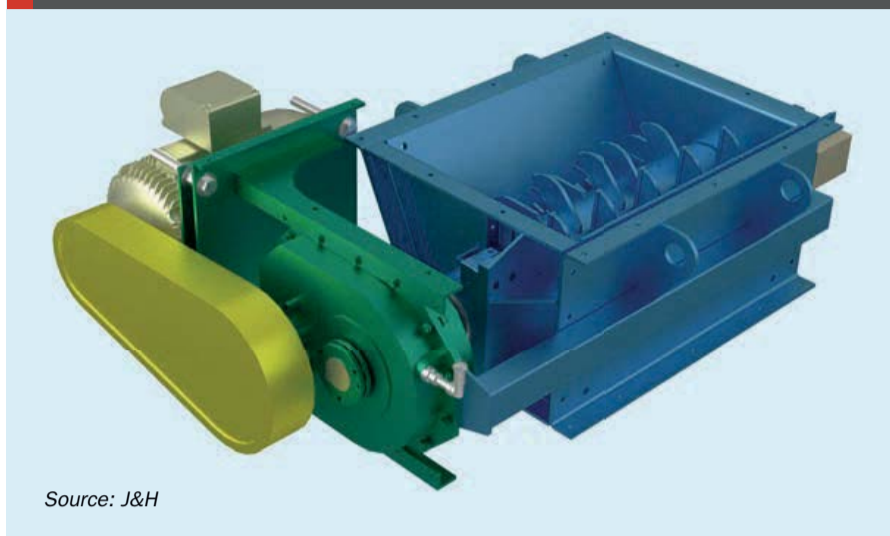
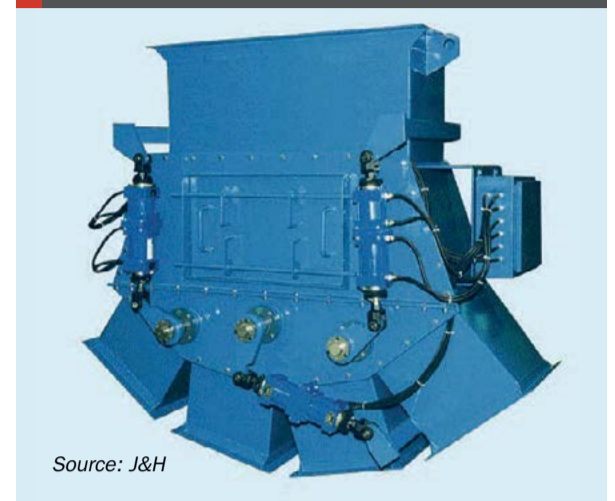


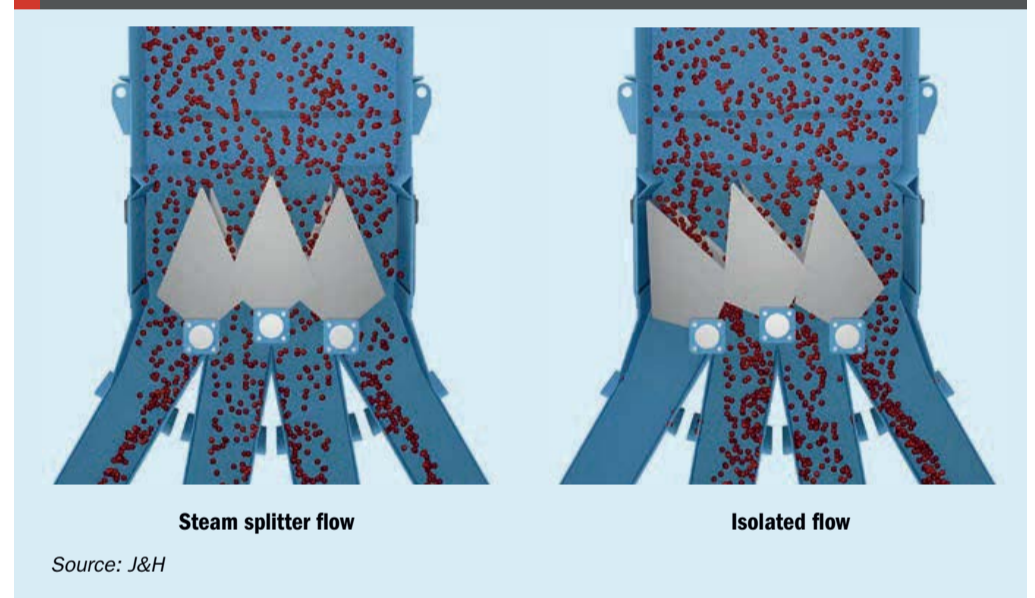
Fig. 3: Material stream splitter, four-way, pneumatically-actuated type



Lump Breaker

After the initial granulation (item 1) and drying stages of the process, material leaving the rotary dryer (item 2) should have a moisture content of 1.5 percent or less and also needs to be reduced to approximately 25 mm (1") in size using a lump breaker (item 3). This is a necessary preparatory step prior to screening that prevents any large lumps emerging from the dryer causing damage to wire cloth screens. A grizzly is used to direct everything larger than 25 mm from the dryer discharge to the lump breaker. J&H's lump breaker (Figure 2) is a 'tooth & comb' type unit operating at about 60 revolutions per minute (rpm).

Fig. 4: Stream splitter operating with all four streams flowing (left) and with one stream isolated (right).



Continuous bucket elevators

Bucket elevators are used at various stages to vertically transport the screen feed (item 4), product discharge (item 5), recycle conveyor feed to the granulator (item 14), and the cooler feed (item 15). Bucket elevators in larger granulation plants are typically continuous, dual-strand chain types with side-hung, high-capacity buckets. These elevators usually operate at a chain speed of around 0.7-0.77 m/s (135-150 ft/min) and have various capacities up to 1,000 t/h of material. Elevator units generally incorporate:

- Hardened steel alloy boot bearings with internal gravity take-ups
- Right-angle shaft mounted drive with internal backstop
- Inching drive, fluid coupling, and mill & chem motor all mounted on a torque arm assembly.

Stream splitter

The stream splitter (item 5) receives material discharged by the rotary dryer (item 2) via the screen feed elevator (item 4) and, using pre-set openings, evenly divides this into three, four, five or six streams – one stream for each screen line. A four-way, pneumatically-actuated type of stream splitter is shown in Figure 3. In this design, splitting blades use pneumatic actuators to divide the input material into four equal streams.

The splitters manufactured by J&H offer the ability to isolate and stop material flowing to one screen line, while dividing the elevator feed equally between the remaining operative screening machines (Figure 4). This allows screen lines to be isolated for maintenance and/or cleaning. Each stream can be isolated in a matter of

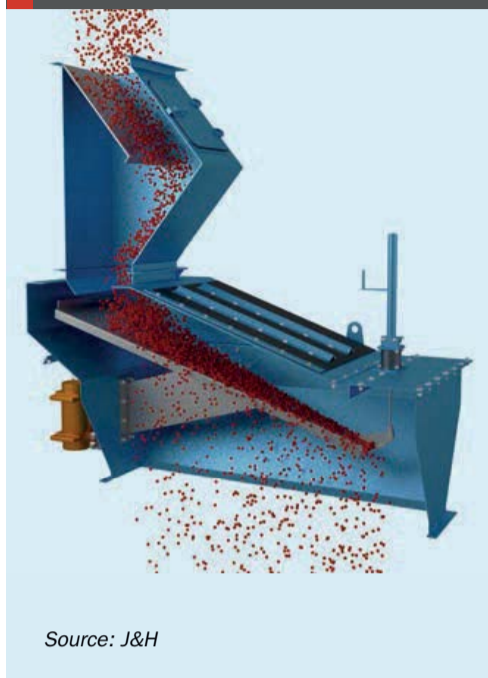
seconds using pre-set positions/settings. (Modulating splitters can also be designed with fine tuning manual adjustment.)

Velocity brake

The speed of material must be reduced before it enters screening machines. Material dropping three metres (10 ft) straight down a chute achieves a velocity of 7.8 m/s (25.3 ft/s) at the feeder or screen entrance, for example. At this velocity, with most machines being 6.1 metres (20 ft) long, the time allowed for screening would be just eight tenths of a second. This compares to the 3-5 seconds residence time materials actually need on the screening surface for effective separation to occur.

However, the speed of material entering screening machines can be reduced by proper chute design and/or the use

Fig. 5: Velocity brake and feeder



Source: J&H

of velocity brakes. Any screening machine with an inlet velocity of 3 m/s (10 ft/s) generally requires a velocity break due to the need to guarantee an acceptable residence time for screen separation. A velocity break is required for this service (Figure 5). The most common installation of the velocity break is directly on top of the feeder inlet.

Screen feeders

Screening machines have become wider and wider in recent years, almost doubling in width from 1.23 metres (4 ft) to 2.15 metres (7 ft). At these dimensions, a screen feeder is mandatory to ensure the whole width of the screening surface

is fully utilised and maximum separation of product and fines is realised.

Oversize screening machine

Oversize screening machines (item 9) are used to separate the product stream (undersize) from oversize material which reports to the oversizer crusher. J&H recommends the use of 36-degree incline vibrating wire machines (2 by 4 mm aperture) for oversize process screening. These have consistently achieved the best product quality, while also being more tolerant of fluctuating loads and process upsets, compared to gyratory machines.

The major design innovation and the big performance breakthrough in process screening in recent years has been the adoption of double-deck oversize screening machines. This configuration was first introduced by Tony Brown at the former operations of WMC Resources (subsequently BHP and Incitec Pivot) in Australia. The top deck of these machines has a standard 4.2-4.4 mm opening. The openings in the bottom deck, in contrast, vary across their length, starting at 2.2 mm in the first panel and ending with 2.7-3 mm in the last panel (Figure 6).

This double-deck arrangement, when used in conjunction with modulating control valves in the hoppers below the fines deck, allows the operator to select the size and amount of recycle returned to the granulator. By configuring the system in this way, operators can ensure that little or no material above 4 mm size is returned in the recycle. This is operationally advantageous as it greatly reduces the

manufacture of oversize material and, correspondingly, increases the production of on-size material.

J&H also recommends installing a manual diverter on the product discharge chute. This allows the operator to stabilise the plant faster by increasing the amount of <3mm material going to the granulator. This is achieved by manually diverting product size material and routing this through the crusher instead. The operator then switches the manual diverter back to product discharge once the granulator is stabilised.

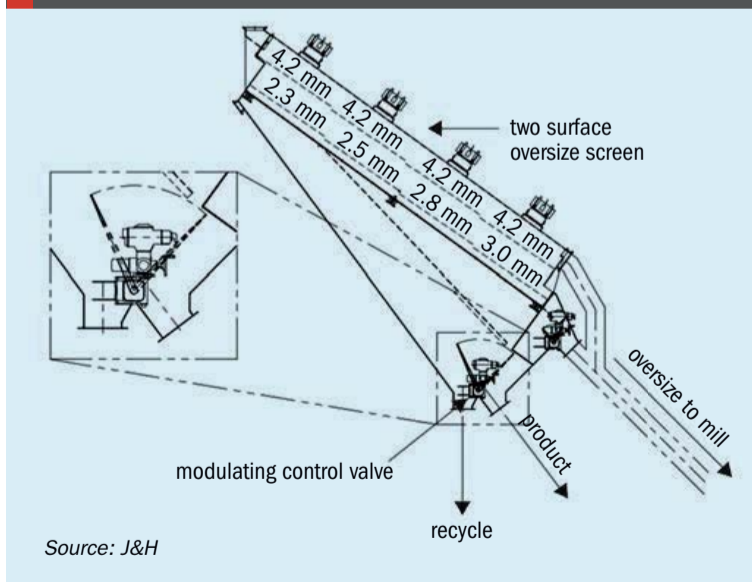
Product screening machines

Product screening machines (item 11) are fitted with full length wire cloth with a 2.2 mm or preferably 2.5 mm opening. Material passing through this cloth is sent directly to recycle conveyor (item 13) while the product material going over this machine is sent to cooler (item 15) and then to storage. As with oversize screening machines, inlet velocity must be controlled – to provide material with a minimum of 3-5 seconds on the screening surface – for this machine to be effective.

Product screens always require a screen feeder. The exception to this rule is when product screens are configured as secondary units, located directly below the oversize machine, and are fed by a full-width chute directly from that machine. (Full width velocity breaks may also be required if the distance between machines is too great.)

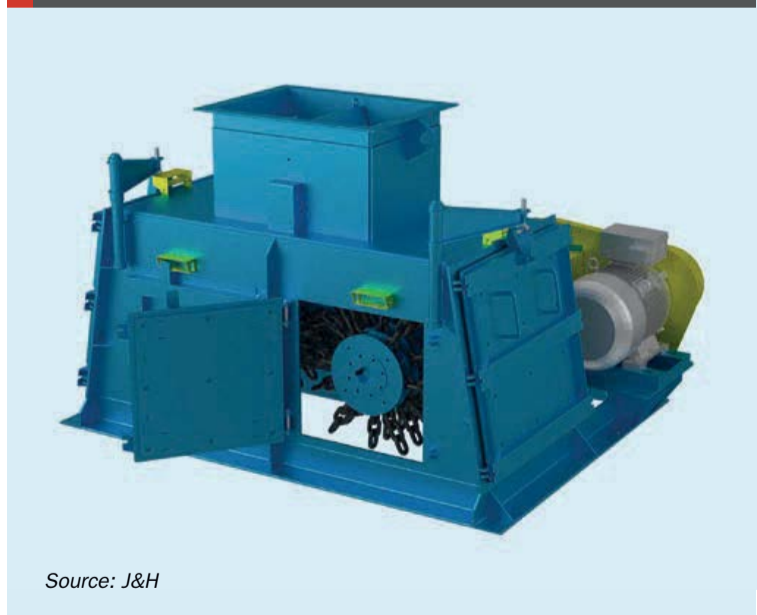
Most modern granular fertilizer plants include two surface polishing screens prior to the storage conveyor. This is to further refine the product's quality.

Fig. 6: A double-deck screening machine with modulating control valve in hopper & product discharge



Source: J&H

Fig. 7: Oversize crusher, dual-rotor chain mill type



Source: J&H

Overall, the key to good oversize and product screening can be summarised as follows:

- Control the velocity of material at the screen inlet
- Even distribution of material at the screen inlet
- Uniformity of wire tension
- Properly sized wire opening and wire diameter
- Optimise wire cloth amplitude, as excessive vibration reduces screening capacity
- Electronic wire cloth cleaning
- Limited (and correct) usage of retarding curtains; only when necessary.

Oversize crusher

Dual-rotor chain mills (Figure 7) make excellent oversize crushers (item 12). Given the right feed and operating at the correct rpm, they are highly efficient, easy to clean and maintain, and are capable of reducing >4 mm size material to well below 1 mm.

The key to good crushing can be summarised as follows:

- Dual-rotor chain mills are the most versatile machine types
- Use vertical feed chutes at the inlet (3-6 m) to properly distribute material in the mill
- Hardened chain and opposing rotating rotors provide synergistic crushing action
- Centre-hung side doors provide easy access with half of the required foot print
- Fit impact areas with 50 mm rubber liners
- Hammers should be avoided as they move too much air and generate substantial imbalances if released
- Excessive material build-up should be avoided as it reduces efficiency and chain life
- Build-up is easily detected by rising mill amperage.

Summary

The key to running a better granulation plant can be summarised as follows:

- Computer-control of the recycle returned from the screens to the granulator
- No particles larger than 3 mm should be returned to the granulator
- Calculate the quantity of total recycle being returned to the granulator (see box)
- Keep liquid feed of NH₃ and phosphoric acid to the granulator constant

Calculating the recycle rate

All recycle materials – from screening machines, cyclones, oversize crushers and the baghouse – are discharged to the recycle conveyor (item 13) and returned to the granulator (item 1) via the granulator feed bucket elevator (item 14).

Usefully, the operating current (amperage) of the granulator feed elevator can be used to calculate the quantity of recycle returned to the granulator. Assuming a 100-foot elevator draws six amps when running empty (friction) and draws 46 amps when carrying material (under load), the elevator’s amperage and height can be used to calculate the quantity of material (tph) delivered to the granulator. See the example calculation below.

Example calculation

- Elevator amperage, under load = 46 amps @ 100 ft of lift (total amps)
- Elevator amperage, running empty = 6 amps (friction amps)
- Amperage attributable to material = 40 amps (lift amps)
- 1 Horsepower (HP) = 1.25 A @ 440 V/3 Phase/60Hz

$$\frac{40 \text{ amps}}{1.25 \text{ amp/HP}} = 32 \text{ HP} \times 33,000 \text{ ft lbs/min}$$

$$= \frac{1,056,000 \text{ ft lbs/min}}{100 \text{ ft (elevator lift)}} = 10,560 \text{ lbs/min}$$

$$10,560 \text{ lbs/min} \times 60 \text{ min} = \frac{633,600 \text{ lbs/h}}{2,000 \text{ lbs/ton (short ton)}} = 316.8 \text{ t/h}$$

Table 1: Calculating recycle amounts returned to the granulator using total current drawn by the bucket elevator

Additional recycle quantity examples			
Total current (amps)	Friction current (amps)	Lift 100 ft current (amps)	Recycle quantity (tph)
36	6	30	237.6
46	6	40	316.8
56	6	50	396.0
66	6	60	475.2
76	6	70	554.5

Source: J&H

- With constant quantity of liquids being fed to the granulator, adjust recycle return from the screen to optimise granulation
- Gradually adjust recycle solids fed to the granulation process to yield less fines and oversize
- Return only smaller particles (below 3 mm) to the granulator.

Increased production rates at granulation plants can be achieved by adopting these guidelines and best practice.

In particular, the performance of granulation plants can largely be controlled by careful regulation of the recycle quantity. This holds the key to optimal plant opera-

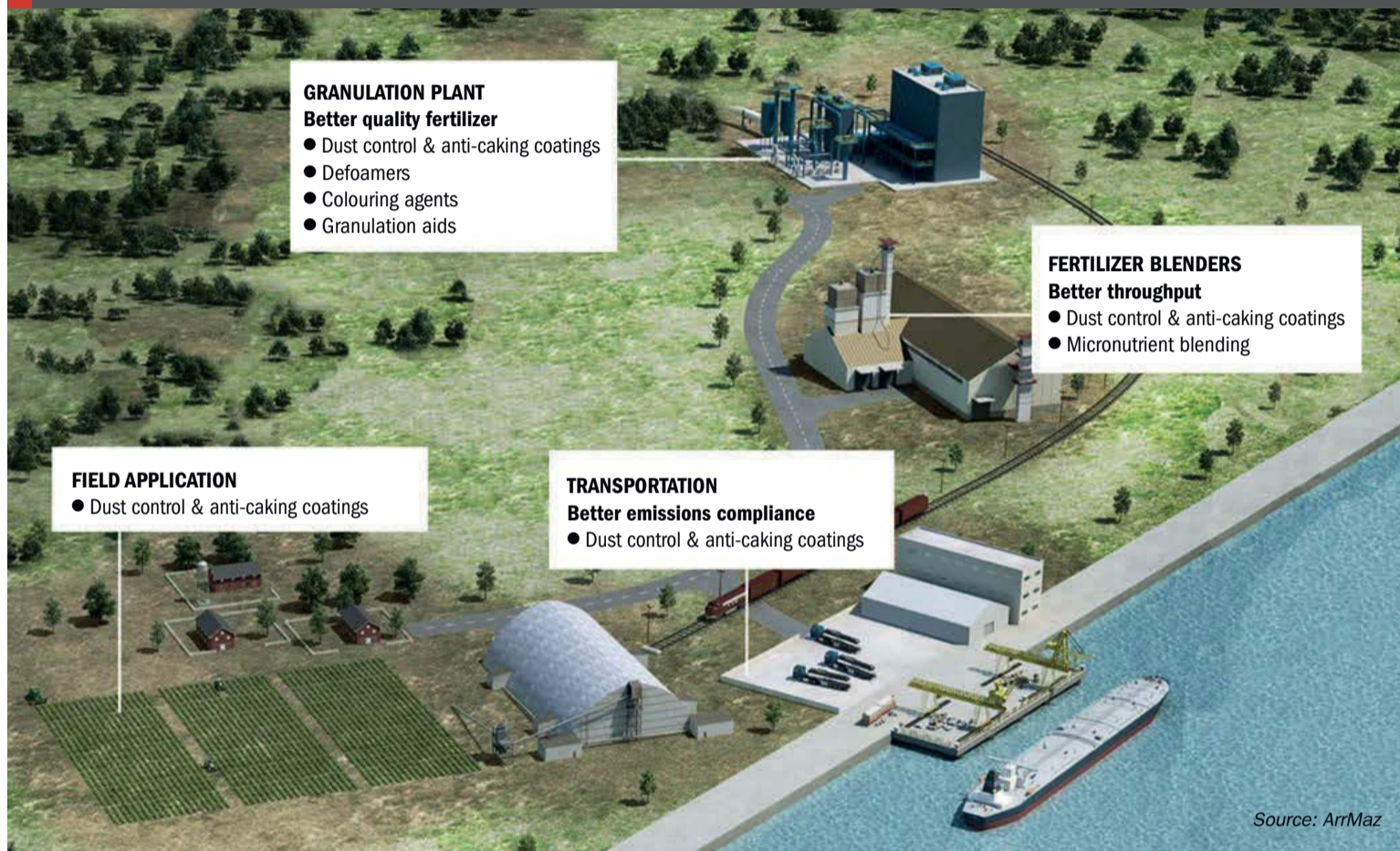
tion. With recycle material smaller than 4 mm and with liquid feed to the granulator kept constant, recycle quantity can be adjusted to stabilise the granulator and keep it running not too wet and not too dry. Stabilising the granulator in this way optimises plant operations as:

- Much less oversize is produced (up to 15% less)
- Build-up in the system is greatly reduced
- Crushers will be able to crush more efficiently
- The plant will produce a high percentage of the right size product (4 x 3 mm)
- Production rate can be increased by eliminating high ‘sine wave’ recycle peaks. ■

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Low-viscosity coatings for dust control

Fig. 1: ArrMaz supplies a range of products to handle the different challenges encountered along the fertilizer supply chain



ArrMaz's *DUSTROL* product line now includes novel low-viscosity, high performance coatings. They combine the excellent handling properties of low-viscosity coatings with the superior dust generation and anti-caking performance of medium- and high-viscosity coatings, as ArrMaz's **Lucas Moore** explains.

The inorganic fertilizers widely-applied in modern agriculture are either mineral-based or chemically-produced. Mineral-based fertilizers are commonly derived from naturally-occurring phosphate and potash ore deposits. These mineral-based raw materials typically go through various forms of processing before being reacted or blended with chemically-derived nitrogen compounds such as urea, nitrates and ammonia.

Supply chain challenges

The resulting finished fertilizer products vary compositionally and are produced in granular, blended or compacted form. The substrates created are prone to handling

challenges as they make their way through long and strenuous fertilizer supply chains. Issues such as brittleness and fracturing can lead to the break-up of granules and dust generation, for example.

Undesirable deliquescence, or moisture uptake in fertilizers, is another challenge. It commonly results in caking, mushiness or moisture adsorption – making handling and crop application difficult. In extreme cases, deliquescence can even lead to the complete dissolution of granules, transforming solid fertilizers into liquids.

Fertilizers travel along an extended supply chain – starting with the move from production to storage, then transportation to wholesalers and retailers, and finally field application by the farmer (Figure 1).

Table 1: Typical performance and handling trends of dust control coatings

Performance			Storage & handling difficulty		
Coating viscosity	Dust reduction	Caking reduction	Spreadability	Heating	Fertilizer Clumping
High	5	3	1	1	1
Medium	3	2	2	2	2
Low	1	1	5	5	5

5=best, 1=worst Source: ArrMaz

Fig. 2: Coating coverage: spray width vs coating viscosity

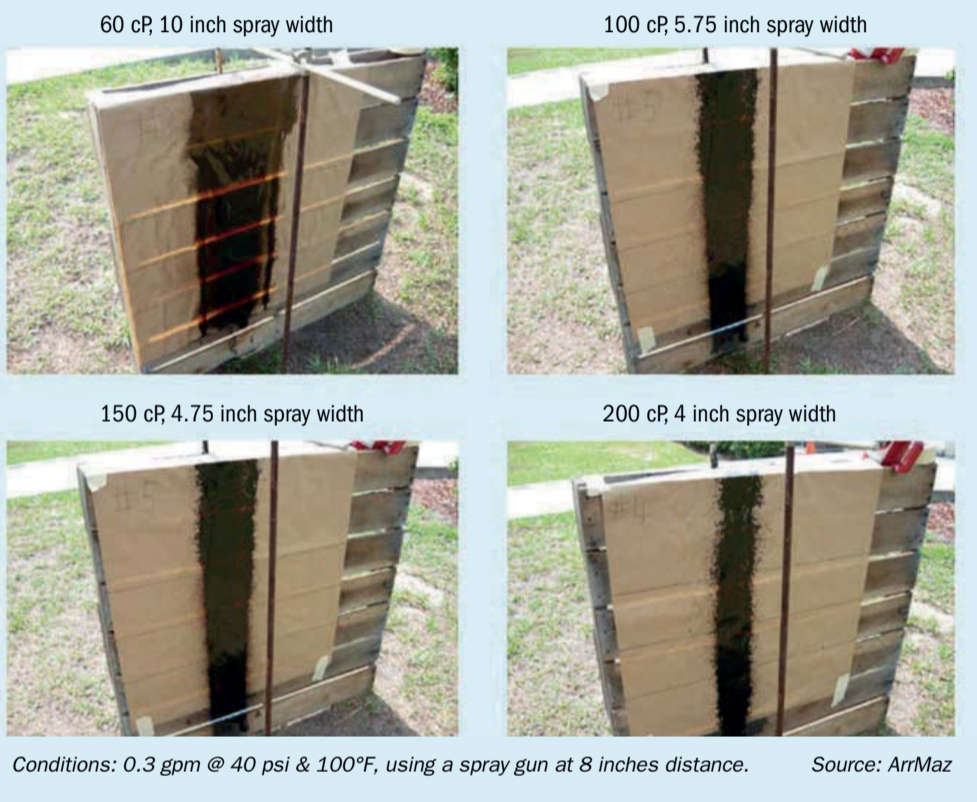
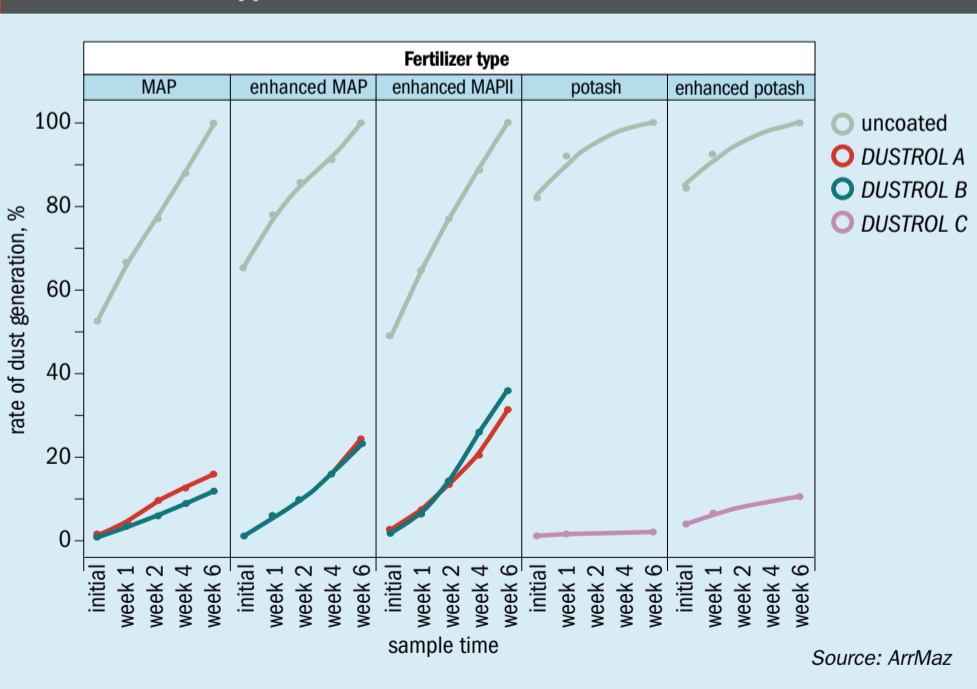


Fig. 3: Production coatings: dust generation reductions using traditional DUSTROL® application



Challenges such as dust generation and deliquescence must be managed and controlled from the time fertilizers leave the production line to their arrival at the farm gate and beyond. This is generally achieved by applying protective coatings to fertilizer granules.

Throughout this supply chain, fertilizers may be exposed to significant temperature and relative humidity cycles before finally reaching the field. Temperatures can range from below freezing to as high as 60°C. Relative humidity inside a railcar can also vary between 30-95 percent, due to exposure to sun during the day and cooling at night. Any coatings applied to the exterior of fertilizer granules must therefore be able to maintain their integrity for extended periods as they endure major fluctuations in temperature and relative humidity.

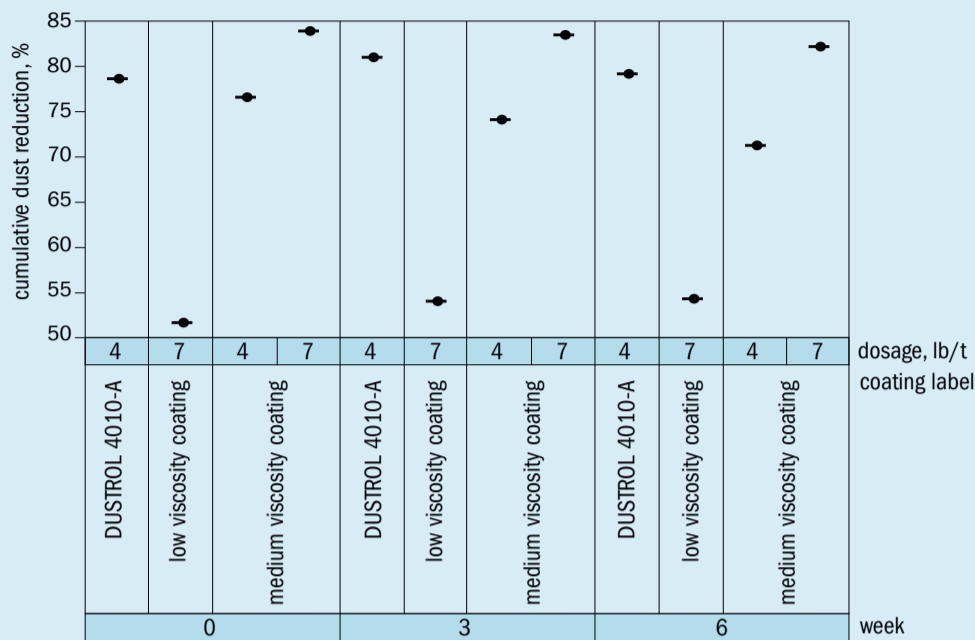
Coating properties

Fertilizer granules are commonly protected during storage, handling and transport by using a substrate- and/or application-specific coating. Different and sometimes competing performance requirements – for dust control, anti-caking control or moisture resistance – means coatings need to have a high level of chemical sophistication and complexity. Higher viscosity coatings, for example, are typically recommended for long-term, high-level dust control. However, the storage and handling of fertilizers – in terms of spreadability, heating and clumping – typically become more difficult as coating viscosity increases (Table 1).

The relationship between temperature and viscosity is also a major consideration when applying coatings to fertilizers. Low-viscosity coatings can be applied to granules at ambient temperature, while high viscosity coatings need to be applied hot. Low- and high-viscosity coatings also have distinctly different granule coverage characteristics when spray coated onto fertilizers.

A low-viscosity coating will yield a greater coating spray width, relative to a high-viscosity coating (Figure 2). This enables greater coverage of the passing fertilizer, and has a positive impact on both mix energy and retention time. However, a typical downside of using low-viscosity coatings is their inability to match the dust reduction levels or performance life of their high-viscosity counterparts – which is why they are typically applied as an additional ‘top coat’ at blending plants or warehouses.

Fig. 4: MAP production coatings: dust reductions for *DUSTROL 4010-A* versus other low- and medium-viscosity coatings



Source: ArrMaz

High-viscosity coatings, in contrast, may create coating spreadability issues during application to the surface of substrate granules. They can also cause potential clumping, an issue associated with either overdosing or poor spreading.

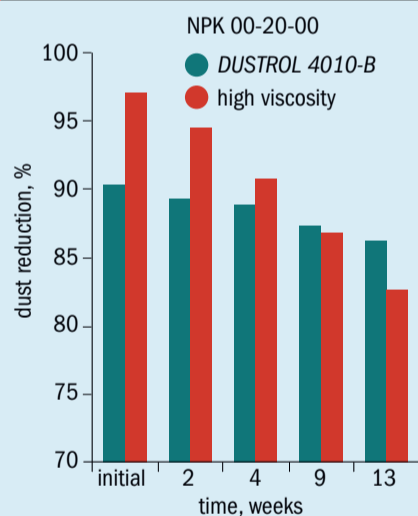
Traditional *DUSTROL* coatings

Understanding how fertilizer substrates generate dust is essential when it comes to ensuring optimal coating performance. Such knowledge helps decide what class of dust control coating will be required, before moving into coating product development. For substrates such as monoammonium phosphate (MAP) and potash, more than 50 percent of the dust is generated during initial production, with dust generation continuing if granules are left uncoated (Figure 3).

MAP and potash producers will often apply a high-viscosity coating directly after production – accepting the difficulties associated with their application – in order to reduce fertilizer handling challenges throughout the supply chain. These coatings are applied when the fertilizer substrate is still hot (typically 48.9-71.1°C, 120-160°F) using a hot coating (around 104°C/220°F).

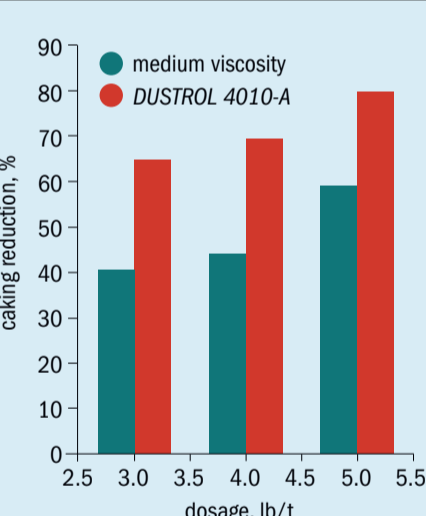
A six-week investigation by ArrMaz has shown that the application of tailor-made *DUSTROL*® coatings for MAP and potash can reduce dust generation by 80-90 percent. However, dust prevention did decline over time, following the addition of other constituents (mineral and nutrient enhancements), ultimately yielding 60-70 percent dust reduction by the end of the study (Figure 3).

Fig. 5: SSP dust reduction over time: *DUSTROL 4010-B* coating applied at ambient temperature versus a hot applied high-viscosity coating



Source: ArrMaz

Fig. 6: Effects of coatings on the caking of MAP: *DUSTROL 4010-A* versus a medium-viscosity coating



Source: ArrMaz

New *DUSTROL 4010* low-viscosity coatings

ArrMaz has developed new *DUSTROL* low-viscosity coating technology. These coatings offer high-performance dust and caking control. They do this by combining the handling property advantages of a low-viscosity coating with the superior dust generation and caking control offered by medium- to high-viscosity coatings.

DUSTROL low-viscosity coatings reduce fertilizer clumping by providing excellent spreadability and coating distribution. The coatings have a viscosity of 50-300 cP (25°C/77°F). This eliminates the need for heated tanks and heat traced lines under most operational conditions, thus yielding significant energy and cost savings.

Table 2: *DUSTROL* low-viscosity coatings: summary of their performance benefits over conventional coatings

Coating viscosity	Performance		Storage & handling difficulty		
	Dust reduction	Caking reduction	Spreadability	Heating	Fertilizer Clumping
High	5	3	1	1	1
Medium	3	2	2	2	2
Low	1	1	5	5	5
<i>DUSTROL 4010</i> (low)	4	4	5	5	5

5=best, 1=worst

Source: ArrMaz

In MAP production, a medium-viscosity coating (>800 cP @ 140°F) is typically applied to hot substrate and requires additional heat for optimal spray distribution. Usually, the substrate is subsequently top-coated with a low-viscosity coating in warehouses prior to distribution. Moving to *DUSTROL* low-viscosity coatings, in contrast, offers significant logistical advantages as well as energy cost savings as they can be applied as a single coating during both production and shipping.

Over a six-week period, the application of *DUSTROL 4010-A* low-viscosity coating to MAP has been shown to yield the greatest average dust reduction (80%), relative to other medium- and low-viscosity coatings, when applied at a dosage rate of 4 lb/ton (Figure 4). These results equate to 48 percent and 29 percent less dust, respectively, than the equivalent low-viscosity and medium-viscosity coatings. Interestingly, even the application of 75 percent more additional medium-viscosity coating yielded only a slight improvement (+3% points) relative to granules coated with *DUSTROL 4010-A*.

Single superphosphate (SSP), although produced hot and prone to dust generation, is often stored uncoated in warehouses initially. A high-viscosity coating is subsequently applied hot prior to transport for protection along extended supply chains.

Initially, during a six-week coating study with SSP, a high-viscosity coating did achieve a slightly better dust reduction performance than *DUSTROL 4010-B* low-viscosity coating. However, *DUSTROL 4010-B* did eventually outperform the high-viscosity coating over time, managing to maintain dust reduction at 86 percent after 13 weeks, while the dust reduction of the high-viscosity coating declined steadily to 83 percent over the same period (Figure 5).

Caking is also a serious problem as many hygroscopic fertilizer substrates readily absorb moisture from the air. While traditional dust control coatings do provide some caking reduction, *DUSTROL 4010-A* has the potential to offer additional protection. For MAP, coating with *DUSTROL 4010-A* achieved an 80 percent reduction in caking, for example. That is a large improvement (+21% points) on the 59 percentage caking reduction achieved by the medium-viscosity coating, relative to the uncoated fertilizer (Figure 6). These results demonstrate the clear potential of *DUSTROL 4010-A* as a substitute for more

costly anti-caking additives to phosphate-based substrates, reducing or eliminating their use.

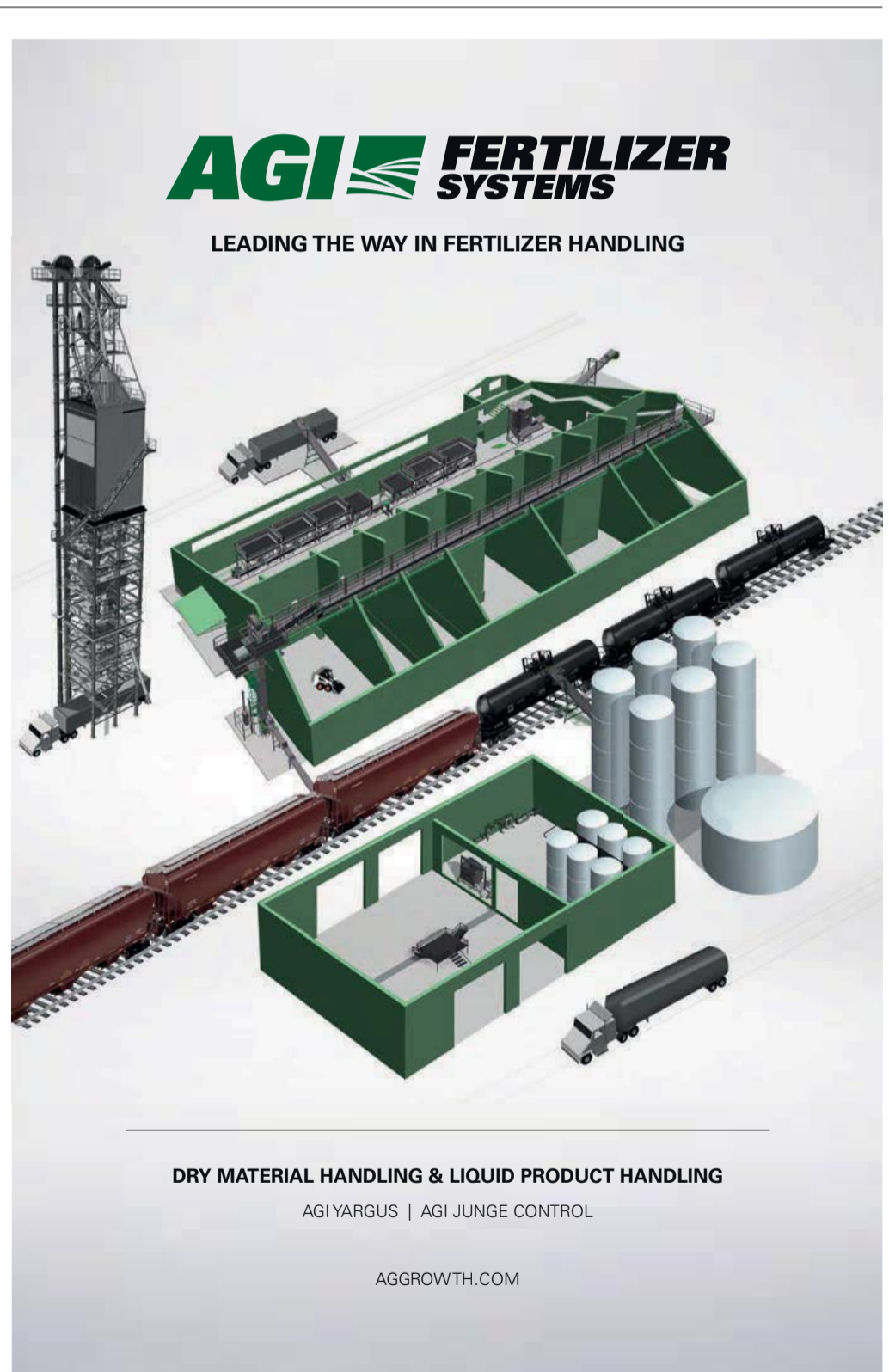
Summary

ArrMaz's novel *DUSTROL* low-viscosity, superior performance coatings possess the handling properties of low-viscosity coatings, while matching the dust generation and anti-caking performance of medium- and high-viscosity coatings (Table 2). Due to their low viscosity,

these new *DUSTROL* coatings also provide energy savings by avoiding the need for heating tanks and lines, while still maintaining optimal coating performance and spreadability. ■

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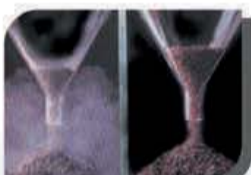
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