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## Excellence through innovation

EGA reduction cell and pot control technologies

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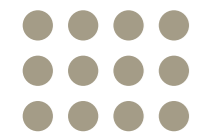
## Delivering more, without compromise

**From the day it poured its first metal back in 1979, Emirates Global Aluminium (“EGA”) has been committed to continuous innovation in the aluminium smelting process. Using proprietary, in-house developed technology, the company has built a reputation for technological innovation and business performance excellence.**

The result is the world’s best quality aluminium products, made to order and delivered direct to customers, while achieving maximum operating efficiencies. EGA’s products and technologies are used around the world in sectors including automotive and aerospace manufacturing, consumer electronics, food and beverage packaging and the construction industry.

For EGA, optimising energy efficiency is a key strategic objective that aims to minimise operational impact on the environment

while ameliorating the significant cost of energy. These factors have underpinned the development of advanced technologies that not only increase productivity, but also reduce an aluminium plant’s impact on the environment through improved energy-efficiency and reduced emission levels. Innovating and using these technologies is integral to EGA’s drive to ensure long-term competitiveness in an industry that is sensitive to product quality, costs, and increasingly, environmental performance.



## More metal, more responsible profits

**The proprietary reduction technologies developed in-house by EGA have made the company a respected competitor in this sector of the global aluminium industry. Indeed, EGA's new-generation DX+ Technology and DX+ Ultra Technology rank among the most efficient reduction cell technologies currently available.**

First developed in 2006 at EGA's Jebel Ali Operations, the first generation of DX Technology was installed in a dedicated industrial 40-cell potline in 2008 and has performed well above the design criteria ever since. The cells began operating at 340 kA, reached 390 kA in February 2014 and 415 kA in May 2016. DX Technology was also implemented in the 756 cells of EGA's Al Taweelah Operations Phase I, which currently operate at 395 kA, with performance levels surpassing projections to provide nominal production of 840,000 tpa.

A project to build the next-generation cells, operating at even higher amperages and offering further optimised performance levels, led to the development of DX+ Technology, which is based directly on the proven, inherently robust DX Technology.

DX+ Technology offers similar advantages to DX Technology in terms of current efficiency, energy consumption and environmental performance indicators; as well as the added advantage of higher productivity at a lower capital cost per installed tonne of capacity. Five cells built in the Eagle pilot line at Jebel Ali Operations began operating DX+ Technology at 420 kA in 2010, with the amperage being increased in successive increments to 450 kA by the end of 2013. DX+ Technology was installed in Al Taweelah Operations Phase II (444 cells in a single potline), which was fully commissioned by mid-2014. It began operating stably at 440 kA and has been operating at above 460 kA since April 2016.

Building on the legacy of DX Technology, the industrial version of DX+ Technology offers several operating benefits:

- Superb productivity of about 3.50 tonnes/pot/day, on average, at exceptionally high purity levels (about 99.94%). This gives rapid returns on investment, plus excellent creep potential, promising even better yields per pot.
- An energy-efficient design that enables specific energy consumption of around 13.45 kWh/kg Al and current efficiency above 94.0 per cent. This saves energy and reduces operating costs.
- Reduced environmental impact through lower fossil fuel consumption (a direct benefit of enhanced energy-efficiency) and reduced carbon consumption (anodes) of less than 0.415 kg C/kg Al. Moreover, the anode effect ("AE") frequency of DX+ Technology cells is very low (less than 0.10 AE per pot per day) but more importantly, EGA's proprietary advanced control logic restricts the average duration of AEs to less than 10 seconds. This results in PFC emissions of below 20 kg CO<sub>2</sub>eq/t Al (a world benchmark for lowering PFC emissions).
- Fully engineered versatility, allowing operating capability plus inherent potential for developing even higher amperage performance capacity.

The transfer of DX and DX+ Technologies for Al Taweelah Operations Phases I and II played an instrumental role in synergising the UAE's two major aluminium giants and their integration to become EGA. Other smelters have also shown interest in EGA technologies, with DX+ Technology selected by Aluminium Bahrain ("ALBA") in December 2012 for its Line 6 Bankable Feasibility Study. ALBA subsequently selected DX+ Ultra Technology for the project.



## Dx+ Ultra: achieving greater energy efficiency

Further efforts to develop even lower energy, high amperage reduction cells have led to the design of DX+ Ultra Technology. By introducing various voltage drop initiatives that address the key energy consumers in a reduction cells, DX+ Ultra Technology will achieve substantially reduced specific energy consumption than earlier generation cells.

Enhancements to overall cell design will enable shorter pot-to-pot distance, in turn translating into lower CAPEX per installed tonne of capacity and higher production per building surface area.

DX+ Ultra industrial cells will operate at above 440 kA with specific energy consumption of less than or equal to 12.5 kWh/kg. In 2014, five DX+ Ultra Technology demonstration cells were built and commissioned in the Eagle demonstration line, replacing the five DX+ Technology cells.

### EGA reduction technologies at a glance

DX TECHNOLOGY		
	DX Technology (EGA demonstration line)	DX Technology (Al Taweelah Operations Potlines 1 and 2)
Amperage	407.3 kA	395.4 kA
Specific energy consumption	13.25 kWh/kg Al	13.44 kWh/kg Al
Current efficiency	94.1 per cent	94.0 per cent
Output	3.09 t Al/pot/day	3.00 t Al/pot/day
AE frequency	0.18/pot/day	0.06/pot/day
PFC emissions **	16 kg CO <sub>2</sub> eq/t Al	27 kg CO <sub>2</sub> eq/t Al
Carbon consumption	0.412 kg C/kg Al	0.416 kg C/kg Al
Aluminium purity	99.93 per cent	99.92 per cent

DX+/DX+ ULTRA TECHNOLOGIES		
	DX+ Technology (Al Taweelah Operations Potline 3)	DX+ Ultra Technology (EGA Eagle pilot line) Jan to June 2016
Amperage	460.2 kA	454.8 kA
Specific energy consumption	13.44 kWh/kg Al	12.75 kWh/kg Al
Current efficiency	94.2 per cent	95.1 per cent
Output	3.49 t Al/pot/day	3.48 t Al/pot/day
AE frequency	0.08/pot/day	0.009/pot/day
PFC emissions **	14 kg CO <sub>2</sub> eq/t Al	5 kg CO <sub>2</sub> eq/t Al
Carbon consumption	0.410 kg C/kg Al	0.402 kg C/kg Al
Aluminium purity	99.94 per cent	99.93 per cent

\*\* PFC is calculated



# Optimising energy consumption through modernisation

EGA's intensive research and innovation has given the company the expertise to retrofit older potlines. This has been successfully demonstrated in a pilot project within DUBAL's Potline 1, where seven D18 Technology cells were completely modernised. Based on this success, EGA has retrofitted the remaining 513 D18 cells with D18+ Technology.

The new D18+ Technology cells are the product of extensive in-house modeling and engineering aimed at incorporating more modern technologies and offer improved performance and economic competitiveness. Net specific energy has reduced from approximately 15 kWh/kg Al to about 13 kWh/kg Al; and current efficiency is above 95 per cent. Coupled with EGA's proprietary cell control logic, the AE frequency of the new D18+ Technology cells is below 0.05/cell/day, thereby containing PFC emissions to less than 50 kg CO<sub>2</sub> eq/t Al - placing D18+ Technology on par environmentally with EGA's advanced high amperage technologies.

EGA has the capability to offer its expertise in retrofitting older potlines and would provide similar support and services as part of a Technology License Agreement, as offered for DX and DX+ Technologies.

## D18+ TECHNOLOGY

	D18 Technology PPF	D 18+ Technology	D 18+ Technology Design projected
Amperage	206.1 kA	209.4 kA	230 kA *
Specific energy consumption	14.74 kWh/kg Al	13.4 kWh/kg Al	13.08 kWh/kg Al
Current efficiency	94.6 per cent	93.1 per cent	95 per cent
Output	1.57 t Al/pot/day	1.57 t Al/pot/day	1.76 t Al/pot/day
AE frequency	0.21/pot/day	0.07/pot/day	0.10/pot/day
PFC emissions **	80 kg CO <sub>2</sub> eq/t Al	28 kg CO <sub>2</sub> eq/t Al	45 kg CO <sub>2</sub> eq/t Al
Carbon consumption	0.421 kg C/kg Al	0.417 kg C/kg Al	420 kg C/kg Al
Aluminium purity	99.90 per cent	99.93 per cent	0.420 per cent

\* There was no booster on the D18+ pilot section, but design amperage is 210 kA

\*\* PFC is calculated





## A complete and sustainable solution

The cost/tonne to construct a smelter incorporating DX+ and DX+ Ultra Technology is highly competitive when compared to other technologies, while the construction period is also significantly shorter. Dependability, prolonged pot life and improved workforce output further contribute to reduced operating expenditure and lower total cost of ownership. These factors, together with increased productivity, improved energy efficiency and reduced environmental impact, mean that DX+ and DX+ Ultra Technologies provide truly sustainable solutions.

Importantly, EGA has the capability to supply complete end-to-end smelter solutions, comprising advanced bankable technology, engineering, project development, long-term raw material supplies, a worldwide marketing and sales network, training and award-winning operational excellence.

EGA also provides comprehensive support to each project where its technologies are deployed. Experienced support teams are seconded to projects, and an engineering package of more than 800 documents – including manuals, drawings and training – is provided as part of EGA's Technology License Agreement for DX+ and DX+ Ultra Technologies.

Each agreement is tailor-made to client requirements. It includes training of supervisory and non-supervisory personnel, as well as on-site services by EGA advisors during the engineering, construction, start-up and early operational phases.

In addition, fully-developed potline and pot management solutions based on EGA's innovative pot control systems are installed with EGA Technology cells; thereby eliminating dependence on other technology suppliers to bring further capital- and operating expense benefits. The EGA pot control system can also be purchased independently, for retrofit to other pot technologies.



## Pot control technologies

EGA's state-of-the-art Pot Control System utilises a Programmable Logic Controller ("PLC") to control and monitor a group of pots in a Potline. The PLC is the heart of the system; it controls the breaking and feeding of pots, anode movement, noise control and anode effect quenching.

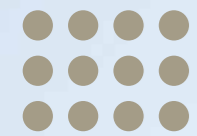
The PLC is standard off-the-shelf industrial hardware, using proprietary EGA-developed application software. It is connected to a field-mounted Human Machine Interface ("HMI") to enable operator interaction during normal operations and upset conditions of the Pot. The HMI enables the operator to perform various routine operations and enter measured process data, and provides alarming, trending, pot status and maintenance information.

The Pot Control System is bundled with EGA's proprietary iPOTS software program for remote monitoring and supervisory control of the pots.

iPOTS is used by potline operations personnel to monitor and control operational parameters in the pots. The default screen shows a group of pots or a whole potline at a glance. In addition to the pot information, iPOTS displays alarms and events and total voltage and amperage of the potline.

iPOTS allows operators to view the status, statistics (history), trace, graphs, constant parameters and reports at pot, section and potline level. In addition, iPOTS also allows operators to modify pot control parameters for a single pot, or a range of pots.





## About EGA

Emirates Global Aluminium (“EGA”) is a jointly-held, equal-ownership company formed by Mubadala Development Company of Abu Dhabi and the Investment Corporation of Dubai by combining their respective aluminium industry interests. EGA’s core midstream operating assets are Dubai Aluminium (“DUBAL”, also known as Jebel Ali Operations) and Emirates Aluminium (“EMAL”, also known as Al Taweelah Operations), whose combined annual production capacity of 2.4 million tonnes per annum (“tpa”) places EGA among the top five primary aluminium producers in the world, (outside China). The UAE-based EGA also owns Guinea Alumina Corporation (“GAC”), a strategic bauxite mine and alumina refinery development project in West Africa; and is currently developing the UAE’s first alumina refinery at Al Taweelah. In addition, EGA has plans for significant local growth and international expansion.

Jebel Ali Operations, where commissioning began in 1979, operates one of the world’s largest single-site primary aluminium smelters. The Jebel Ali Operations complex, built on a 4.75 square kilometre site in Dubai, comprises a 1.05 million tpa smelter, a 2,350 MW power station, a large carbon plant, extensive casting operations (more than 1.2 million tpa), a water desalination plant, dock and other facilities.

Al Taweelah Operations, where commissioning began at the end of 2009, is the world’s largest single-site primary aluminium smelter. The Al Taweelah Operations complex, housed on a 6 square kilometre site in Abu Dhabi, comprises a 1.38 million tpa smelter, a 3,100 MW power station, a large carbon plant, extensive casting operations (more than 1.8 million tpa), a water desalination plant, dock and other facilities.

The EGA portfolio comprises high quality primary aluminium products in three main categories: high purity and foundry re-melt products (for electronics and aerospace and automotive applications respectively); rolled products (for packaging, lithographic sheets and the automotive industry); and billets for extrusion and forging (for construction, industrial, transportation and automotive purposes). Busbars and anode bars are also made for the electrolytic process used to produce primary aluminium from alumina ore. Over 300 customers are served in at least 60 countries, predominantly in Asia, Europe, the MENA region and the Americas.

