

Potlines Extension Project in EGA Al Taweelah Smelter

Abdallah Abdelrahman Rahbar¹, Kamel Al Aswad², Ishaq Al Kharusi³, Shaikha AlShehhi⁴, Yousuf Ahli⁵, Abdalla Alzarooni⁶, Nadia Ahli⁷, Najeeba Al Jabri⁸ and Sergey Akhmetov⁹

1. Senior manager Potlines DX+
2. Director Potlines DX
3. Sr. Superintendent Potlines DX
4. Senior manager Process Control
5. Senior Vice President Reduction
6. Vice President Technology Development & Transfer
7. Manager Technology Transfer Contracts
8. Vice President Technical
9. Executive Vice President Midstream

Emirates Global Aluminum (EGA), Al Taweelah, Abu Dhabi, United Arab Emirates
Corresponding Author: arahbar@ega.ae

Abstract

DX technology is operating in Potlines 1 and 2 in EGA Al Taweelah smelter, and DX+ technology in Potline 3. The three potlines were expanded by 66 pots in a brown field expansion project, named P100. 52 DX pots were added in Potlines 1 and 2 and 14 DX+ Ultra pots in Potline 3. This project increased the production capacity in Al Taweelah smelter by approximately 80 thousand tonnes per year. This paper will describe the brown field execution and coordination including equipment upgrade. It will also include pot start-up and early operation, including the cut-out pots in the existing potlines, operational KPIs for each technology and the challenges during the project. It will cover critical decisions made to minimize the production losses and impact on the process during construction.

Keywords: EGA Al Taweelah brownfield potline expansion, DX technology, DX+ technology, DX + Ultra technology, Early operation pot performance KPIs.

1. Introduction

EGA is the largest industrial company in the UAE outside oil and gas and the world's biggest 'premium aluminium' producer. EGA is an integrated global aluminium producer, with operations from mine to metal. EGA operates aluminium smelters at Jebel Ali in Dubai and at Al Taweelah in Abu Dhabi, an alumina refinery in Abu Dhabi and a bauxite mine and associated export facilities in the Republic of Guinea. The two aluminium smelters had a combined production capacity of some 2.5 million tonnes of cast metal in 2021. The smelter in Jebel Ali has seven potlines operating six EGA-developed cell technologies: D18+, CD20, D20, D20+, DX and DX+ Ultra.

The smelter in Al Taweelah was built in two phases, Phase 1 included Potlines 1 and 2 (PL 1 and PL 2) and the second phase (Phase 2) was Potline 3 (PL 3). The three potlines totalled 1200 reduction cells prior to the extension. The potlines are operating with three technologies: DX in Potlines 1 and 2, DX+ in Potline 3 and DX+ Ultra in the most recent extension of Potline 3 [1]. The extension project involved the extension of all three potlines, with a total of 26 pots added to potline 1 and 2 respectively and 14 pots added in Potline 3. It added an estimated total metal production capacity of approximately 80 000 tons of hot metal per year. Table 1 gives the potlines data before and after the extension.

Table 1. Potlines data.

Description	Unit	Potlines 1 and 2	Potline 3
Before potline extension			
Number of potlines		2	1
Total number of pots		756	444
Number of pots per potline		378	444
Potline current	kA	42.2	465
Potlines extension - FEED study			
Additional pots per potline		26	14
Total number of additional pots		52	14
Number of pots per potline		404	458
Total number of pots		808	458
Potline current	kA	425	465

2. Brownfield Start-up Plan

2.1 Brown Field Complexities

The brown field start up carries with it a lot of complexities and bottlenecks. Assessment of the potline extension impact on the reduction main areas and/or equipment such as potline substation, gas treatment center, pot feed system, and potroom equipment was performed. It was established that facilities would be suitable for the increased capacity, considering the optimised modifications. The work has to take place keeping the current conditions of the potline operation. One of the main challenges of the potline extension is that it requires relocating the existing busbar crossover between two potrooms to the end of the extension while keeping the busbars energised for the existing potlines. This could represent an electrical hazard with operating amperages 420-465 kA. This requires engineering of the electrical insulation requirements for work in space-limited areas on different pot-to-earth potentials.

Contingency plans were set to accommodate a variety of emergency scenarios for pots in operations that can occur during the project execution. All existing buried services and new required services were identified considering the system capacities and any required upgrades. The Potline 3 extension involved tie-in of the new DX+ Ultra technology with the existing DX+ technology. That required a major upgrade in some of the critical equipment which challenged operations due to the equipment availability during the upgrading. In addition, complex safety and coordination requirements had to be followed to get safe access and execute the daily tasks with minimal disturbance to running operations.

2.2 Planning and Decision Making

The team (Hatch and EGA Capital Projects and Operations) considered the above requirements while preparing a suitable execution plan. The first decisions were made on the 66 extension pots layouts in both existing phases of operations, Phase 1 and Phase 2. The requirements in Phase 1 were more or less straightforward where 13 pots were distributed equally on every east side of the 4 potrooms for a total of 52 pots (Figures 1 and 2). The remaining 14 pots for Phase 2 were designated to one potroom only and that decision was taken based on many aspects (Figures 3 and 4):

- Optimising the civil work requirements by building 1 potroom extension instead of 2
- Reducing the access and operational disturbance to 1 potroom
- Optimising equipment upgrade and utilisation
- Optimising workforce by focusing to 1 potroom

Another important decision was to construct the new extension pots infrastructure building/ civil work just after the existing building, instead of continuing from the last existing pot. The following were considered:

- Complex buildings and floor electrical insulations requirements
- Production loss during civil construction stage as last operating pot need to be taken out of service
- Significant disturbance to potlines operations with limited access and high number of heavy equipment mobilisation and movements
- Risk to people working in the vicinity of energised potline and the construction zone where insulations were not fully established yet.

It was decided to extend Phase 1 with the same DX technology. Only a modification of the cathode bus bar was introduced to decrease external (busbar) voltage drop.

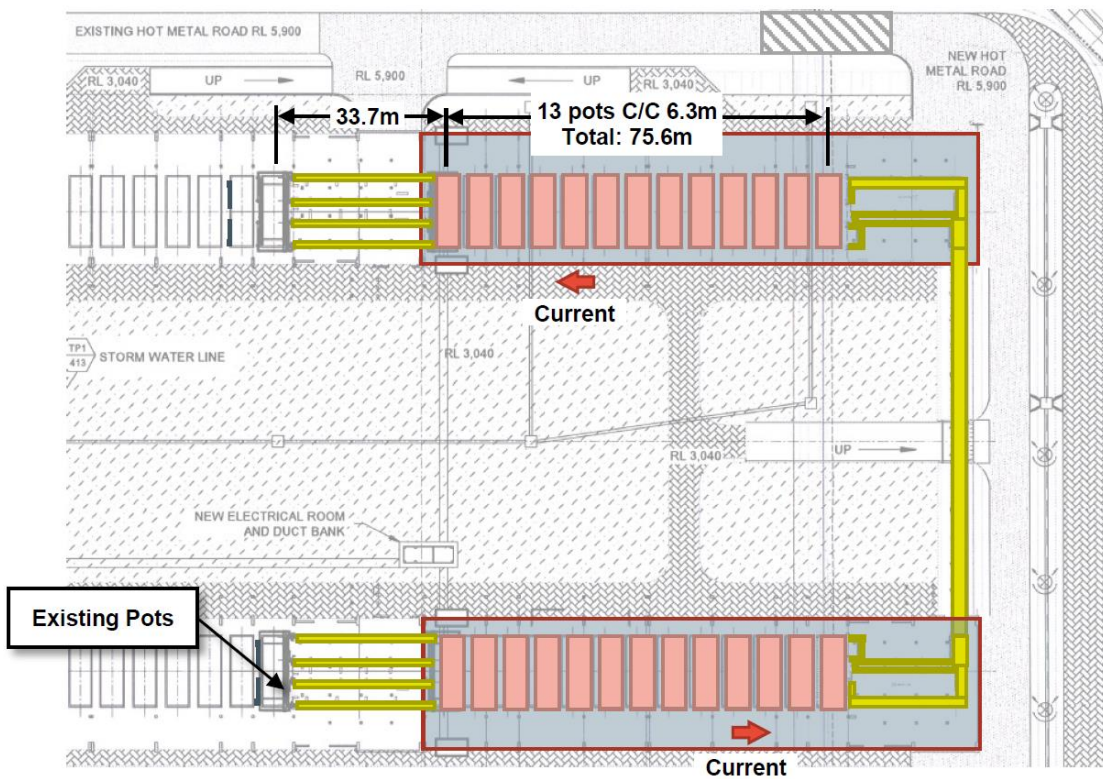


Figure 1. PL 1 and 2 extension layout.

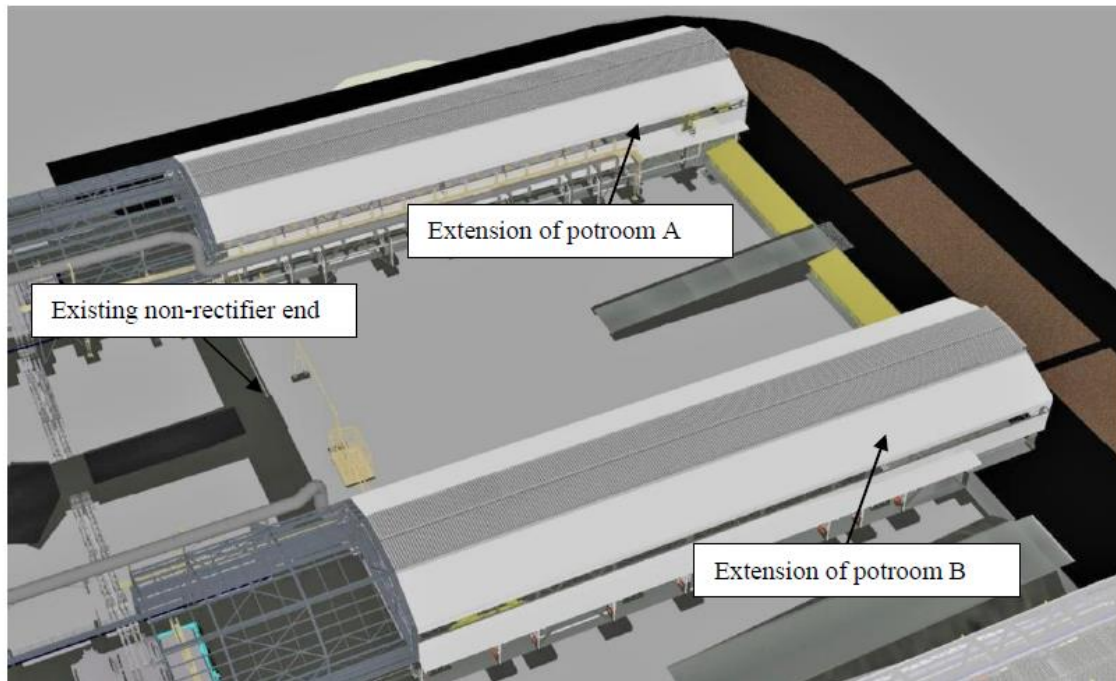


Figure 2. 3D Extension Layout for PL 1 and 2 [1].

EGA's latest industrialised technology, DX+ Ultra, was selected as the the operating pot technology for the Phase 2 extension. In addition, a strategic vision of operating Potline 3 at 500 kA in the future supported this decision, in spite of the modifications required on some existing Pot Tending Machines (PTMs), Anode Beam Raising Equipment (ABRE), pot preheat equipment, and the PTM transfer gantry.

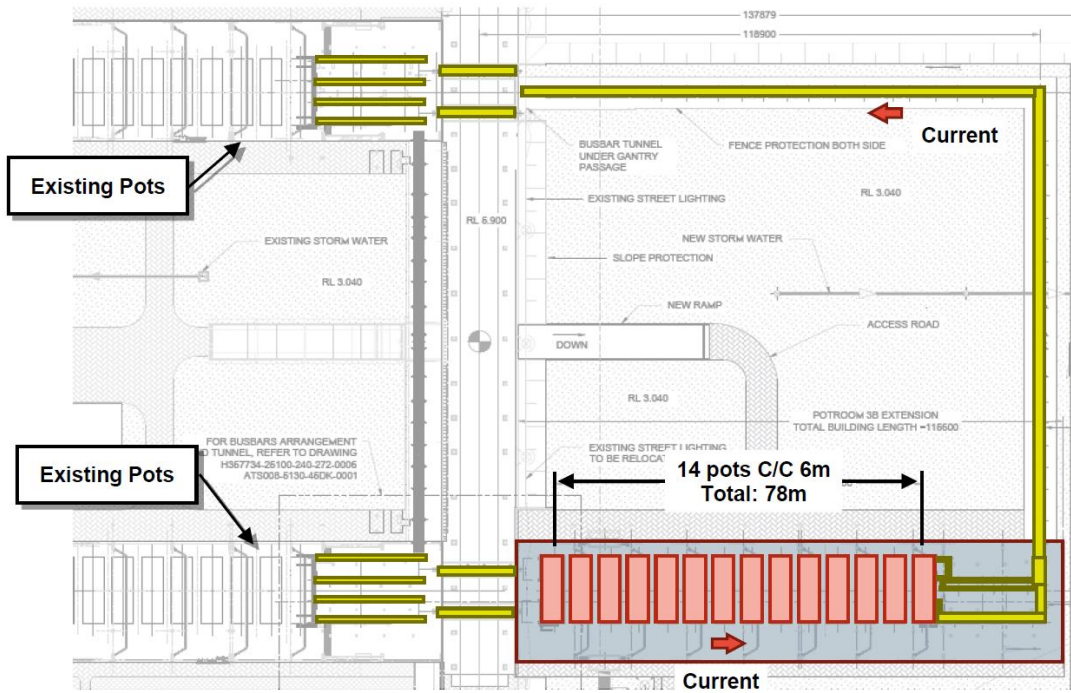


Figure 3. PL-3 Extension layout.

The plan also included laying a Temporary Cross Over Busbar (TCOB) to bypass the last 3 operating pots in each room. This was required to ensure de-energisation of the portions of the bus bars that were to be connected to the new pots. This also provided safe working conditions for busbar welding, and reduced the magnetic field to allow for high welding quality.

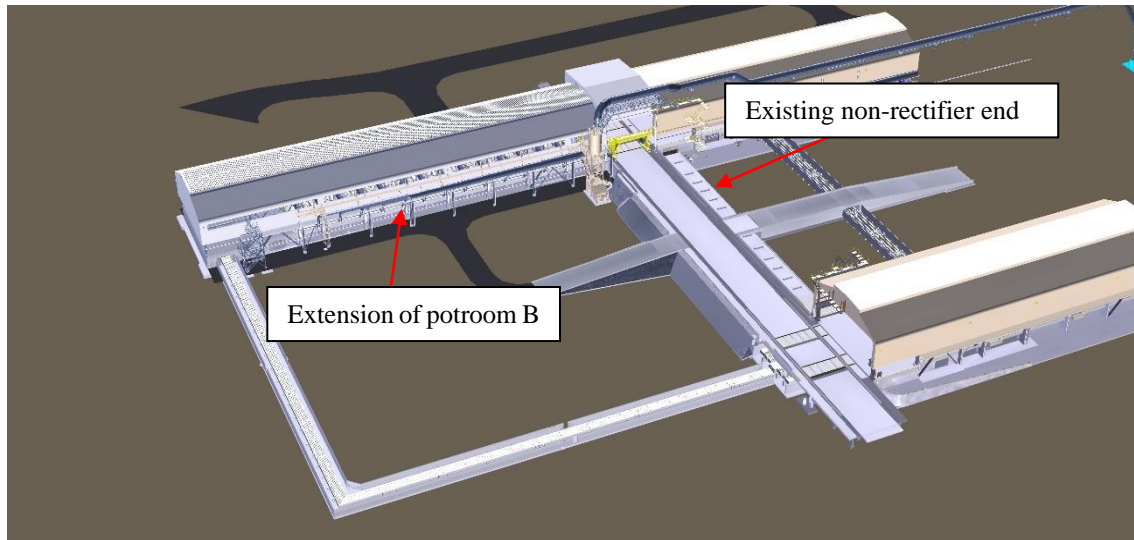


Figure 4. 3D extension layout for PL-3 [1].

3. Operational Challenges

The extension project was executed on time despite many challenges during the project execution. In this section we are going to talk about some of the challenges that were encountered during the project.

3.1 Crossover Installation

To connect the existing pots to the new extension, remove the existing busbar crossover and carry out the demolition and modification works in the existing east end passage, a temporary crossover was required for each potline (Figure 5) [1]. Installing the Temporary Crossover Busbar (TCOB) required extensive safety precautions and measures in addition to meticulous planning and coordination. The courtyards had to be prepared with temporary electrical insulations to prevent any earth leakage incidents throughout the 3-week construction period. Moreover, pot cut-out should be planned in the right time to ensure minimum production loss and avoid project delays. The last 3 pots at the end of the potrooms were cut out as part of the plan. This was followed by immediate pot replacement, installation of new shell and activation of some essential pieces of TCOB inside the potrooms. These parts were installed using PTMs and construction overhead crane. Close coordination between many operations departments was required to ensure safe and timely execution of this task.

Potline power reduction was required to energise the TCOB. Continuous measurements were conducted to ensure the amperage sustainability and effectiveness of temporary electrical insulations. The activities were executed in spite of operational challenges in Phase 1 which created additional limitation for materials and PTM availability to perform the above tasks.

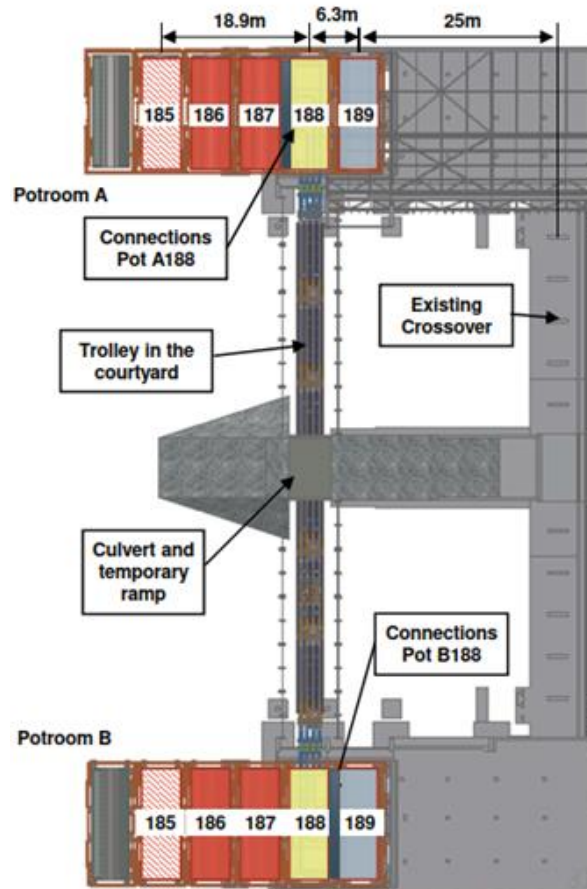


Figure 5. Phase 1 TCOB layout [1].

3.2 Cut-Out Pots

Three pots at the end of each room in Phase 1 and four pots in Phase 2 were cut out as part of the project bus bar tie-in requirements. This was executed safely and on time as planned with minimal disturbance to the operations. However, some challenges arose in operating neighbouring pots next to the temporary cross over. Additional 2 pots in each potline were affected due to the magnetic field increase from the temporary crossover. This change introduced high MHD instability and required to stop these 2 pots.

Some operational challenges in the two potlines evolved which could contradict with the project plan. Some pots were abnormal, and operations were busy restoring and normalising the pots. At the same time, some pots were cut out on regular schedule of old pot replacement. This put high strain on the traffic in operating sections and decreased the availability of PTMs for the extension project, which was on a tight project timeline. Many regular pots were cut out longer than usually. Despite all the challenges, the project was executed on time through close coordination and engagement from all teams.

3.3 Equipment Modifications in Phase 2

In Phase 2, three out of the 15 PTMs needed modifications as part of compatibility design to operate DX+ Ultra technology. This induced PTM shortages for normal operations, some breakdowns, and for the construction of the 14 new pots, a few PTM breakdowns as well as the additional cut-outs of normal pots.

In addition, one out of three Anode Beam Raising Equipment (ABRE) was. This affected the availability of ABREs in the potline. Additional transportation of this huge equipment in different passages had to be provided by a trailer equipped with all safety measures. Moreover, an additional electrical panel was installed to operate the gantry as bridge in the same potroom and use the available fuel-based system as redundancy.

3.4 Pot Constructions Logistics

During civil construction most of the access was granted with no conflict with operations. The challenge arose during potshell and superstructure installation in addition to TCOB assembling. Entry and exit through the sections were only through the specialised overhead cranes and PTMs. This meant disturbing all operations activities by moving PTM to provide access for the cranes at the end of the potroom. The conflicting demands were effectively managed:

- Project potshell transportation
- Superstructure transportation.

All potshells in Phase 1 were transferred from the center passage to the expansion area at the end of the potroom. Close coordination between the operations team and project team was established to decide the right transferring time frame. Phase 2 potshells were brought by trailers directly to the project area as there was a transfer gantry at the east end next to the project area.

The superstructures were routed directly to the project location at the end of the room with trollies and with the available construction crane at the site. This was introduced to reduce the disturbance on routine and non-routine operations.

4. Pot Start-up

4.1 Busbar Energization

The busbar energization was executed according to the plan. The cut-out pots due to operational instability caused by TCOB, were started up ahead of time. In Potline-3, there was a delay of two weeks in bus bar energisation due to the delay in the TCOB associated civil works.

4.2 Start-up Plan and Start-up Rate

A plan was prepared for fast start-up rate of 2-4 pots per day. The responsibility of the start up team was to coordinate preheat and process control, follow up on bath generation, carry out bath-up and metal pouring, as well as pot early operation and control. Milestones were met despite some delays. In Potline 1, the bath up was started on 5 May 2021 and completed on 19 May 2021. The initial plan involved starting up the pots in both potrooms to complete the task in 1 week (1-2 pots per potroom). However, a change of plan was necessary as pot feeding system was not ready in B room by the time of bus bar energisation. Therefore, 13 pots in A room were started first. In parallel, the project team was working in B room to commission the pot feeding system. To overcome this delay, start up rate per room was increased to 2-3 per potroom to mitigate

production loss. This put more pressure on a single room operation, which was managed with additional allocation of resources.

In Potline 2, pot start ups commenced on 10 July 2021 and completed on 27 July 2021, following a similar strategy to Potline 1. However, extra resources and planning were put in place to accommodate the additional challenges associated with the normal pot replacement.

In Potline 3, the bath-up started on 6 November 2021 and completed on 7 December 2021. There was a delay compared to the plan of almost 3 weeks. One of the contributing factors was the delay in the GTC fume duct installation. This limited the capacity of GTC gas suction and in turn restricted the number of pots to be started. In addition, there was a delay in commissioning of the pot feed system which slowed down the remaining pot start-ups.

Bath generation was managed from existing line at the beginning and then from the new cells in the project. There was a designated team to follow up on the bath-up and early operation. The team ensured smooth commissioning of new cells as well as provided sufficient bath. Bath donor pots were also closely monitored to ensure their operational stability.

5. Improvements and Performance Expansion Pots

Pots in both phases have delivered expected KPIs and delivered the expected production performance.

5.1 Production KPIs

The projected production capacity is expected to be 78 000 tonnes per year which is achievable based on the current trends by the end of 2022. The additional contribution from the extension project is will be higher in the future due to the planned amperage increase.

DX technology is currently operating at 435 kA and DX+ Ultra is at 465 kA. Figure 6 shows the increase in the amperage and the increase in production associated with the expansion project. Potline one and two contributed additional monthly production from May and June 2021, respectively, due to the expansion project. Potline 3 has contributed hot metal from November 2021 onward.

5.2 KPIs for Established Pots until 31 July 2022

Table 2 gives KPIs for the expansion pots. The KPIs are for established pots (> 56 days old). All P100 pots were established at the beginning of each period in Table 2, DX pots were all established, but all DX+ Ultra pots were established only from 1 February 2022.

In all three lines, the P100 extension pots have excellent performance. DX (PL 1 and 2) average current efficiency is 94.1 % and DX+ Ultra (PL 3) 94.9 %. In DX pots, net specific energy consumption (SEC) is 13.47 kWh/kg Al and in DX+ Ultra 13.00 kWh/kg Al.

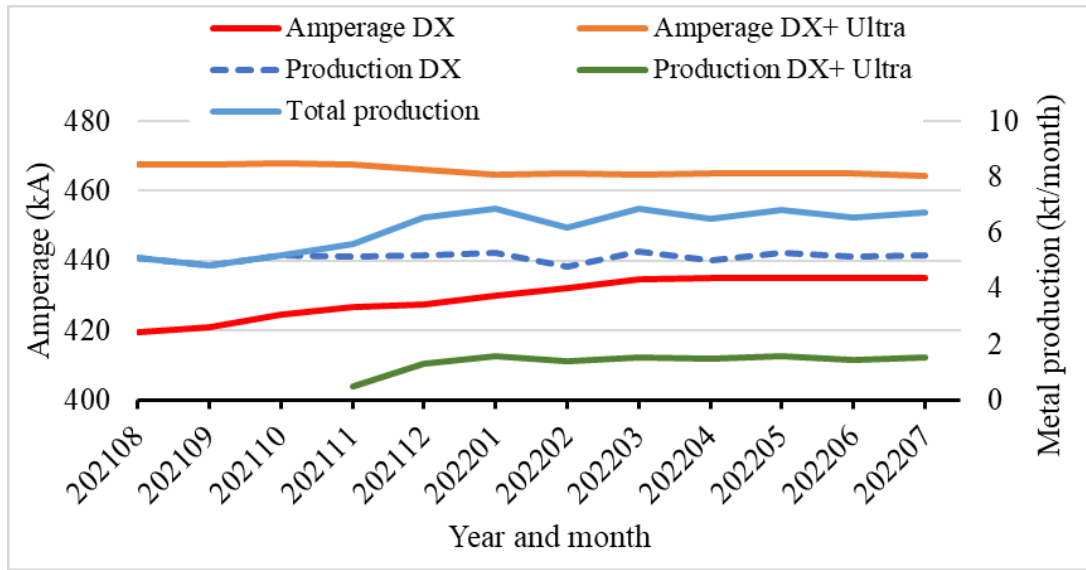


Figure 6. Amperage and monthly hot metal production in potlines extension during the last year from August 2021 to July 2022: DX pots (PL 1 and PL 2), and DX+ Ultra pots (PL-3).

Table 2. Main KPIs of potline extension, from 1 January to 31 July 2022.

Parameter	Unit	PL 1 1 August 2021 to 31 July 2022	PL 2 1 Oct. 2021 to 31 July 2022	PL 3 1 Feb. 2022 to 31 July 2022
Amperage	kA	429.7	431.5	464.8
Current efficiency	%	94.1	94.0	94.9
Metal production	kg/pot-day	3252	3263	3552
Net pot voltage	V	4.254	4.248	4.138
DC net specific energy	kg/t Al	13.47	13.47	13.00
Net carbon consumption	kg/t Al	408	408	413
Gross carbon consumption	kg/t Al	547	550	548
Fe	%	0.074	0.061	0.094
Si	%	0.028	0.027	0.025
Bath temperature	°C	959	959	958
Excess AlF ₃	%	8.5	8.7	10.1
AE Frequency	AE/pot-day	0.050	0.053	0.145
AE duration	s	12.0	9.7	25.0
PFC emissions, CO ₂ equivalent*	CO ₂ eq kg/t Al	11	9	66

* CO₂ equivalent is calculated as in Reference [2], using the Tier 2 method and SAR (Second Assessment Report).

6. Conclusions

EGA successfully added 52 DX pots in Al Taweelah Potlines 1 and 2 and 14 DX+ Ultra pots in Potline 3. This increased production capacity by approximately 80 000 tonnes per year. DX technology is currently operating at 435 kA and DX+ Ultra at 465 kA. The performance of the potline extensions is excellent with 94.1 % current efficiency and 13.5 kWh/kg Al specific energy consumption in Potlines 1 and 2, and 94.9 % current efficiency and 13.0 kWh/kg Al specific energy consumption in Potline 3.

7. References

1. Nicole Teeling, Olivier Charette, Jean-Denis Carrier and Saif Alhashmi, Smelter potline extension at EGA Al Taweelah smelter, *Proceedings of 39th International ICSOBA Conference*, Virtual, 22-24 November 2021, Paper AL03, *Travaux* 50. 647-657.
2. Ali Zarouni et al., DX+ - An optimized version of DX technology, *Light Metals* 2012, 697-702.