Alba Reduction Line 1 Outage and Recovery

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https://doi.org/10.71659/icsoba2025-al010

Abstract

Aluminium Bahrain B. S. C. (Alba) is one of the world's largest single-site aluminium smelters outside of China, operating with six reduction potlines, Alba achieved a record production of above 1.62 million metric t per annum (Mtpa) in the year 2024. Alba experienced a catastrophic power outage on 13 November 2024 that affected Reduction Line 1, Alba's oldest potline. A fire in a critical rectiformer (R16) caused a full line current interruption for approximately 8 h, leading to solidification ("freezing") of electrolytic bath and metal in about 60 % of the line's reduction cells. Conventional industry wisdom suggests that potline recovery becomes extremely difficult after 4 hours without power, and that a full potline shutdown is usually inevitable beyond 8 hours of outage. Defying these odds, Alba successfully restored roughly 40 % of the pots on Line 1 even after this prolonged outage and achieved full line restart in an unprecedented 44 days – a timeframe believed to be the fastest ever for such an event. This paper details the incident and Alba's recovery strategy, including immediate response measures, pot "triage" (sorting) and cleaning innovations, and novel restart methodologies such as the "Crash-Start" process. Through disciplined planning, technical innovation, and extraordinary team effort, Alba not only minimized the production loss but also preserved pot integrity and safety. The outcome offers valuable lessons on emergency preparedness and showcases Alba's resilience and ingenuity in crisis management. Insights from this case are discussed in context of global smelter outage incidents, highlighting how extreme ownership, innovation, and strategic execution can turn a potential disaster into a success story.

Keywords: Aluminium Bahrain Alba, Potline recovery after power outage, Crash-start of Montecatini technology cells, Cell preheating with resistor, Crisis management.

1. Introduction

Aluminium Bahrain B. S. C. (Alba) is known as one of the world's largest single-site aluminium smelters, operating six reduction lines with a total production capacity exceeding 1.62 million tonnes per annum (Mtpa) as of the 2024 fiscal year. All six lines utilize Hall-Héroult prebake cell technology, operating at varying amperages depending on design. Lines 1 and 2, originally commissioned in the early 1970 s with Montecatini technology, began operation at approximately 100 kA and have since been progressively upgraded to around 143–144 kA. Each of these legacy lines comprises of 114 electrolytic reduction cells (pots) connected in series. In contrast, Alba's newer Lines 4 to 6 operate at much higher amperages (ranging from 415 to over 478 kA) and feature modernized cell configurations. Despite their age, Lines 1 and 2 have proven exceptionally robust and reliable, remaining critical to Alba's production strategy.

On 13 November 2024, the resilience of Alba's operations faced an unprecedented challenge. A critical equipment failure and fire at Rectiformer R16—responsible for converting and supplying direct current to Line 1—led to a complete and abrupt power outage at approximately 04:12 a.m. The entire line was de-energized, and despite swift emergency response efforts, power could not be restored for nearly 8 hours. In aluminium electrolysis, such a prolonged loss of current poses a severe risk: without continuous electrical heating, the cryolite-based electrolyte and molten aluminium in the pots begin to solidify. By the time power was partially restored, approximately 60 % of Line 1 pots had frozen, rendering them inoperable and effectively shutting down a majority of the line.

Faced with a potentially catastrophic scenario, Alba's leadership was at a crossroads. Conventional industry guidance suggests that after 6–8 hours of total outage, a full shutdown and potline rebuild is inevitable. However, driven by an unwavering commitment to operational continuity and supported by deep technical expertise, Alba embarked on an aggressive recovery effort. Rather than abandoning the line, the company pursued an ambitious plan to restart all pots in a shortest period. Within just 44 days, a timeline considered extraordinary by global standards, Line 1 was fully restored to normal operations. This paper presents a comprehensive overview of the incident and the strategic measures that enabled this successful recovery.

2. Impact of Power Outage in Aluminium Smelting

Unplanned power outages are among the most perilous events for aluminium smelters. The Hall-Héroult reduction process depends on a continuous supply of high-amperage current to maintain molten aluminium and cryolite-based electrolyte at around 960 °C. When power is interrupted, pots begin cooling rapidly. As the temperature drops, the risk of solidification increases potentially freezing the cell and leading to permanent damage. Industry experience suggests that outages shorter than 2 hours are usually manageable, with sufficient residual heat to restart normal operations. However, beyond 4–6 h, the likelihood of cell freeze rises sharply.

The vulnerability of a smelter during a power outage depends significantly on its cell technology and design. Most modern electrolytic cells are engineered for thermal efficiency with thinner linings and enhanced heat transfer, but this means they also lose heat faster and are at greater risk during prolonged power cuts.

Against this backdrop, Alba's Line 1 outage was particularly critical. The power loss lasted approximately 8 hours at the upper threshold of cell survivability. The successful recovery of dozens of cells under these extreme conditions is a rare and remarkable achievement in the aluminium industry.

3. The Incident

On the 13th of November 2024 at 04:12 a.m., Line-1 which is almost 55-year-old, experienced a complete power trip due to the failure of rectiformer R16 which is responsible of feeding Line-1 and therefore the current has dropped from 144 to 0 kA. This marked the beginning of a prolonged power outage that lasted nearly 8 h, during which the line remained inactive.

Current restoration efforts began at 12:12 p.m., with an initial ramp-up to 50 kA. The line current was then gradually increased in a controlled, stepwise manner to avoid thermal shock and to protect the integrity of the pots. By 1:29 p.m., the current reached approximately 70 kA, followed by progressive increments throughout the afternoon. At 2:30 p.m., it reached 90 kA, and by 3:10 p.m., 100 kA. Continued ramp-up brought the current to 120 kA by 3:40PM and 130 kA by 4:15 p.m.. Full restoration to 140 kA was achieved by 4:41 p.m., successfully completing the recovery process of the line electrical current within 12.5 hours of the initial trip (Figure 1).

- Establish “Crash-Start” as a Contingency Plan for Other Lines

The innovative “Crash-Start” technique, where frozen metal is left in place and melted using gas burners, proved instrumental in reducing recovery time to 44 days. This procedure will be adapted for Lines 4–6 using diesel burners due to the absence of direct gas supply.

- Critical Spares Management

The incident exposed shortages in essential tools, such as pot cutout knives. A comprehensive review of critical spares across all lines will be conducted to ensure readiness during emergencies.

- Enhance Cross-Training and Workforce Flexibility

Operational staff from other lines were unfamiliar with Line 1 systems during the recovery. Cross-training programs will be strengthened to improve adaptability and preparedness during crisis situations.

- Formalize Use of Data Command Centre in Emergencies

Although the Line 1 control room was used during this event, a formal SOP for deploying the Data Command Centre during major incidents will be developed, along with mock drills for familiarization.

- Strengthening Crisis Management Protocols

A more robust crisis management framework will be initiated, including clear communication protocols, data-driven risk detection, and coordinated stakeholder engagement during emergencies.

12. Conclusions

In conclusion, the recovery timeline was significantly compressed from an initial target of 120 days to just 44 days, reflecting a major achievement in strategic execution and process innovation as shown in Figure 5. This success was driven by the adoption of advanced techniques, Crash-Start method, the introduction of new machineries, and the optimization of gas preheating practices. This event has reaffirmed Alba’s reputation as an industry leader in operational resilience, rapid recovery, and technical excellence

13. References

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