# Surviving an Extended Power Outage after a Breakdown in the Sub Station

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**Abstract**



TRIMET Aluminium SE operates the Essen aluminium smelter with three potlines in Germany. On 12 April 2016 a smoke alarm in the substation triggered an emergency shutdown of the whole plant. The smoke alarm was triggered by a short circuit on a 21 kV bus bar. While Potline II and III could be restarted within two hours, the damaged bus bar had to be removed, separating Potline I from the redundant high voltage power supply and fixing it on a single 220 kV transformer. When Potline I was able to be restarted, the 220 kV transformer was found to have an insulation fault. An emergency bus bar replacement was welded in place and Potline I could be re-energized after 5 hours 50 minutes and 30 seconds. Due to the immediate steps taken in the potrooms, any pot loss could be prevented and the potline was back to normal operation in 12 hours.

**Keywords:** Power outage, aluminium reduction, recovery from power outage.

## 1. Introduction

The aluminium reduction process is an electrochemical process operating close to 960 °C. This temperature is necessary to keep the electrolyte in a molten state. Typically, the process temperature is only a few degrees Celsius above the liquidus temperature of the molten electrolyte. The sole heating agent is electrical current pathing through the cell and enforcing the electrolytic reduction of alumina. As soon the heating is interrupted, the cells start to cool and immediately the superheat of the electrolyte is reduced to around zero °C and solidification starts. As pure cryolite starts to solidify first, the concentration of additives in the electrolyte, such as $AlF_3$ increases and in turn keeps the bulk of the electrolyte liquid. As long as enough electrolyte is liquid in all of the cells, the potline can be restarted. Typically, this period is stated as 4 hours by Øye and Sørlie [1] and 3 to 5 hours by Tabereaux [2].

Continuity in electrical power supply is therefore of very high importance for operating a smelter. However, there are regular instances of power outages affecting aluminum smelters. Nevertheless, detailed publications on power outages and their effects on potlines are limited. Øye and Sørlie detail some outages, but seldom is the exact duration or the cause given and measures to preserve heat in the cells or steps taken to re-energize the potline are typically not discussed. Effects vary from little effect, to 10 - 20 % of the production being shut down, to failures of full potlines, References [3, 4 and 5].

Effectively, this limits successes of recovery to the experience (and nerves) of the staff on site. While there can be no universal emergency plan, there are some simple rules and guidelines to at least increase the chances for success for re-energizing the potline.

This paper summarizes the experiences made in Essen during a 6-hour power outage in one of the potlines.

## 2. Course of Events

On 12 April 2016 at 05:10:35 h the full plant dropped off-line while a smoke alarm in the building of the medium-high voltage was detected. The fire brigade was called to investigate the cause and did not find a fire source. After ventilation, maintenance was cleared to enter the building (still devoid of power) and found partly scorched and melted bus bars in the 21 kV switch room.

The damaged section was a redundancy cross link enabling potline I to receive electricity from another than a single 220 kV transformer. Thus, the bus bar was perceived as uncritical for the immediate restart. The damaged section is shown in Figure 1.

**Figure 1. Scorched 21 kV busbar.**

The damaged section was removed and the plant including the compressed air station, cast house and GTC were smoothly restarted. Potline III and potline II could be restarted at 7:23 am and 7:25 am respectively with slightly more than 2 hours power outage.

Potline I could not be energized. Isolating and removing the damaged 21 kV bus bar had isolated potline one on a single 220 kV transformer. When this transformer was switched on, it immediately failed.

With the usual redundancy removed and isolated on a damaged transformer, a contingency plan was needed. The potroom relining department, who also repairs and modifies potroom bus bars when damaged, were called in to prepare an emergency weld to bridge the gap the removed bus bars had created. While this was in preparation the plant was scourged for material that could be used as 21 kV bus bar – both in material quality as well as in diameter and length. Replacement bus bars were welded in place on all three phases and the potline could be reenergized at 11:01am, close to 6 hours after the initial power outage.

Post event analysis showed the course of events leading to the damage as follows:

- In one 21 kV panel for the auxiliary power a cable end sealing of one phase failed in isolation towards earth.
- This led to an arcing short circuit with a neighboring phase.
- About 10 ms later a full 3-phase short circuit developed with a short-circuit current of up to 25 kA.
- About 100 ms later the vacuum power switch disconnected the affected transformer as expected.

failures were recorded on the day of the restart. On that day and the following, 19 anode spikes were found and removed from the cells – 10 of which were in Potline I.

## 6. Conclusions

The Essen smelter survived a major power outage in one of the 3 potlines. The potline was without power for close to 6 hours. The recovery was considered smooth and the potline was operating in a stable condition within 11 hours after restart and electrolyte temperatures normalized within 4 days. The section equipped with Shell Heat Exchangers® showed less impact to the power outage than the rest of the line.

The following key points can be highlighted as critical for this success during the power outage:

- Install an emergency team and communicate all relevant information,
- Retain heat in the cells,
- Do not touch the cells,
- Prepare for all options while there is time (emergency shut-down teams, logistics, on-call response people),
- Prepare electrolyte,
- Prepare hot anodes,
- Distribute the work and name responsible persons,
- Let these people do their job,
- Prepare contingency plans.

During the restart:

- Block alumina feeding for the restart,
- Block automatic AE quenching,
- Buzz down all beams for 1 second when the energy is back.

Last but not least, it should be mentioned that such a crisis cannot be managed if the whole team in the plant is not working hand in hand to solve any issue that might arise. A big ‘thank you’ to everybody who was involved in the restart and the subsequent recovery.

## 7. References


1. Harald A. Øye and Morten Sørlie, Power failure, restart and repair, *Aluminium International Today*, 2011, *http://www.aluminiumtoday.com/contentimages/features/Oyeweb.pdf*, accessed on 5 August 2017.
2. Alton Tabereaux, Electrical power outages and potline recovery with partially frozen bath, *The 35th International Course on Process Metallurgy of Aluminium, Trondheim*, Norway, 29 May – 2 June, 2017.
3. Hydro Årdal power outage has limited effect on production, *http://www.hydro.com/en/press-room/Archive/2016/Hydro-Ardal-power-outage-has-limited-effect-on-production/*, 1 February 2016, accessed on 5 August 2017.
4. Sarmad Khan, Power outage slows Dubai smelter, November 10, 2008, https://www.thenational.ae/business/power-outage-slows-dubai-smelter-1.503397, accessed on 5 August 2017.
5. Power Outage Idles Two of Noranda’s Three Smelters, *http://aluminiuminsider.com/power-outage-idles-two-of-norandas-three-smelters/*, accessed on 5 August 2017.
6. N. Depree, Romel Düssel et al., The 'Virtual Battery' – Operating an Aluminium Smelter with Flexible Energy Input, *Light Metals* 2016, 571-576.