# MIREA – An on-line real time solution to check the electrical quality of anodes

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**Abstract**



Fives ECL has introduced on the market a new tool called MIREA. This tool is used to measure the quality of anodes, which will be used in pot lines for the production of primary aluminium. The system is based on a non-destructive measurement of the anode electrical resistance imitating the current distribution of an anode in use. It is inspired by the work undertaken by Chollier-Brym et al. [1] and numerous measurement campaigns carried out under the supervision of Rio Tinto/AP Technology™ experts since 2012. This technology is now under commissioning in a mature anode plant (Alouette Smelter in Sept-Îles, Québec), who gave a strong support in the industrialization process. MIREA has many advantages compared to the traditional core sampling process. It helps the carbon plant of a primary aluminium smelter to control more effectively its anode production process; all anodes are measured in real time. It also helps the Reduction sector to identify and reject anodes having internal cracks, which could lead to premature failure of the anodes in use or unacceptable energy consumption. Globally, the use of MIREA helps reducing carbon waste and increasing pot performance.

**Keywords:** Carbon resistivity; Anode resistance; Anode voltage drop; Real time measurement.

## 1. Introduction

Anode electrical resistance is increasingly recognized as a key parameter for pot operation. Generally, evaluation of the electrical performance of an anode population is based on weekly resistivity averages taken on a limited number of anode core samples. Few anodes are cored weekly since this operation is time-consuming and destructive. Core sampling also provides limited information on the spatial variability within an anode. For example, cracks in a specific anode section could remain undetected due to the absence of sampling in that specific region. Furthermore, resistivity measurements in smelters are typically based on the ISO standard 11713 [2]. With this standard, the current distribution in the core sample is almost ideal (top-bottom current distribution) and cannot take into account the specific current distribution near the stub hole vicinity [1]. Indeed, current distribution is mostly horizontal in this region of the anode.

Consequently, anode coring methods cannot provide an accurate assessment of the electrical performance of an anode population due to the insufficient number of samples taken every week and the lack of spatial resolution. Furthermore, resistivity results are usually obtained weeks after the introduction of the anode in the pot. Therefore, technical teams in smelters cannot take sound decisions or immediate corrective actions.

For the above-mentioned reasons, an instantaneous and non-destructive R&D device was developed by Rio Tinto to evaluate the contribution of different anode regions on the anodic electrical resistance. The acronym for MIREA is derived from a French translation "Instantaneous Measurement of Anodic Electrical Resistance". The R&D device was initially introduced by Chollier-Brym et al. [1]. In their paper, comparisons were made between the MIREA measures and an intensive anode coring campaign. It was shown that the trend between the MIREA measures and the core samples corresponded in the lower part of the anode. However, the coring samples underestimated the resistivity in the upper part of the anode due to the top-to-bottom current distribution of the core sample, as explained earlier. They also investigated the influence of two forming processes (press and vibroformer) on the anode electrical resistance. This work was followed by a second paper summarizing six MIREA campaigns held at different anode plants around the world [3]. More than 600 anodes were characterized. These campaigns highlighted resistance heterogeneity problems such as highly resistive tops and helped detect non-optimized vibroformers in some anode plants. For example, an important gap of apparent resistivity (~17 μΩm), in the top anode section, was observed between two carbon plants producing a similar anode format. This resistivity difference had never been detected before due to the absence of core samples in this specific region. It should be noted that an important resistivity, in the top section of the anode, will penalize the anode voltage drop throughout the entire reduction cycle since this anode section will always be present.

Following the success of the MIREA campaigns, an industrial version was developed in collaboration with Rio Tinto/AP Technology™ experts, Fives ECL and Alouette Smelter (Sept-Îles, Québec). The first industrial version of this technology is now under commissioning at Alouette. All anodes can be measured in real time to provide not only an electrical resistance estimate of the anode population, but the exact resistance and dispersion of the population itself. Alouette is on track to efficiently characterize its anode production process. Algorithms are now being set up to identify and reject anodes having critical deficiencies leading to premature anode failures in the pots or leading to excessive energy consumption.

This paper presents a first glimpse of the capacity of this on-line process technology by summarizing the resistance measurements of more than 10 000 anodes produced between June and August 2015. A description of the industrial MIREA device is presented in the first section of this paper. This section is followed by an analysis of individual anodes and a statistical evaluation of the Alouette anode population. Finally, a simple straightforward rejection algorithm is proposed as an initial step to identify anodes having critical deficiencies.

## 2. Description of the industrial MIREA

### 2.1. MIREA integration in the process chain

Alouette integrated the industrial MIREA device on their baked anode conveyor servicing two anode baking furnaces in the anode handling area. Consequently, every baked anode produced by the two baking furnaces passes through the MIREA device for measurement or bypass. Anodes rejected, based on the MIREA results, are then redirected to an alternative conveyor to be withdrawn from the production.

The MIREA device was designed to handle anodes exiting the anode baking furnaces at temperatures up to 400 °C. However, it was found that the MIREA is exposed to anode spectrum of the Alouette population, were also performed and showed similar capacities (analysis not included in this paper).

## 4. Conclusion

This paper presented a preview of the capacity of this on-line process technology by summarizing the resistance measurements of more than 10 000 anodes produced between June and August 2015. Alouette smelter is on track to fully characterize the electrical performance of their anode population and control more efficiently the anode production process. It must be added that it was the first time, in prebaked aluminium technology history, that such a large batch of anodes was individually characterized. This achievement represents a major breakthrough in baked anode quality control.

The standard Mahalanobis analysis presented in this paper allowed an initial classification of the anode resistance quality. Other algorithms are now being set up to identify and reject anodes having specific deficiencies leading to premature anode failures in pots or leading to excessive energy consumption. These algorithms will continue to be refined as Alouette obtains more data on the anode performance during the electrolysis cycle.

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