First Years of Operation of the Rio Tinto AP 60 OZEOS Gas Treatment Centre: Solid Results and Promising Future

Bernard Cloutier[1], Jean-Nicolas Maltais[2], Philippe Martineau[3], Raymond Émond[4] and Simon Gaboury[5]

1. Sales Manager, Fives Solios Inc.
2. Consultant, Environmental Technologies Group, Rio Tinto. Jonquière, Québec, Canada
3. Director of Technology, Fives Solios Inc., Montreal, Quebec, Canada
4. AP 60 Scrubbing Process Technician, Rio Tinto. Jonquière, Québec, Canada
5. Research Scientist, Environmental Technologies group, Rio Tinto. Jonquière, Québec, Canada

Corresponding author: bernard.cloutier@fivesgroup.com

Abstract

The gas treatment centre of Rio Tinto AP 60 potline, treating gases from 38 pots, has reached its full operation at the end of 2013. It features the most advanced scrubbing technology designed by Fives, OZEOS, built with state-of-the-art fresh alumina distribution system, scrubbing modules with integrated reactors and a capability to operate in Cascade feed mode when required (ex. high gas temperature). These basic elements are combined with low energy consumption fans and extended surface bags on one filtration unit (out of five) to achieve the best scrubbing efficiency and lowest emissions possible. This paper summarizes the first years of operation, presents benchmark emission results and demonstrates the specific features that will improve the performance of this technology in the future.

Keywords: Gas treatment centre (GTC); aluminum electrolysis pot emissions; HF scrubbing; Cascade feed.

1 Introduction

In 2013, RTA and Fives specialist teamed up to start up and bring to normal operation a new scrubber technology. The cooperation of both teams during the start-up and operation was an important contribution in the achievement of these state of the art performance results.

This new generation of GTC process filter modules has been developed by Fives over the last decade. It is called OZEOS and has been tested since 2005 in RTA's LRF Research center in Saint-Jean-de-Maurienne, France. In 2010, the OZEOS technology was selected by Rio Tinto Aluminium to treat the gas of its new AP 60 potline at their Jonquiere site in Quebec (Figure 1). It features a more compact design that best suits the large gas volume treated by centralized GTCs for modern high amperage pots and includes a lower velocity reactor that reduces the risks of scaling, abrasion and alumina attrition. It is provided with bag length up to 8 m and can be equipped with conventional or with extended surface type filter bags, both using micro-denier polyester for best particulate filtration.

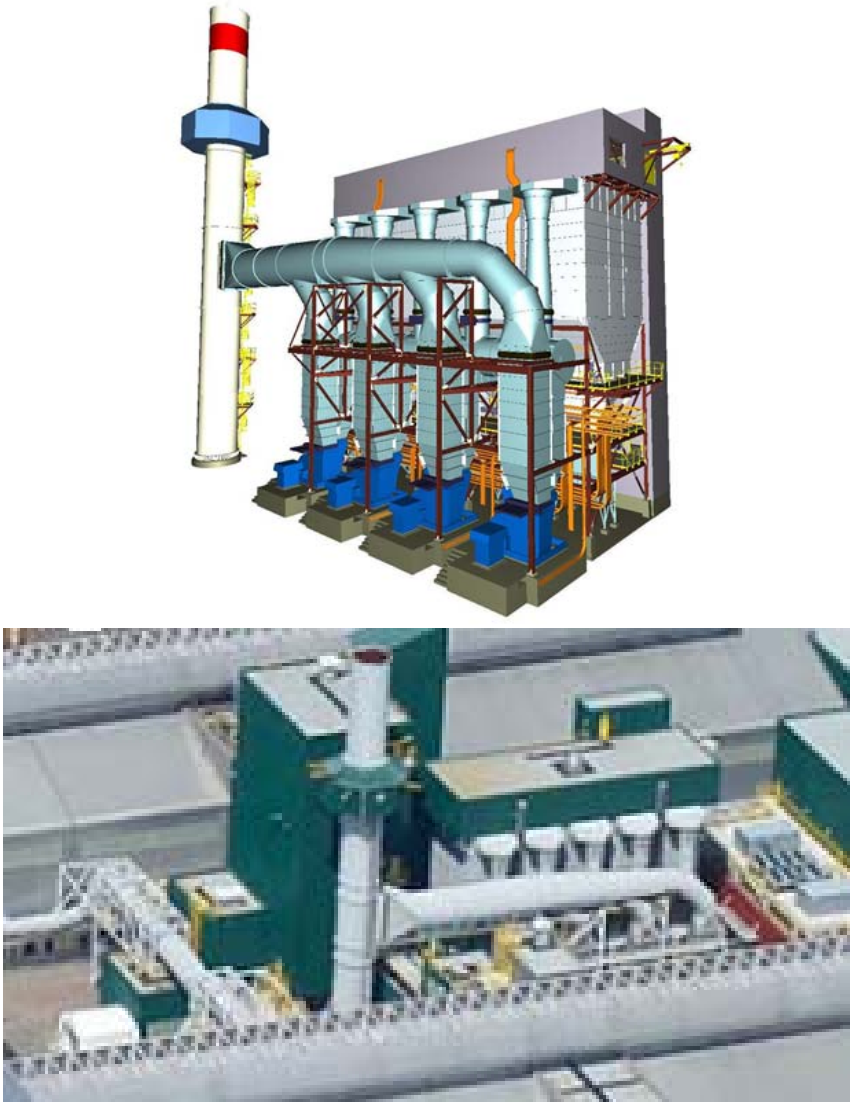

Figure 1. OZEOS - the state-of-the art scrubbing technology for modern smelters.

This advanced dry scrubbing system also includes a series of features to facilitate control, maintenance and to improve fluoride scrubbing. These features are:

- Bag leak detection at each filter module with automatic detection of the leaking row.
- Readiness for continuous monitoring of gaseous fluoride (HF) at each module outlet which allow improved tracking of the GTC performance and to help trouble shooting.
- Control of the gas volume treated by each module through continuous gas flow measurement combined with a modulating filter outlet damper. This is particularly useful when the plant start changing bags one module at a time as new bags offer lesser resistance to flow.
- Finally, best in class fresh alumina distribution system with a unique offering of three modes of operation aimed at providing the lowest GTC fluoride emission:

- The classic mode using a distribution box with calibration system and individual air conveyors that ensures an equal distribution of fresh alumina to each reactor/scrubber module (Figure 2).

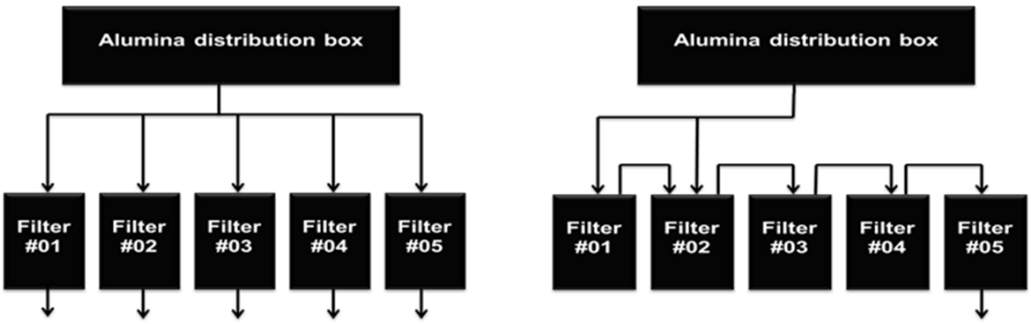

Figure 2. Classic feed mode (left) and Cascade feed mode (right) of alumina to filters.

- The fully automated Cascade feed mode (Patent US7731924 B2) where fresh alumina cascades from one module to the next, enriching itself in fluoride progressively, which provides improved HF scrubbing (Figure 2).
- The dual outlet mode: The distribution box was also provided with dual calibration outlets for each module. In the classic mode only one outlet is used. The second outlet allows for the occasional increase of fresh alumina injection at one reactor based on the feedback from the HF monitoring at each module outlet (in the future). The dual outlets feature has already been useful in Jonquière where one module is equipped with extended surface bags that can handle up to 15 % more gas volume. In such operating condition, it made it easy to inject more alumina in the module with extended surface bags in order to keep a balanced distribution of fresh alumina over the total gas volume to be treated.

2 Performances of the First Two and a Half Years of the AP 60 OZEOS Gas Treatment Center

The performance of a gas treatment center (GTC) is based on key process indicators (KPI) which are: energy consumption, fluoride scrubbing efficiency and particulate emissions. Another KPI is the pot capture efficiency. Achieving a uniform gas flow distribution of each pot ductwork branch allows optimization of the total gas volume handled by the GTC.

The GTC energy consumption is mostly related to the selection, quantity and size of induced draft fans installed. It is a function of the planned total flow and of the gas pressure drop throughout the upstream ductwork and the GTC. Compressed air used for the filter bag cleaning can also impact the energy consumption.

The fluoride scrubbing efficiency is sensitive to many operating parameters such as balanced gas flow between filter modules, balanced alumina distribution per filter modules, inlet gas temperature, fluoride inlet concentration and alumina recycling rate.

The pot capture efficiency is key to minimize potroom roof emissions. The main parameters that influence capture efficiency are the pot suction rate, the pot hood design and the application of good practice by the potroom operators when they proceed with an anode change (number of hoods removed, etc…).

Particulate emission levels will vary depending on the selection of the filtering velocity (air to cloth ratio), the pulse cleaning technology and the filter media selection.

The design of a robust GTC equipped with proper measurement and control instrumentation and capable of operating in different modes will help achieve solid performances. The OZEOS GTC was started on August 28th 2013, and the first AP60 pot was started on the August 29th. The first

year of operation results were already communicated in a previous paper [1]. This paper presents the results of the first two and half years of operation, and confirms the trend of solid performances.

2.1 Energy consumption of the OZEOS AP 60 GTC

The OZEOS GTC features a lower overall pressure drop than prior GTC technology. This is mainly due to its low velocity reactor and to its capacity to accommodate extended surface bags that reduces the filtration pressure drop. In order to achieve low energy consumption, the fan selection is very important. The Jonquiere GTC is provided with four (4) centralized ID fans with airfoil wheel and 750 kW motor. The fans were designed to maintain 100 % of the target pot extraction rate with one fan out of service (N-1). Furthermore, the design includes a 10 % safety factor on gas volume to allow dilution air cooling during the warmest days (while keeping target pot extraction rate) and a 10 % safety factor on total pressure drop to provide the capability to add boosted pot suction if required in the future.

During the first year, three fans were in service as expected for an N-1 design. However, it was obvious to the operators that the fans had extra capacity for the usual operation (no boosted suction, rare dilution). In order to save energy, the plant decided to use only two fans (N-2) which allow the operation with the fan inlet dampers almost fully opened to maximize the fan mechanical efficiency.

As shown in Figure 3, the GTC consumed fan power expressed in kW per Nm^3/s per pot was reduced by 30 % from approximately 13.5 kW/(Nm^3/s) per pot (first year) to 10.5 kW/(Nm^3/s) per pot, once all controls were optimized.

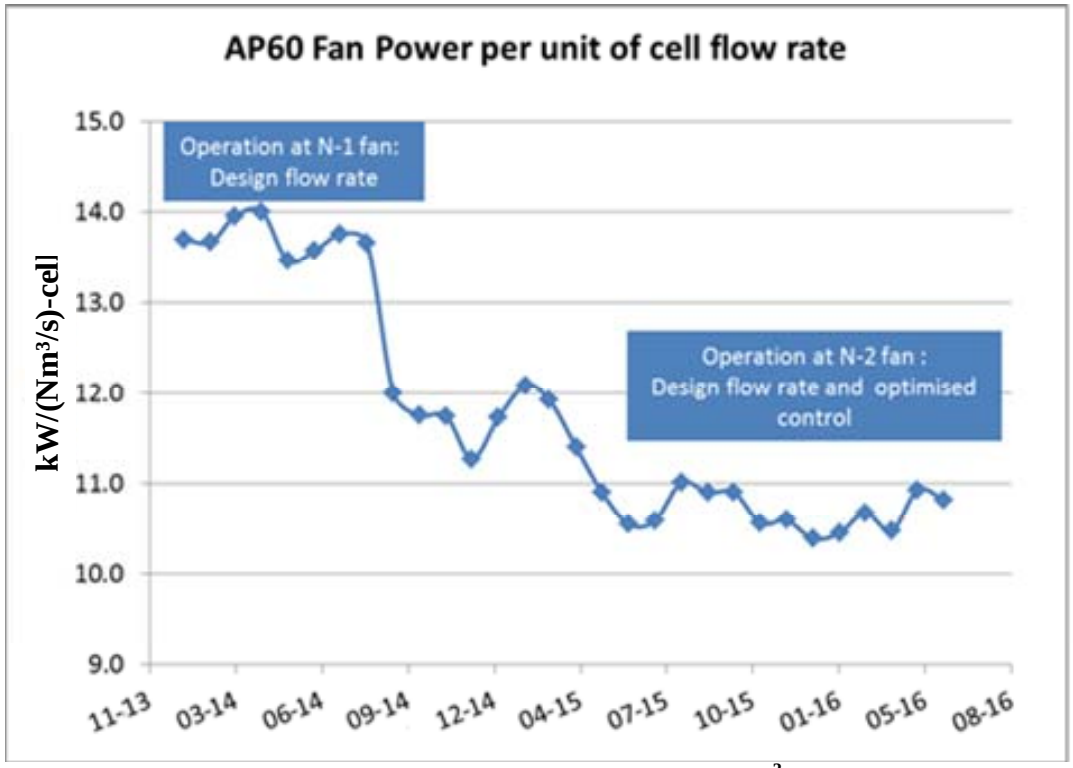

Figure 3. Monthly fan power required to provide one unit, (Nm^3/s)/cell, of flow rate at the stack, from December 2013 to June 2016.

2.2 Fluoride scrubbing efficiency

The performance of the GTC in terms of fluoride emission has been excellent with total fluoride emission in the range of 0.01 – 0.02 kg/t Al during the winter months and 0.03 - 0.05 kg/t Al during the summer months. As shown in Figure 4, the monthly average gaseous fluoride concentration at the stack always stayed below the design criteria of 0.65 mg/Nm^3, even in the summer months.

This performance is the result of specific features that are part of the OZEOS GTC design:
- A balanced distribution of gas and alumina at each module.
- A robust alumina recycling system that is simple, using interchangeable orifices to vary the recycle rate and a U shape air conveyor to inject combined fresh and recycled alumina at eight (8) points into the reactor.
- Capability to inject fresh alumina in Cascade feed mode during the summer months to reduce HF emission when gas temperature exceeds a certain level.

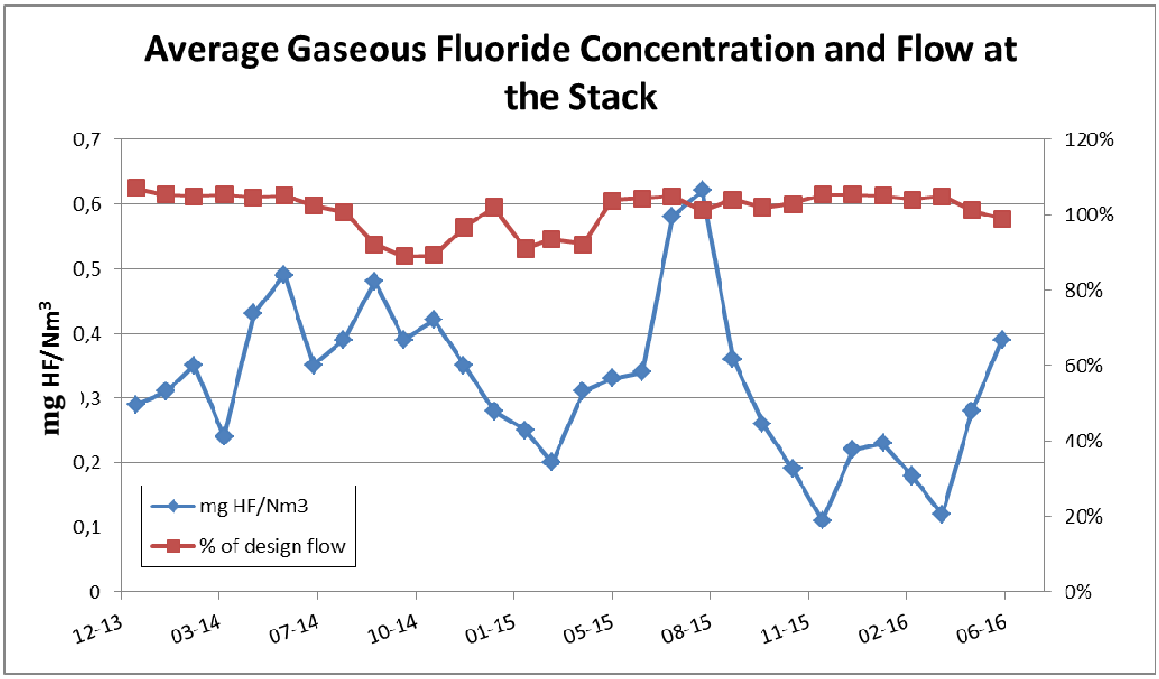

Figure 4. Monthly average HF concentration measured at the stack versus the ratio of the real flow rate on the design flow rate, from December 2013 to June 2016.

2.3 Pot capture efficiency

The pot capture efficiency has been maintained in the range of 99.3 to 99.5 % (see Figure 5), leading to low total fluoride emission (stack + potrooms vents emission in the range of 0.20 kg F_t/t Al as yearly average). This is achieved without boosted suction and results from an optimum pot extraction rate, good flow balancing between pots, quality pot hood covers and good practice by the pot operators. We acknowledge that pot flow balancing and operator performance might be easier to achieve with a smaller potline of 38 pots. For a larger potline, the add-on of an automated boosted suction system might be required to achieve similar or even better performance. RTA has allowed for this in the GTC design with a safety factor on fan pressure rise.

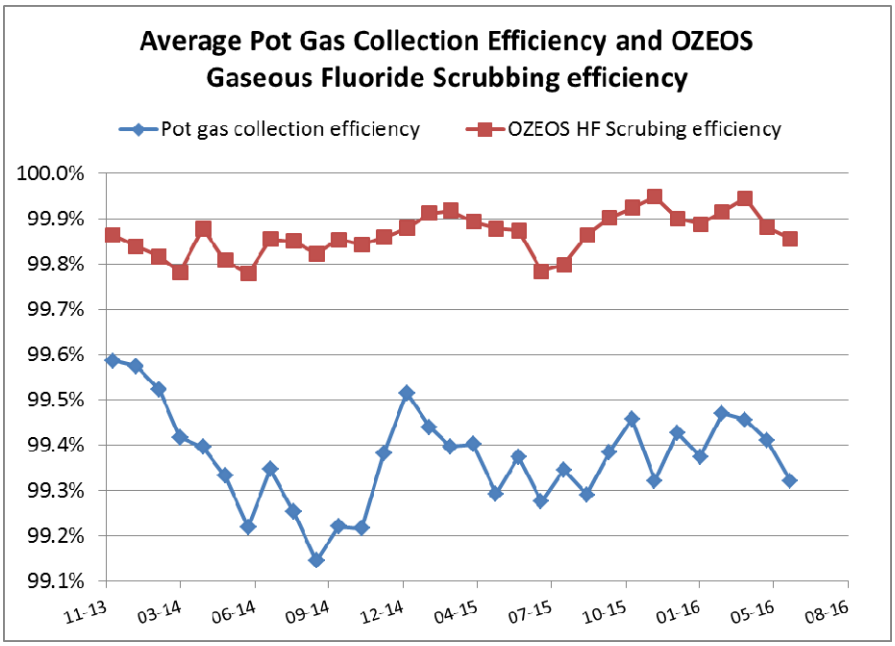

Figure 5. Monthly average pot collection efficiency and HF scrubbing efficiency, from December 2013 to June 2016.

2.4 Cascade mode operating conditions

Fives patented Cascade alumina feed system has been developed to reduce the noticeable rise in stack HF emission when gas temperature exceeds a certain level. The HF emission at high gas temperature is also very much influenced by the fluoride content on alumina and increases exponentially with the % F on alumina (even at percentage below alumina saturation). The operation in Cascade mode reduces the fluoride content on alumina in the upstream modules lowering the HF emission at the outlet of those modules for an overall HF reduction in the range of 40 % as shown in the Figure 6. The beneficial impact of the cascade feed mode increases with stack gas temperature. Another advantage when operating in that mode is that if there is a temporary upset in the temperature and/or gaseous fluoride concentration of the gas at the GTC inlet, the risk of having temporary higher gaseous fluoride emission is lower (less peak). From these first years of operation, it is estimate that the yearly gaseous fluoride emissions at the GTC stack would be between 20 - 30 % higher, if the AP 60 OZEOS GTC wouldn't have the Cascade feed mode.

2.5 Particulate emission and Extended surface bags

The particulate emission guarantee of 2 mg/Nm^3 was more stringent than on past projects (typically 5 mg/Nm^3). Polyester felt bags with micro denier fibers concentrated on the filtration surface were selected for improved filtration. The first three annual stack sampling results have confirmed an emission of less than 2 mg/Nm^3 (less than 0.17 kg/t), with filter bags in normal conditions.

One important feature to ensure low dust emission and long bag life is the tracking of bag leaks. Each module is equipped with a FilterSense bag leak detector with 4 - 20 mA signal that can be used to easily identify the leaky row.

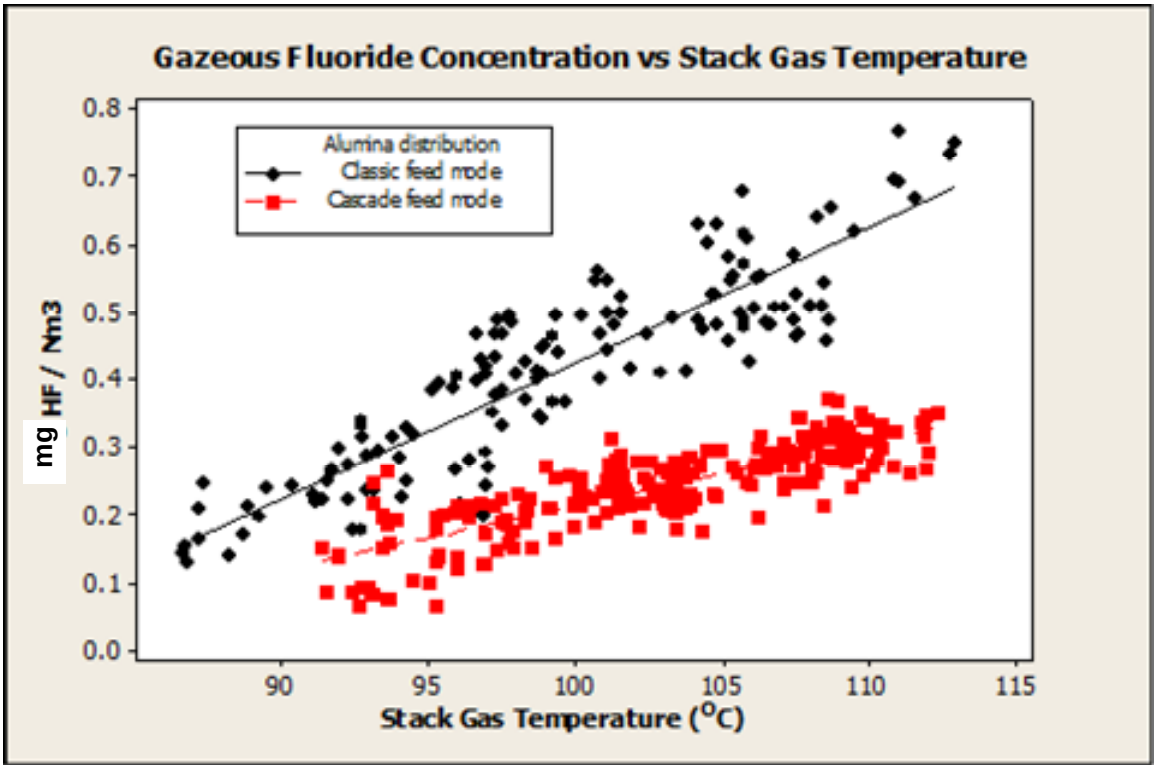

Figure 6. HF concentration vs stack gas temperature measured at the stack, comparing the classical alumina feed mode (black circle dot) and the cascade feed mode (red square dot) during formal tests carried in 2014 at AP 60 smelter, in otherwise similar operating conditions.

It was also decided at the design stage to equip one module with extended surface bags to compare it with modules equipped with standard bags. The filter media was the same for both types of bags. The extended surface bags provide 75 % more filtering area than regular bags which provide the following benefit:

- Capability to handle up to 15 % more gas flow in a module,
- Reduce tube sheet pressure drop and cleaning cycle for energy savings.

The capability to control the flow at each module was essential to achieve the desired gas flow distribution. As can be seen in Figure 7, HF concentration at the same flow rate, operating under the same conditions, is similar between the two types of bag up until around 34 Nm^3/s. When flow increases above that value, performance of standard bag begin to drop significantly, while extended surface bags maintains the HF level up until 36 - 38 Nm^3/s. This difference can be explained by the thinner filter cake and the higher frequency of bag cleaning that is required to maintain an acceptable pressure drop with standard bags when operating beyond the design gas volume.

After 30 months the benefits of extended surface bags were confirmed. At this stage, there is no need to increase the total volume of gas to be treated and it is likely that the plant will not install extended surface bags in the short term in the four other modules. Although it might be a good option for a future increase in capacity, extended surface bags and cages are more expensive and more difficult to install when you proceed with a bag change out.

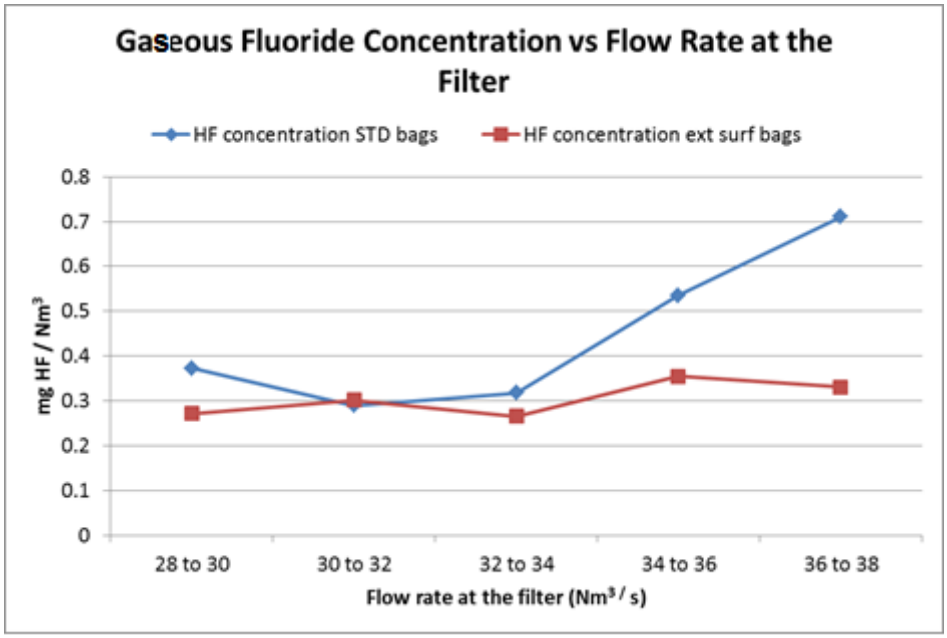

Figure 7. HF concentration at different interval of filter flow rate comparing standard bags with extended surface bags, during different period in 2014 and 2015.

2.6 GTC maintenance and improvements

The overall maintenance requirements of the GTC have been low. In the first 30 months, only a few bags (less than 10 out of a total of 4 000) have been changed. The module fluidized hoppers have not required any cleaning yet which indicates a low scale formation. The more important maintenance issue has been the replacement of some of the piston pulse valves that had a tendency to jam. After a thorough investigation of the possible causes, a solution was found with the replacement of the compressed air inlet filter upstream each pressure regulator. The selection of filters with smaller mesh openings (20 micrometers instead of 40 micrometers) has resolved this problem.

Another part of the equipment that needs to be serviced twice a year is the U shape horizontal air conveyor that feeds fresh and recycled alumina into the reactor. This is a zone where small scales and other impurities accumulate (depending on the performance of the fresh alumina vibrating screen). Vacuuming this air conveyor twice a year is needed to ensure good fluidisation and optimal alumina feed to the reactor.

3 Conclusion

The OZEOS dry scrubber has proven to be a very robust and efficient technology to treat the gas from ultra-high amperage pots. The Jonquière installation includes state-of-the-art instrumentation and control that help the operation personnel in ensuring the GTC maintains optimum performance. The Cascade feed technology has demonstrated its benefit in lowering fluoride gas emission during the summer season. The OZEOS scrubber design, with low velocity reactor, new alumina injection system, fan selection and potential retrofit with extended surface bags, has all the features to maintain excellent emission performances in the future.

4 Reference

1. Philippe Martineau et al., Start-up of the OZEOS gas treatment center (GTC) for RTA AP 60, *Light Metals* 2015, 623-625.