Light Metals 2015
Edited by: Margaret Hyland
TMS (The Minerals, Metals & Materials Society), 2015

Impact of Operational Practices and Cell Hooding on Total Fluoride Emissions in the Aluminium Smelter Plant of Aluar

Del Punta, Melisa[1]; Lifschitz, Juliana[1]; Zavatti, Jorge[1]
[1]Aluar Aluminio Argentino SAIC; Puerto Madryn, Chubut, U9120OIA, Argentina

Keywords: Total Fluoride Emission, Hood Index, Ft concentration, Roof emissions, Operations

Abstract

EPA Method 14A is one of the most widely used methods for measurement of total fluoride (gaseous and particulate phase expressed as Ft) emissions through roof monitors in aluminium primary smelters. In order to obtain the Ft concentration emitted from the potroom, several cassette arrangements are placed in predetermined locations and later removed from the roof monitor for the analysis of each run.
Because Aluar operates a total of 8 potrooms and this kind of environmental testing is costly and elaborate, an alternative approach is required to keep monitoring the emissions on a daily basis. A robust and cost effective option is to identify those pots that are missing at least one hood simultaneously due to operational and/or maintenance practises.
This paper presents the development of tests with the purpose to find a correlation between Ft concentration measured with EPA method 14A and the sum of pots with at least one hood opened, as well as to establish a theoretical factor to relate the amount of pots in such condition to specific emissions in potrooms where we use the original Aluar type PFPB end-to-end cells.
It was estimated that during normal operation an increase of 0.03 kg of Ft per (metric) ton of aluminium produced (equivalent to 0.36 kg Ft per hour) is added to the current Ft emission per pot with one hood opened.

Introduction

Aluar smelter follows the USEPA 14a method for Ft emission monitoring. The method states that a minimum of 4 cassette arrangements are strategically located at equal intervals across the potroom roof thereby covering at least 8% of the total length of the potroom [1]. Anemometers and temperature sensing devices are located within the cassette arrangements for mass flow rate determination. Since every potline in Aluar is composed of two potrooms, a sum of 8 cassettes is placed within each potline.
Three monthly samples are taken from each one of the potrooms and each sampling period was at least 24 hours .

An lifting device is necessary to be able to change out the cassettes, as well as to measure temperature and air flow. Because the cells are orientated end-to-end, in our case we normally use a telescopic boom lift , as can be seen in the figure 1.

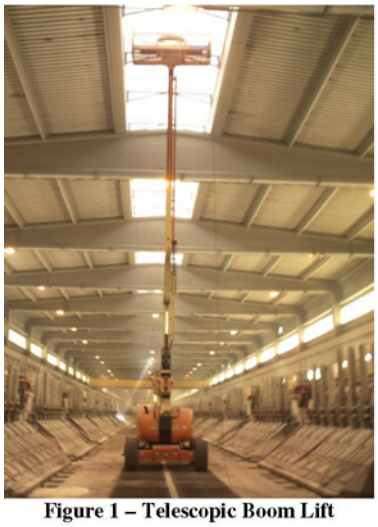

Figure 1 – Telescopic Boom Lift

However, this is a costly and difficult procedure when considering the cassette preparation and analysis together with high risks to workers associated to the lift interacting with normal pot operations (anode change, metal tapping, etc.). Therefore an alternative approach is sought after in order to manage fluoride emission control on a daily basis.

Pot Hooding Controls

Although several potline improvements have been achieved since they first started to produce in 1974, it only takes one hood of one side of the cell to be opened for the emissions to intensify. In this case it is more important to compute the number of pots with at least one hood opened per side, rather than the number of hoods opened in one cell. Each pot has 18 hoods that each can be opened independently.

Visual inspections of pot hooding quality have been performed in Aluar smelter for over 14 years. During these checks, calculating the percentage of pots with at least one hood missing, yields a standard named “hood index”:

$$HI = \frac{\text{Total number of pots with at least one hood missing}}{\text{Total number of cells (400)}}$$

The Hood Index contemplates the number of cell with at least one hood open divided by the total numbers of pots (200) multiplied by a factor of 2, which takes into account both sides of the cell.
The plant standard limits a maximum of 3 pots with one hood opened at the same time.

Experiments

Two of the four USEPA 14a method cassettes above 18 control pots were selected for the experiment. Pots were subjected to different conditions:

- State 1: Base line. No hood missing within the 18 pots.
- State 2: Two pots with only one opened hood.
- State 3: Four pots with only one opened hood.
- State 4: Six pots with only one opened hood.
- State 5: Twelve pots with only one opened hood.
- State 6: Eighteen pots with only one opened hood.

The conditions described above are shown in Figure 3.

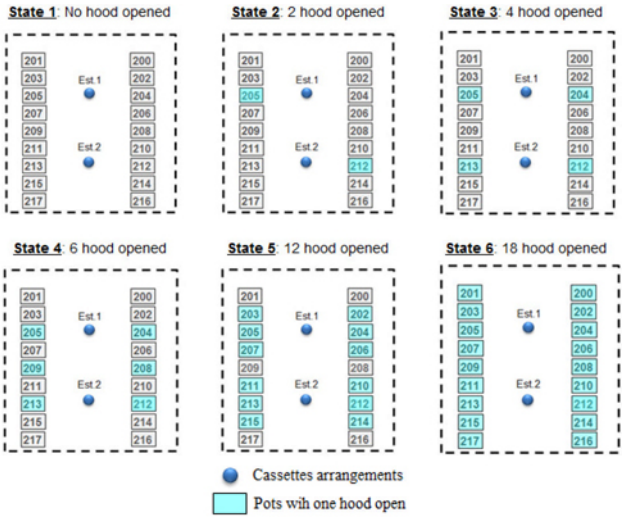

Figure 2 – States implemented in control pots

No operation was carried out on the 18 control pots during the tests in order to avoid possible impacts on the Ft emissions other than hood opening. Special interest was put into hooding. See Figure 3.

Figure 3 – Control Pots Hooding Quality

Results and Discussions

Theoretical Relation Estimation

An exponential relation was found between Ft concentration determined through USEPA 14a method and the number of pots with one hood opened. See figure 4.

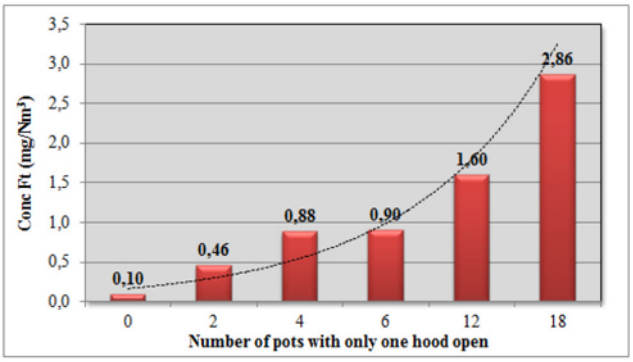

Figure 4 – Ft concentration for different states of the controlled pots

Ft concentration obtained from controlled pots was then extrapolated to the entire potline, since hood indexes are normally performed on the 200 pots in one potline. The concentration found in State 1 was 0.10 mg/Nm^3 and is assumed for the rest of the cassettes outside the area of the controlled pots. See Figure 5.

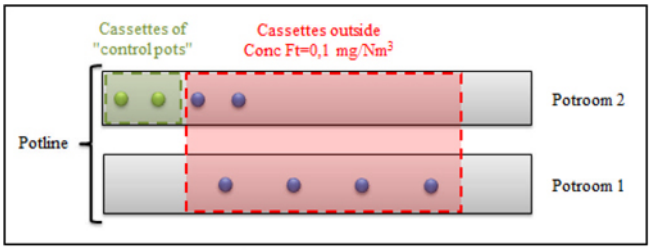

Figure 5 – Cassette Potline Distribution

Following this the Ft specific emission was then calculated for each state thereby computing fluoride concentrations, gases flow rate and aluminium production. Based on this a relation between Ft emission and hood index for the entire potline was obtained. This relation is shown in Figure 6.

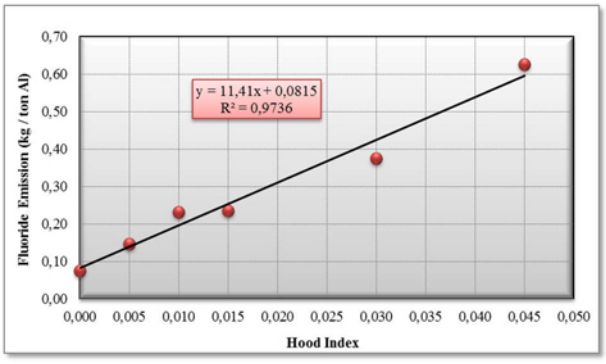

Figure 6 – Theoretical relation between Ft emission and Potline Hood Index

The "theoretical" equation of Ft emissions under controlled conditions (no operation being executed on the pot) is:

$$Ft\ (kg/ton\ Al) = 11.41 * HI + 0.0815$$

An increase of 0.0025 in the hood index, i.e. one more pot with one opened hood, yields a 0.03 kg Ft/ton Al rise in the Ft emission, equivalent to 0.36 kg of Ft per hour released to the atmosphere.

Practical Relation Estimation

The equation above does not reflect Ft released from actual operations being executed on the pots, plus anode butts and or poor hooding quality. In order to find a more realistic correlation, additional tests were carried out; this time with Hood Indexes conducted during normal potline operation and actual fluoride emission measurements. Hood indexes were completed during every hour of the 72 hour sampling period.

A new equation relating Ft emission with HI was obtained:

$$Ft\ (kg/ton\ Al) = 11.41 * HI + \alpha$$

Where α contemplates for additional Ft emissions of the pot other than hood opening. An average hood index of 0.0090 and fluoride emission of 0.424 kg of Ft per ton of aluminium, yield α equal to 0.32 kg/ton of Al. This new equation is a better reflection for potline fluoride emissions. Both equations are shown in Figure 7.

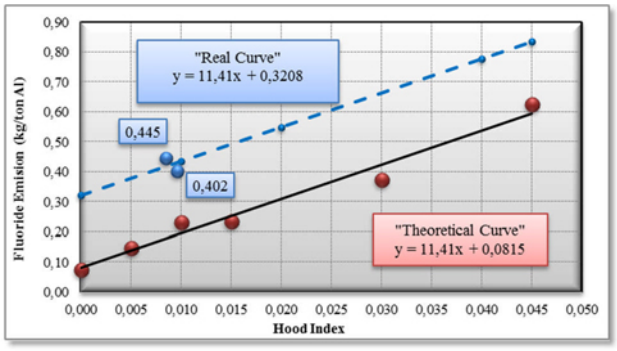

Figure 7 – Theoretical and Practical Relation between Total Fluoride emission and hood index

Conclusion

Several tests were performed in an effort to find a correlation between pot hooding and Ft emission measured according to USEPA 14a method in a specific potline at Aluar.

Both theoretical and practical equations were derived after correlating the data and the "real curve" stands for a more realistic approximation of actual Ft emissions from the pots. The equation allows us to estimate Ft emission on a daily basis without having to make considerable costs for daily measurements using USEPA 14a Method measurements.

References

[1] Method 14A – Determination of Total Fluoride Emissions from Selected Sources At Primary Aluminium Production Facilities - http://www.epa.gov/ttn/emc/promgate.html