Light Metals 2012 *Edited by: Carlos E. Suarez*
TMS (The Minerals, Metals & Materials Society), 2012

Light Metals 2012

ALUMINUM REDUCTION TECHNOLOGY

ORGANIZER
Olivier Martin
Rio Tinto Alcan
Saint-Jean-de-Maurienne, France

Light Metals 2012 *Edited by: Carlos E. Suarez*
TMS (The Minerals, Metals & Materials Society), 2012

Light Metals 2012

ALUMINUM REDUCTION TECHNOLOGY

Environment I

SESSION CHAIR

Margaret Hyland
Light Metals Research Center
Auckland , New Zealand

Light Metals 2012 *Edited by: Carlos E. Suarez*
TMS (The Minerals, Metals & Materials Society), 2012

DEVELOPMENT OF LOW-COST VIDEO EMISSIONS MONITORING TECHNIQUE FOR ALUMINUM SMELTING APPLICATIONS

Michael Gershenzon[1], Neal R. Dando[1], Nathan W. Westendorf[1], Stephen J. Lindsay[2]
[1]Alcoa Inc.; Alcoa Technical Center; 100 Technology Dr. Alcoa Center, PA 15069, USA
[2]Alcoa, Inc.; Primary Metals; 300 N. Hall Rd. MS S-29, Alcoa, Tennessee, 37701, USA

Keywords: Video Emissions Monitoring, HF, fluoride, Smelter Emissions

Abstract

Aluminum smelting plants emit gaseous and particulate fluoride, sulfur dioxide (SO_2), carbon oxides (CO and CO_2), perfluorocarbons (CF_4 and C_2F_6), and other by-products of aluminum electrolysis processes. Potroom fugitive emissions intensity for some of these pollutants (most notably, fluorides) is strongly correlated with potroom work activities and work practices (e.g., anode change operations, metal tapping practices, pot hood placement, etc.). Therefore, work practice standardization and potroom personnel education regarding the impact of their day-to-day activities on smelter emissions are important components of pollution control and prevention strategy.

This work introduces a low-cost video emissions monitoring technique utilized at Alcoa that allows overlaying real-time emissions measurements (e.g., HF, SO_2, dust, etc.) on video recordings of specific work activities. The developed capability is used to more effectively and uniformly communicate the impact of work practices on plant environmental performance. Specific examples of high-impact work practices are presented and discussed.

Introduction

The aluminum smelting process evolves both gaseous and particulate fluorides, SO_2, COS and other gaseous/particulate by-products. The vast majority of these evolved species are captured by active hooding systems and are transported to fume treatment centers. The non-captured fraction of the evolved stream escapes into the potroom, and is ultimately released into the atmosphere through roof ventilators. This component of smelter emissions is known as "fugitive", or "roofline", as opposed to "stack" emissions. In spite of the fact that the non-captured emissions flow typically represents only ~5% or less of the total exhaust flow (i.e., >95% hooding efficiency), these emissions can contribute 50% or more to overall smelter emissions intensity because they bypass emissions control systems. In addition, fugitive emissions tend to have poor dispersion in the ambient atmosphere due to lower release points and velocities (roof vs. stack). Thus, they create the potential for work-place personnel exposures. Prior studies have suggested that exposure to HF or SO_2 either alone or in concert could play a role in the occurrence of "potroom asthma."[1-3]

Currently, fugitive emissions monitoring is accomplished using two types of techniques: 1) path-averaging optical detection analyzers, and 2) point-sampling (e.g. electrochemical detectors, etc.). Each of these methods has its advantages and limitations. For instance, in open-path optical detection systems, a light beam is transmitted through the air to a reflector array, which serves to return the light back to the transmitter/detector unit. The path-averaged light absorbance signal is used to calculate the average species' concentration over the optical path-length. The use of lasers as light sources in this measurement technique results in high detection specificity, fast response time, real-time results, and high sensitivity. However, the measured gas concentration represents a path-averaged value providing little insight into the source of emissions and associated process conditions. Point sampling techniques, such as, the NIOSH (National Institute for Occupational Safety and Health) method for sampling peak exposures to gas-phase HF (NIOSH Method 7902), employs pulling known volumes of air through treated filters. These filters are then leached and analyzed by ion selective electrode or ion chromatography to provide an integrated total fluoride measurement over many minutes (typically >15) of sampling. The inherent deficiency of this method is poor time resolution and off-line data analysis. Thus, the feasibility for cause-and-effect-type analysis is likewise limited.

This work introduces a low-cost video-emission monitoring (VEM) technique, in which emission or exposure measurements obtained by using a real-time sensor (e.g., open- or closed-path optical sensor, noise analyzer, dust sampler, etc.) are overlaid on video recordings of specific work activities or process conditions, producing unequivocal and impactful determinations of emissions/exposure root-causes. The developed capability can be used to more effectively and uniformly communicate the impact of work practices on plant environmental performance.

Experimental

The idea behind video emissions/exposure monitoring technique is not new. Currently, several vendors (e.g., KOHS PIMEX, SKC and others [4-5]) offer commercially-available products capable of recording and presenting simultaneous video and emission measurement information. These products typically cost in excess of US$10,000, require custom instrument-camcorder interfacing and are limited to an array of implemented instruments. In contrast, the method described here is instrument-independent, and is based on post-processing of the measurement data and overlaying it on video clips captured with a consumer-grade video camera. Since no physical interfacing between the measuring device and video camera is required, this method is highly flexible and significantly less expensive than the techniques noted above.

In short, a VEM video clip is created by overlaying graphical representation of the measured emissions/exposure data onto a video record of associated work/process condition. To do that, two types of input files are required:

1) Video footage capturing actions/process conditions on the floor (a video cassette/dvd record or a computer file

of any video format – avi, mov, mpg, mpg2, mp4, ifo, wmv, etc.)

2) Data files containing real time measurements reflecting the impact of floor activities.

A key pre-requisite is that both files contain timestamps to enable synchronization during the post-processing (mixing) procedure. The video clip can contain a timestamp on the screen, while the data file has to contain timestamps associated with each sampling data point. An example of suitable data file format is given below:

Timestamp	Concentration
12:00:00 AM	0.495
12:00:02 AM	0.531
12:00:04 AM	0.530
12:00:06 AM	0.551
12:00:08 AM	0.527
12:00:10 AM	0.515
12:00:12 AM	0.527

Any consumer-grade video camcorder can be used to capture the video, and any real-time instrument capable of 1-3 second time resolution and data storage can be used to create a corresponding data file. It is recommended that the camera is mounted on a tripod to minimize vibrations, etc. and real-time sampling instrument is set to log data every 1-3 seconds. An example of VEM setup is shown schematically in Figure 1.

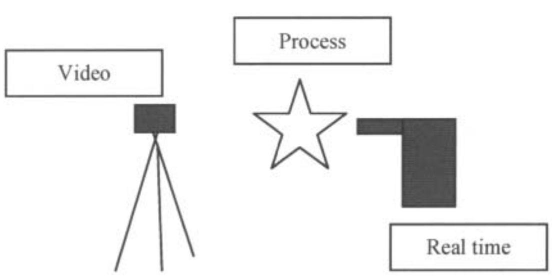

Figure 1. Schematic diagram of video-emissions/exposure monitoring system setup.

Once raw input files are created, a VEM clip can be produced by "mixing" the graphical data output with the video file. In this work a software package from NIOSH (VEM v.3.0c)[6] was used to create graphical data output. The computer screen output signal was then mixed with the video file by using TVOneTask 1T-C2-150 down-converter. Before overlaying procedure is initiated it is important to ensure that the timestamps on the video output and data files are synchronized. A schematic diagram of video mixing setup is shown in Figure 2.

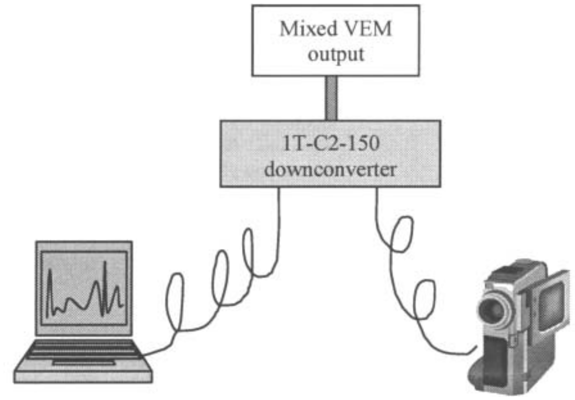

Figure 2. Schematic diagram of video mixing setup.

Results and Discussion

Figure 3 shows a snapshot of video emissions monitoring file output. In this example, an open-path optical HF instrument (Boreal GasFinder) was used to measure HF concentration immediately above pot panels, next to anode rods, or stems. In figure 3, the measured HF concentration is represented by the blue bar (in arbitrary units on a scale from 0 to 12 a.u.) on the left-hand side of the figure. The instantaneous numerical [HF] value and timestamp are also displayed on top of the figure.

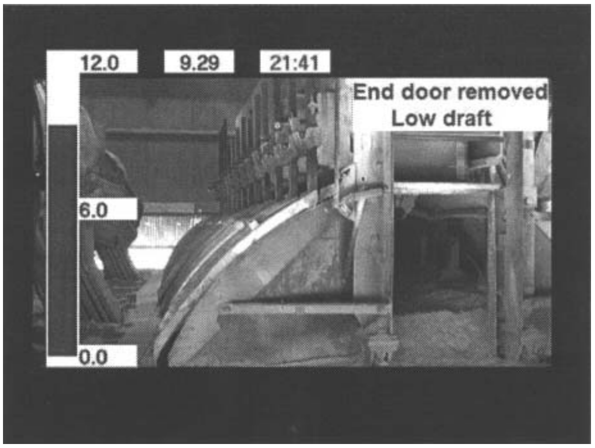

Figure 3. Example of video emissions monitoring output file (single pot HF fugitive emissions (arbitrary units) is represented by the blue bar on the left-hand side of the figure).

The utility of video emissions representations, such as shown in Figure 3, is immediately evident. The emissions/evolution information presented in this form can be used to:

1. Demonstrate the impact of work actions, such as opening side panels, end doors, etc. and process conditions, such as low draft vs. high draft, anode change, pot tapping, etc. on plant emissions on a per-pot basis.

2. Identify work activities associated with highest potential for personnel exposure and possible countermeasures.
3. Identify and document best practice procedures.
4. Provide training to new personnel.

Figure 4 shows snapshots of HF emissions from a single smoking pot on low (Figure 4A) and high (Figure 4B) draft. As can be seen from Figure 4, fugitive HF emissions increase by a factor of ~10 when a pot is not properly dressed and high draft ventilation is not used. This example demonstrates the importance of proper pot dressing for controlling HF fugitive emissions.

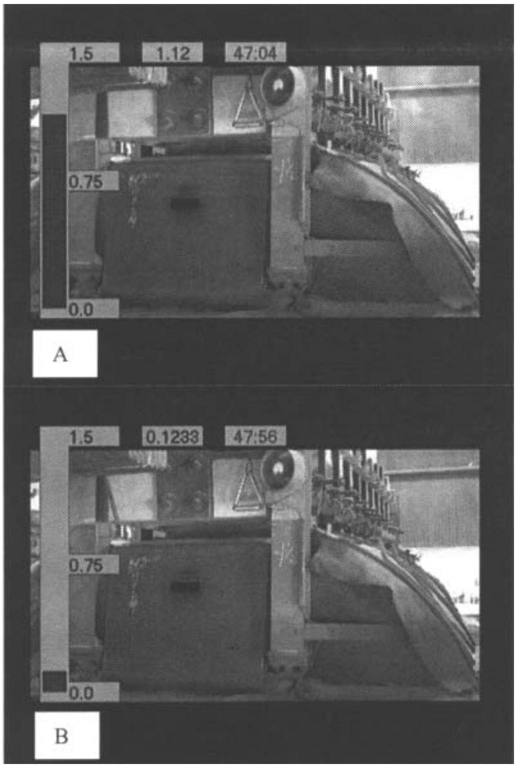

Figure 4. HF fugitive emissions from a single pot on low (A) and high (B) ventilation.

Figure 5 shows snapshots of single-pot HF emissions with side panels poorly (A) and properly (B) placed. Here, similarly to the case shown in Figure 4, HF fugitive emission rate increases by a factor of ca. 20 as pot seal is broken. Examples shown in Figures 4 and 5 not only provide quantitative characterization of pot emission rates but also document process and operational conditions leading to elevated contaminant concentrations in the potroom.

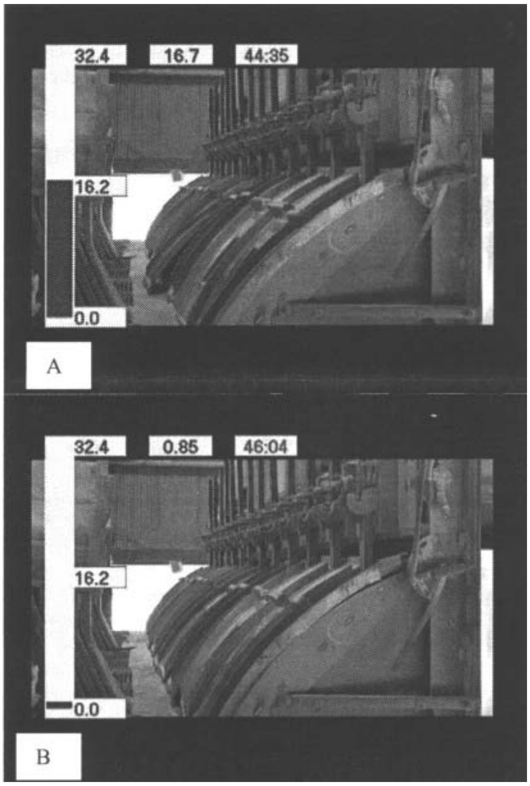

Figure 5. HF fugitive emissions from a single pot with side panels poorly (A) and properly (B) placed.

Figure 6 shows a top-down view on a pot being tended by an operator. The blue and red bars on each side of the Figure represent dust concentration levels at the roof ventilator and on the floor, respectively. A video presentation like the one shown in Figure 5 allows gauging the effect of work actions on both fugitive emission levels and on employee exposure potential.

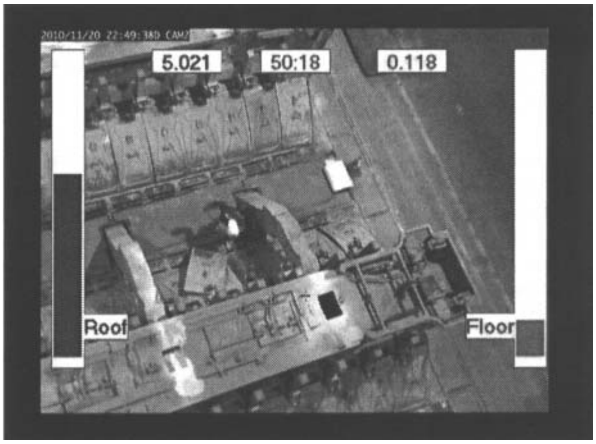

Figure 6. Concentrations of dust at the roof ventilator (blue bar) and on the floor level (red bar) during pot tending.

This method has already proven itself to be a powerful tool for training in the pot room environment. Figure 7 is just one example of how VEM-based training can have immediate impact.

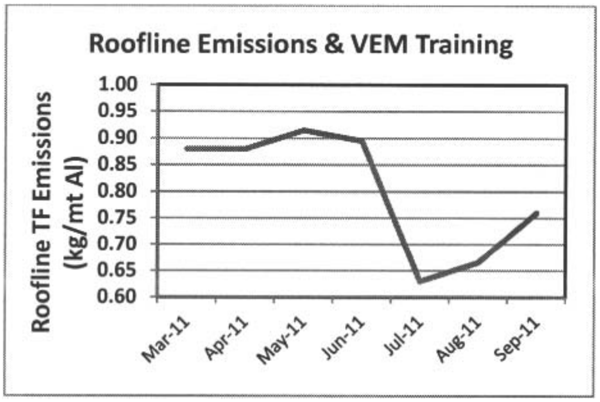

Figure 7. Example of the impact of shop floor VEM training in June, 2011 upon total fluoride emissions from a pot room roofline

On this particular pot line total fluoride emissions were compliant with regulatory standards, but above internal targets. VEM training modules were created on-site at the end of May and were deployed to all crews and supervisors in the month of June. Other improvement efforts were underway at the same time. But, VEM training was the singular stand-out of what was being done differently going into summer months.

Conclusions

A low-cost method for visualizing the impact of work practices and/or process conditions on potroom emissions/personnel exposure has been developed. The tool allows for superimposing real-time measurement data on the video stream of associated operating conditions or pot tending practices. The technique is demonstrated to be a powerful tool for creating training lessons for potroom personnel training and fugitive emissions reduction. Results of such efforts have been both immediate and effective. The cost of method implementation is significantly lower compared to commercially-available products.

Acknowledgements

The authors would like to thank Mike Gressel of the National Institute for Occupational Safety and Health for sharing the expertise and software required for video overlaying and Neale Frisch of Alcoa for alerting the authors to the low-cost VEM method capability. The authors would also like to thank Alcoa for encouraging publication of this work.

References

1. O'Donnell, T.V.: Asthma and Respiratory Problems – a Review. *Sci Total Environ*, 163(1-3): 137-45 (1995).
2. Soyseth, V., J. Kongerud, J. Ekstrand and J. Boe: Relation between exposure to fluoride and bronchial responsiveness in aluminium potroom workers with workrelated asthma like symptoms. *Thorax*, 49(10): 984-9 (1994).
3. Soyseth, V. and J. Kongerud: Prevalence of Respiratory Disorders among Aluminium Potroom Workers.
4. http://www.pimex.at/en/index.php
5. http://www.skcinc.com/prod/770-7500.asp
6. M. Gressel, NIOSH, private communication 2010.