

Extended Surface Filter Bags in Reverse Air Cleaning Filters

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Abstract

The use of Extended Surface Filter Bags (ESB) is nowadays widely practiced in the aluminum industry for Gas and Fume Treatment Centers. The benefit in reduction in differential pressure to allow for more draft from the potline and reduced cleaning cycles or even reduction in electricity consumption is proven around the globe. There is a significant amount of reverse air cleaning filtration technology in the market – commonly known as Vibrair filters. These filters do not have a pressurized pulse cleaning system, but clean the filter media solely by reverse air, which is a more gentle cleaning process and allows for longer bags life. Vibrair users face the same challenge as other aluminum smelters with ever increasing amperage or more stringent environmental regulations. Consequently they seek an increase in filtration area. One way to achieve that increase is by converting the Vibrair filters from the pocket bag system to Extended Surface Filter Bag system whilst keeping the reverse air cleaning approach. The paper will show case studies that demonstrate successful trials and now full conversions of reverse air filters with the help of extended surface bags.

Keywords: Extended Surface Bags, ESB, Reverse Air Filter, Vibrair, GTC, conversion.

1. Introduction

Aluminum smelters are facing ever growing economic and environmental pressures: increasing efficiency and output whilst maintaining, or even better, reducing emissions. To battle the increasing HF and dust emissions (roof and stack), Extended Surface Filter Bags (ESBs) are nowadays commonly used by many plants around the world, successfully allowing for increased airflow from the potline and consequently reducing emissions at the stack as well as roof ([1], [2]).

All major groups use ESBs in their smelters today – yet the use is limited to the Gas or Fume Treatment Centers (GTCs or also referred to as FTCs) using a pulse cleaning system. There is an alternative established technology in the market for gas cleaning systems that does not rely on pulse cleaning systems, but works based on reverse air: the Vibrair Technology. The paper focuses on the introduction and implementation of the ESBs into the Vibrair GTCs.

1.1. Vibrair Technology

The Vibrair filter technology (see Figure 1) was developed by Fives Solios (Procedair) in the late 1960s and has been installed in more than twenty aluminum smelters worldwide from 1972 to 2012 to treat potline gas and capture fluorides. Many of the Gas Treatment Centers using that technology are still in service today.

The Vibrair unit features a compact filter module of 5, 8 or 10 cells that each house a filter block (see Figure 2) that has 12 multi-channels pocket bags. The Vibrair pocket bags are cleaned by Reverse Air. However, the air flow through the bags and the filtering velocity of 2 cm/s are typical of pulse jet filters. Each cell is cleaned on demand, one at a time in off-line mode: a poppet damper travels between two orifices to isolate the outlet plenum during cell cleaning mode or to isolate the reverse air manifold during cell filtering mode.

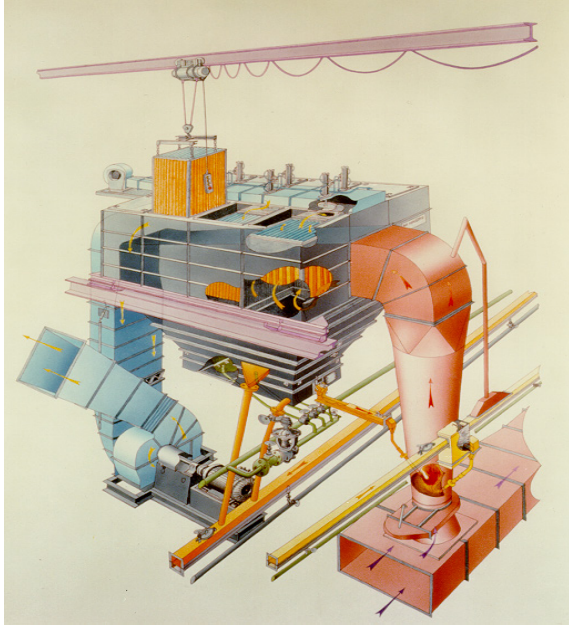


Figure 1. 8-cell VIBRAIR module.



Figure 2. Filter block with 12 pocket bags.

Each pocket bag is divided into 29 or 32 independent filtering channels. The total filtering area of one cell (12 pocket bags) is 185 m² when provided with 29-channels bags or 198 m² when provided with 32-channels bags. The assembly /disassembly of a filter block is typically done in specially designed maintenance room that is part of each Gas Treatment Centre. If there is a bag leak (1 filtering channel leaking), the usual procedure is to plug the channel with a pad of rock wool or polyurethane foam while the remaining channels can be maintained in filtration mode.

The soft cleaning system with reverse air ensures a long pocket bag life (5 – 6 years typical) but is not as effective as a pulse jet cleaning system to control a low pressure drop. Hence it is typical for those units to operate with a bag pressure drop of 320 to 350 mm WG.

1.2. Extended Surface Filter Bags

Extended Surface Bags get their name from the increased surface of the filter bags whilst maintaining the same physical dimensions as standard filter bags. The surface increase is balanced to allow for maximum increase in surface whilst maintaining an optimal cleaning capacity in high dust environments. Pleated filter elements were used for some time but they are not as suitable with high dust loads.

The current state-of-the-art design includes 12 pleats and has, in case of round filter elements, a surface increase of 120 % (more than double the surface) compared to the same length standard bags (Figure 3):

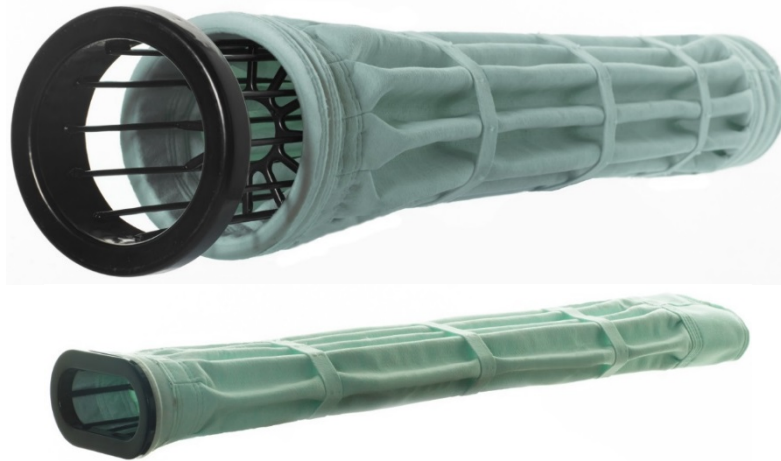


Figure 3. Examples of extended surface filters: round with a 12-pleat design and oval with an 8-pleat design.

With the increase in surface area, the air-to-cloth ratio is practically cut in half (assuming similar bag length). That leads to a reduction in differential pressure that can now be used for process improvements, depending on the main driver for the upgrade:

- a) Increasing airflow from the potline to
 - i. Increase draft from the pots to reduce roof emissions
 - ii. Increase airflow for additional air cooling
- b) Reduce bag cleaning frequency to
 - i. Reduce stack emissions (HF and dust)
 - ii. Reduce energy consumption on the cleaning system and fans
- c) Reduce operating differential pressure in the GTC to
 - i. Reduce energy consumption on the cleaning system and main ID fans

Examples in case of pulse cleaning systems have been shown in case studies, e.g. [2].

The consequent next step was to implement the ESB System also on the Vibrair revers air cleaning filters.

2. Increasing the Capacity of Vibrair GTC

Many of the Vibrair GTC that are still in operation have been installed in the 1980s and 1990s on 180 kA to 330 kA pots. Pot amperage creeping projects are quite common to increase smelter production, they often require to increase the capacity of the existing GTC to extract more heat for the pot thermal balance and to reduce plant fluoride emission.

To achieve that, the Vibrair plants would require to increase the surface area in their GTCs. This can be done by adding filters modules or increasing the current filtration capacity by

- a) Increasing the number of channels of the pocket bags, or
- b) Installing ESBs

The addition of filter modules (reactor, Vibrair filter and fan) requires a high investment and is often difficult to implement due to the space constraints in the narrow courtyards where are installed the GTCs. It is best justified when a minimum capacity increase of 20 % is required.

The pocket bag manufacturers have implemented upgrades to their bags to increase the number of channels. Nowadays the 29-channel system is the basis. 32-channel pockets are established and the next upgrades are being tested. The gain in total filtering area when converting from the 29 to the 32-channel pocket bags is somewhat limited (7 %). Furthermore, the challenge with these types of bags is that they are cumbersome to handle (bag change, leak detection and handling, etc.).

The use of ESBs was first considered as a potential solution in 2013. However, at the time, the understanding was that it would require the conversion of the Vibrair filter into a pulse jet unit to effectively clean the ESBs.

In the autumn 2013, Fives Solios and Advantetex met with the Alcoa Deschambault Environment group to present the ESB technology. The smelter was looking for solutions to increase the capacity of their GTCs to match its next increase in pot amperage. The smelter is located in the Province of Quebec in Canada. Like many other smelters, it has increased productivity over time and sees ever increasing potline gas temperatures which reach challenging level in summer time.

Converting the Vibrair filter into a pulse jet technology filter to use with ESBs was quickly dismissed as too expensive. However, the idea came of simply replacing the pocket bags with ESBs that would be cleaned by the existing Vibrair filter Reverse Air system.

The goal was to make such conversion as simple as possible with the possibility to revert to the pocket bag technology if the trial was not satisfactory. In order to support the ESBs, a tube sheet must be installed into each cell. A tube sheet was designed to fit the dimensions of the existing filter block that would rest on the existing filter block support channel and gasket, requiring no welding on site.

3. A First Installation in Alcoa Deschambault

The Deschambault smelter has two (2) main GTCs each with eleven Vibrair filters of 10-cell design that were started-up in 1992. In 2002, two (2) smaller GTCs (each with four 5-cell design Vibrair filters) were installed in parallel to increase pot flow by 18 %, which allowed for the addition of dual suction system and capacity for pot amperage creeping. In 2014, the plant was mainly using 29-channel pocket bags, but had installed the 32-channel version a year earlier into two 10-cell Vibrair filters. The plant people were interested comparing the ESB technology to the 32-channel pocket bag as they considered an increase in GTC capacity to suit future pot amperage creeping.

The first step was to make a trial of the ESB technology by installing it in May 2014 in a single cell of a 10-cell Vibrair filter. This first test aim to demonstrate that the ESBs could clean well just based on reverse air and without the requirement for a compressed air cleaning system. To make the test more representative, Alcoa requested the installation of shorter ESBs (2400 mm) in order to have the same filtering area in the test cell as in the other nine cells equipped with 29-channel pocket bags.



Figure 4. First converted Vibrair chamber.

The initial trial was successful: the bags were cleaning well and the Vibrair flange to flange pressure drop recovery after cleaning the ESB cell was identical to the one achieved during the cleaning of the other cells which received new pocket filters at the same time the ESBs were installed.

After a twelve month observation period and good operation of the ESBs, Alcoa Deschambault decided to proceed with a more comprehensive test and to convert a full 10-cell Vibrair filter with ESB technology in May 2015. This time, the conversion was using full length 2800 mm long ESBs. At the same time, Alcoa Deschambault installed new 29-channel pocket bags in a neighbouring Vibrair unit for comparison purposes. The ESB-converted system had a 16 % surface area increase over the 29-channel pocket filter.

The plant people were rapidly convinced of the benefit of the technology over the pocket bag:

- a) The short time required to install new bags. A team of three people can make a cell bag change in approximately 90 minutes.
- b) The capability to replace filter bags in situ without the need to transport filter blocks into a maintenance room. The bag replacement is then similar to what is done in the other filter units at the plant and does not require to be done by specially trained workers.
- c) The benefit to operate at all times with 100 % of the available surface further to a leak detection. The leaky bag is easily replaced at low cost. With the pocket bags, the standard procedure is to plug the leaky channels hence reducing the total filtering area as it is too costly and time consuming to replace a pocket bag.

There was an intense observation of the performance of the ESB-converted Vibrair, looking at differential pressure, cleaning cycles and comparing it to the performance of the standard Vibrair. The cleaning set-point was put at a lower differential pressure to compensate for the additional surface area. During the initial five months, the airflow to the ESB filter was kept the same air flow and both Vibrair show similar cleaning cycles (aside from operational upsets or differences).

After five months, the plant decided to increase the flow rate through the ESB Vibrair by 10 % (each filter module has individual ID fan that help making such change). This resulted in an increase in filter pressure drop to 340 mm WG (similar to the one of the standard Vibrair operating with 10 % less flow). The two units have kept the same operation parameters (flow and pressure drop) since that time and the plant continues to compare the cleaning cycles. After two years operation, the Vibrair unit with ESBs continues to handle 10 % more flow than the standard Vibrair while keeping the same pressure drop set point and an equivalent cleaning cycle.

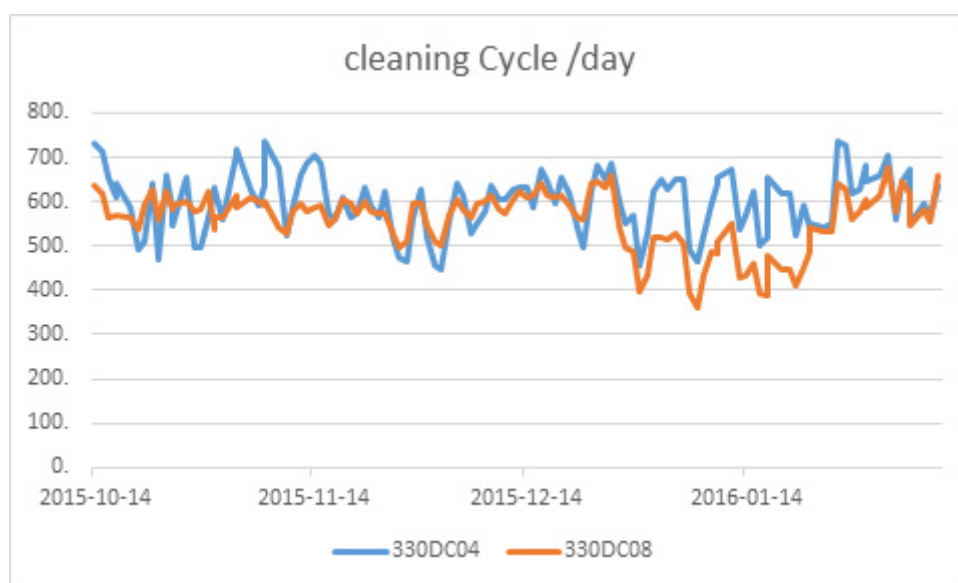


Figure 5: Monitoring of filter cleaning cycles.
DC04 is filter with ESB, DC08 is filter with 29-channel pocket bag.

Although the first Vibrair with ESBs demonstrated a 10 % increase in capacity over the standard 29-channel filter unit, it was estimated that after a full GTC conversion, the increase in capacity would be of approximately 5 % if the ID fans were operated at their limit prior to the conversion. The existing fans are often a limiting factor: part of the gain in filter pressure drop is used to compensate the additional ductwork losses since a higher flow is pulled through the duct system.

In order to increase further the GTC capacity with the ESB technology, Fives Solios proposed to Alcoa a new design of tube sheet allowing the installation of 100 ESBs per cell for an increase in surface area of 29 % over the 29-channel pocket bag. With this configuration, the capacity of an existing GTC can be increased by approximately 7.5 % if the fans were operating at their limit prior to the conversion. Alternatively, if the GTC has extra fan capacity, an increase of 10 % to 15 % can be achieved after such conversion.

In the autumn 2016 the plant was now convinced of the full benefit of the technology and decided that it would convert all its Vibrair to the ESB technology over a period of 4 to 5 years as it proceeds with its regular bag replacement schedule. In May 2017, the Deschambault smelter installed 7000 Extended Surface Bags and Cages into its GTC: 3000 ESBs to retrofit three 10-cell Vibrair of the primary GTC and another 4000 ESB to retrofit eight 5-cell Vibrair filters of the complementary GTCs.

Contrary to the main GTCs, the smaller GTCs have extra fan capacity that make it possible to operate the converted Vibrair filter units with an increase of 10 % - 15 % in flow. With 29-channel pocket bags the flowrate through the smaller GTC (4 filter units of 5-cells) was in the range of 72 to 76 actual m^3/s (52 to 55 Nm^3/s). Once converted to ESB, the plant operated these GTC at a flowrate of 86 actual m^3/s (63 Nm^3/s) during the June and July 2017. The GTC bag leak detection system went to zero after the conversion (no detection of particulates passing through the bags.).

Although the fan had capacity to pull more flow, any increase beyond 10 % - 15 % needs to be monitored closely since Vibrair filters have never been operated at these higher flow which could create abrasion or scaling problems.

4. Other Conversions

In parallel to the evaluation phase at Alcoa Deschambault, other Vibrair users were considering a conversion of their Vibrair GTCs to the Extended Surface bags system.

4.1 ABI

Aluminerie de Bécancour (ABI) is a plant owned by Alcoa (75 %) and Rio Tinto (25 %) and located in Bécancour, Canada. It has a total of six (6) GTCs installed in 1986 (phase 1) and 1992 (phase 2). Each GTC has nine 8-cell Vibrair filters. The smelter has increased pot amperage over the years without making any changes to their GTCs. The plant is now looking at increasing pot amperage further but will need to increase pot flow to reduce GTC inlet gas temperature. In December 2016 the plant converted one filter unit (8 cells) with a total of 720 ESBs of 2800 mm long for an increase of 16 % in surface area (see Figure 6). The plant is now planning the full conversion of its GTCs to ESB technology.



Figure 6. ABI GTC team.

4.2 TRIMET Essen, Germany

The TRIMET group has four locations for primary aluminum production. The smelter in Hamburg, Germany is using ESBs in their pulse cleaning GTCs since 2014. The Essen smelter is operating the Vibrair technology in their GTC.

With the Virtual battery approach [3], opening the electrolysis process for a flexible energy supply and consequently changing amperage in the pots, the Essen plant needs a better flexibility in the GTC to allow for additional airflow in times of higher amperage operation.

The GTC allows for one additional Vibrair, but the investment is high and it will not be enough to cover the possibly up to 25 % increase in airflow. Hence the Essen plant decided in autumn 2016 to convert one of their 8-cell Vibrair filter to ESBs. The conversion took place in November 2016. Their benchmark for comparison are the 32-channel pocket filters. The ESB installation increased the surface area by 14 % over the existing pocket set-up.

The conversion was executed (including installation of cell plates, Extended Surface Bags and Cages) by plant personnel within 2 days. The operators specifically liked the ease of installation.



Figure 7. Trimet cell plate design.

The start-up of the filter was done by plant personnel as well. After an initial three-month observation period the airflow to the compartment was increased by 14 % and is running stable ever since.

TRIMET Essen is continuing the roll-out of the ESBs and is testing different types of filtration fabrics. They plan a full conversion to ESBs if the concept is proven in the next steps, and will evaluate the need for additional measures to achieve the anticipated airflow increase.

5. Conclusions

The current installations show that the Extended Surface Bags perform very well in reverse air cleaning systems, like the Vibrair filter. The longest installation to date is now 3.5 years and still in operation.

With the ESB technology, the filtering area of a Vibrair filter that was equipped with 29-channels pocket bags can be increased by up to 29 %. If the GTC fans were operating at their limit prior to the conversion, the full conversion of a GTC to ESB technology can allow an increase of approximately 7.5 % in gas flow. On the contrary, if the GTC ID fans have excess capacity, the conversion can allow an increase in flow of up to 15 %. Increasing the flow beyond will have to be tested and could likely be limited by problems of abrasion and increase scale formation.

Long term durability of the ESBs, especially with the increased airflow and consequently higher incoming air velocity remains to be validated. The pocket filters have proven an average of 5 to 6 years life, under standard operating conditions.

The users give a very positive feedback: the handling, installation and if needed replacement of the bags have proven to be very simple and easy.

6. References

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