Filtration & Technology in Alumina Refineries
Leadership in Filtration Technology – Centre of Excellence for Solid/Liquid Separation

BOKELA is the HighTech company in the field of separation processes and innovations. Our unique know-how and comprehensive services are asked for by clients world-wide and give us an outstanding position.

*In dialogue with the Alumina industry we perform solutions for filtration.*

*Dialogue needs mutual acceptance. Acceptance needs operational experience. Experience creates valuable expertise. Expertise forms trust.*

Thus, we have achieved leadership in filtration technology for Alumina refineries.

Our engineers are in a permanent dialogue with the experts from the worldwide Alumina family and perform high efficient solutions for filtration tasks. Our rotary vacuum filters and backflush filters for

- seed filtration, product filtration, oxalate filtration, pregnant liquor purification
- and especially the Hi-Bar Filtration and Hi-Bar Steam Pressure Filtration technologies which allow filtration of bauxite ore and which provide dry bauxite residue

are pace-making technologies which define the state of the art.

With our revamping concept for the modernization of running filter plants we have achieved market leadership. By upgrading and modernization of used filters we make it possible to improve the filtration process significantly or even to re-vitalise shut down filters for new applications.

BOKELA provides unique engineering services and after sales services around any filtration step which are used by our clients to design most modern separation processes and to open access to remarkable cost savings.

In the global Alumina family our name stands for:

- tailor-made solutions,
- long-termed partnership,
- integral project engineering,
- unique revamping of running filters,
- excellent know-how for the refinery process,
- pace-making in modern filtration technologies.

**BOKELA Rotary Filters and BOKELA Backflush Filters**

Our filter technologies for filtration tasks in Alumina refineries such as seed, product, oxalate, red mud, bauxite ore and pregnant liquor filtration comprise

- vacuum disc filters
- vacuum drum filters
- vacuum pan filters
- Hi-Bar and Hi-Bar Steam Pressure disc and drum filters
- backflush filters.

The innovative design of our high performance filters is the result of pioneering research and reflects the experience in filter operation and the know-how from numerous filter optimisation projects. It is also the result from an uniquely academic calculation of the hydrodynamic of each filter detail due to our close co-
operation with the University of Karlsruhe. BOKELA engineers have upgraded filter systems of nearly all major original equipment manufacturers (OEM) in Alumina refineries and in various other industries all over the world leading to significantly improved process results. Faced with the weak points of these technologies we designed the new generation of filters which define a new state of the art.

Our filters represent the filtration technology for the Alumina industry. Their excellent hydraulic characteristics provide for the extremely high performance capacity and the control philosophy leads to the unique operational reliability and flexibility.

In short, the BOKELA control philosophy means

- adapted filter performance by filter speed control instead of continuous slurry overflow,
- fully automatic filter operation instead of visual control by the operators,
- controlled and simple maintenance and easy operation.

**BOKELA Disc Filter Boozer**

The disc filter Boozer has set a new standard for Al-hydrate filtration in Alumina refineries. When the first filter Boozer started operation in 1995 this was the beginning of a string of success. In the following few years the Boozer became the leading technology in Al-hydrate filtration and gained the major market share.

The excellent hydraulic characteristics are the reason for the high filter capacity, the safe operation behaviour and improved economy. The BOKELA control philosophy enables automatic operation control that allows the adaptation of the filter performance to changing slurry and process conditions. So, the Boozer runs without continuous slurry overflow. Each Boozer disc filter is designed according to the specific demands of the individual filtration task.

Compared to conventional disc filters the disc filter Boozer

- provides up to 100 % more throughput
- enables a fully automatic filter operation, start and stop
- runs without slurry overflow
- needs no agitator
- ensures 99 % availability
- increases the plant capacity due to the reduced amount of re-circulated spent liquor
- enables a filter cake wash
- reduces energy consumption and operation costs by 20 % per t of solids
- reduces investment costs due to the low space demand and less peripheral equipment
- simplifies maintenance work
- can be equipped with FrameTrak™ – the unique cloth fixing system

Boozer disc filters are manufactured with three disc diameters as Boozer L-type, M-type (MI with filtrate pipes inside of the barrel and ME with filtrate pipes outside of the barrel), S-type and XS-type.
Figure 1: Seed filtration with the Boozer M-type and L-type: Perfect cake discharge from a Boozer M-type (left), Boozer L-type (middle) and cake discharge from a Boozer L-type (right)

Figure 2: Boozer L4-type (left) and installation of “Boozer” disc filters in an Alumina refinery (right)

Table 1: Boozer disc filter sizes (* max. filter area / ** 2 separate troughs in case of 2 control valves)

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>XS</th>
<th>S</th>
<th>ME</th>
<th>MI</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disc Diameter</td>
<td>[m]</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Filtration Area</td>
<td>[m²]</td>
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<td></td>
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<tr>
<td>Number of Discs per Control Head</td>
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<tr>
<td>No. of Control Heads per Filter</td>
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<tr>
<td>No. of Segments per Disc</td>
<td>[-]</td>
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<tr>
<td>Filtrate Pipe Design</td>
<td>[-]</td>
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<tr>
<td>Trough Design</td>
<td>[-]</td>
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</tbody>
</table>

Table 1: Boozer disc filter sizes (* max. filter area / ** 2 separate troughs in case of 2 control valves)
BOKELA Drum Filter

The BOKELA vacuum drum filter is the “washing machine” in our rotary filter family. It convinces with innovative design features, high performance capacity and – of course – excellent cake washing and cake steaming.

Compared to conventional drum filters BOKELA vacuum drum filters
- improve cake wash by 30 % without increasing the moisture content
- discharge the cake to 100 % by compressed air blowback or roller discharge even at high filter speed
- have a pre-separation control head which is designed for high hydraulic capacity (the pre-separation of filtrate and air in the control head provides for low pressure drops and prevents filtrate entrainment from cake formation zone to cake wash and/or dewatering zone)
- provide up to 75 % more throughput
- reduce energy consumption and operation costs by 10 -15 % per ton of product
- offer a special design for red mud filtration with extra piping to break the active vacuum at cake discharge (roller discharge) without the need of an additional control valve
- run in automatic operation
- ensure easy maintenance and long maintenance intervals
- can be equipped with FrameTrak™ – the unique cloth fixing system

Our vacuum drum filters are individually adapted to the requirements of the special filtration task and are available with different methods of cake discharge like roller discharge, scraper /compressed air blowback but also leaving cloth or knife discharge for precoat filtration.

The filter sizes range from 0.5 m² up to 125 m² filter area. As special feature our vacuum drum filters can be equipped with a steam cabin that allows a still more intensive washing and dewatering of the cake by steaming. This reduces cake moisture by some 2 %-points for Al-hydrate.

Figure 3: Two BOKELA oxalate drum filters in the workshop (86 m² each)
BOKELA Pan Filter

The pan filter is the horizontal type of our rotary filter family and convinces with the typical characteristics of the BOKELA rotary filters like:

- outstanding high performance capacity allowing smaller filter units
- sharp separation of filtrates – the precondition of our excellent washing results
- high operational reliability and flexibility
- self-controlling operation by intelligent interlock system
- innovative design features resulting in optimal process results and low operational costs
- a special designed steam cabin giving the chance for very low moisture content
Compared to conventional pan filters the BOKELA pan filter

- enables a controlled filter operation with constant cake thickness even along the pan radius due to our innovative "forced feeding system" which provides for 4 equal slurry sub-flows to 4 equal filter areas on the pan leading to an absolutely flat and constant cake surface
- improves cake washing by 30 % without increasing the moisture content
- reduces wash liquor consumption by 25 % and allows a three-step counter-current wash
- discharges the filter cake to 100 % even at high filter speed by an automatically controlled discharge scroll with variable speed drive (self adjusting system)
- provides 50 % more throughput
- runs independently from changes in the feed flow, feed solids concentration or particle size distribution
- reduces energy consumption and operation costs about 10 -15 % per ton of product
- enables a high efficient re-slurring of the remaining cake layer by very effective heel-breakage
- can manage overflow of up to 125 % of the slurry flow
- can be equipped with FrameTrak™ – the unique cloth fixing system

Measurement of the cake thickness in combination with the variable speed drives of the pan and discharge scroll enable the BOKELA pan filter to run with thick filter cakes of constant cake thickness. This results in an improved filter cake wash and constantly low Na₂O content. As a special feature our pan filter – as well as the drum filter – can be equipped with an innovative steam cabin that provides for a still more intensive washing and dewatering of the cake by steaming what leads to some 1 to 2 %-points lower cake moisture content. Each pan filter is individually adapted to the requirements of the special filtration task.

Figure 5: BOKELA pan filter
Figure 6: BOKELA pan filter (general arrangement)

Table 3: BOKELA pan filter sizes

<table>
<thead>
<tr>
<th>filter type</th>
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<th>S</th>
<th>M</th>
<th>L</th>
<th>XL</th>
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<tbody>
<tr>
<td>pan diameter [m]</td>
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<td>5.8</td>
<td>7.7</td>
<td>8.6</td>
<td>9.6</td>
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<tr>
<td>filtration area [m²]</td>
<td></td>
<td>25</td>
<td>43</td>
<td>54</td>
<td>68</td>
</tr>
<tr>
<td>slurry feed [-]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>forced distribution for homogeneous cake thickness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>filter speed [-]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>up to 2.0 rpm (variable) with cake thickness control</td>
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<td></td>
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<td></td>
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<tr>
<td>cake discharge [-]</td>
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<tr>
<td>scroll with speed control</td>
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</table>
FrameTrak™ – New Cloth Fixing Methods for Drum, Disc & Pan Filters

FrameTrak™ is a new method of attaching filter media to disc, drum and pan filters designed and developed by Madison Filter and BOKELA. It replaces the old-fashioned, burdensome caulking method or the more modern bolt down clamping methods on drum and pan filters as well as the bag method for disc filters. Its main function is to eliminate the numerous Operational Health & Safety issues associated with the existing methods of re-clothing filters. Filter cloth can be secured to a filter without the use of power tools.

FrameTrak™ consists of three parts: 1. A special designed steel profile. 2. An extruded elastomer polymer profile with cloth inserts. 3. A second extruded elastomer polymer profile, which acts as a locking strip. The major advantage for drum filters is the cloth exchange time can be remarkably shortened and only those filter cells which need a cloth change can be re-clothed. The same reasoning can be applied to pan filters. The main advantage for disc filters is the cloth can be exchanged without removing segments. Main benefits of FrameTrak™ are:

- improves sealing and filtrate clarity
- easy and quick cloth mounting without power tools or excessive force
- avoids cloth damaging during rough installation procedures
- reduced OH&S risks with no force required to fit elastomer locking strip
- quick removal of used media
- individual cloth panels of drum & pan filters are replaced without disturbing neighbouring panels
- eliminates caulking – better and stronger cloth fixing on drum and pan filters than caulking
- eliminates wire-bound rotary vacuum drums
- FrameTrak™ can easily mounted on existing filters by BOKELA revamping services

Figure 7: FrameTrak™ cloth fixing system for drum filters (a), drum filter with FrameTrak™ (b), drum filter with FrameTrak™ in operation (c)
Hi-Bar Steam Pressure Filtration –
Breakthrough Technology for Dry Bauxite Residue

Future methods of bauxite residue treatment must be capable not only to improve the red mud handling but to provide material with very new product characteristics and, thus, to allow at least a simple and risk-free transport storage and reclamation of disposal sites or even an industrial re-usage of dry bauxite residue. The target is clearly defined:

- achieving a dry residue material in an economic way
- making re-usage feasible instead of disposal
- minimizing the loss of valuable soda.

Our innovative Hi-Bar Steam Pressure Filtration is a patented process successfully applied in various industries that shows the way for future bauxite residue treatment.

This continuous Hi-Bar Filtration can be realised as pressure filtration process with compressed air or as steam pressure filtration. The plant design is based on rotary drum or disc filters which are installed inside a pressure vessel that is filled with compressed air. Over-pressure of up to 6 bar is applied for filtration and cake dewatering. For the patented Hi-Bar Steam Pressure Filtration superheated, pure steam is applied for filter cake treatment. For this process a specially designed steam cabin covers a part of the filter area and forms a separate room with superheated steam.

Thus, filtration, washing and dewatering of bauxite residue is performed in a new quality and leads to

- a really dry bauxite residue with an extremely low moisture content of 21 – 25 %
- an excellently washed and clean material with very low soda content
- a bulk-like, sandy and easy to handle material which can be safely transported over long distances and processed like a bulk material.

This breakthrough technology in red mud filtration leads to product characteristics never achieved before in one process step. Residue with this consistency can be easily stored, transported and processed and offers new chances for an utilisation. Hi-Bar Filtration plants are available with drum filter areas up to 81 m² and disc filter areas up to 168 m².

Figure 8: Hi-Bar drum filter and dry bauxite residue discharged from a Hi-Bar steam pressure filter

Dry Bauxite Residue –
a bulk-like, sandy product
Filtration of Bauxite Ore after Pipeline Transport – a World Premiere

The continuous pressure filtration is the chosen technology for the dewatering of the worldwide first pipeline transported bauxite at an Alumina refinery of Alunorte (Alumina do Norte do Brasil S/A) in Brazil.

When Vale was designing the mining and beneficiation of the Paragominas mine it was to decide by which means the bauxite should be supplied to the Alumina refinery. Beside ship or railroad transport the most preferred option was pipeline transport of the bauxite. Pipeline transport of bulk materials such as kaolin or iron ore is not only a proved but also a more economical and environmental method than ship or railroad transport. Cost for pipelining is lower than ship or railroad transport. At the refinery, however, the pumped slurry has to be dewatered and it is a decisive condition for realizing pipeline pumping of bauxite to have a feasible filtration technology available which is capable to dewater the arriving slurry to a low residual moisture content in an economical way. This intensive dewatering step has to guarantee a very low moisture content below a critical moisture of 14 % due to the following reasons:

- the amount of water entering the refinery process has to be below a critical point
- above a certain moisture content the bauxite filter cake becomes sticky and has poor transportation and processing characteristics (very similar to bauxite residue)
- different sorts of bauxite have to be blended which requires a dry and mixable filter cake
- the portion of fines can vary due to changing quarries

Analogous to the bauxite residue (red mud) the fine milled bauxite is difficult to dewater. After extensive analysis by Alunorte, BOKELA and other expertised groups the continuous pressure filtration was preferred against filter presses since these filters achieve better moisture content and require less invest and operation cost. BOKELA designed a process flow sheet which ensured that the continuous pressure filters achieve the required moisture content of below 14 % which can be improved by application of the BOKELA Steam Pressure Filtration to even mc = 10 - 12 %. The first five pressure disc filters of 168 m² each were commissioned in May 2007 already prepared to be equipped for Stream Pressure Filtration. The engineering and supply of these filters was managed by a consortium of Andritz AG, Graz (Austria) and BOKELA based on a comprehensive feasibility study done by BOKELA. Meanwhile 10 pressure disc filters of 168 m² each are in operation and Alunorte has ordered the next three filter units to match future capacity.

BOKELA Backflush Filter

The BOKELA Backflush Filter is of advanced hydraulic design which is the basis for pregnant liquor purification with improved performance and improved operation. The BOKELA Backflush Filter comprises mainly a vessel, filter elements arranged in a star-shape, a top reservoir, pneumatic valves with fast opening/closing characteristics and a new developed auto-control system with excellent mechanical-electrical integration. Vertical filter elements inside the vessel are connected to external manifold via syphons each equipped with an isolating valve and sampling valve, by which filtrate quality can be monitored. In case of turbidity the relevant isolating valve can be closed, so that filtrate quality can be guaranteed. The filter runs in completely closed operation to prevent exposure to air what minimises crust formation over the bags and provides for long lifetime of filter bags. Fully automatic operation makes handling easy.

The main important improvements in design and operation of the BOKELA Backflush Filter are

- comprehensive PC-PLC control, excellent mechanical-electrical integration and user-friendly man-machine interface resulting in a stable optimized process sequence with the consequence of superior pregnant liquor throughput
- strong filter elements of double-layered stainless metal with firm mechanical properties
- special reliable pneumatic valves with fine dynamic characteristics (e.g. half-ball valve for sludge discharge with fast opening/closing characteristics)
• improved cake discharge by uniform backwashing in all filter elements
• individual cone angle of depending on product instead of fixed cone angle.

The filter elements are of strong design and made of double-layered stainless metal providing firm mechanical properties. Reduction of the open flow area during operation is minimized which is a precondition for high capacity. The flow patterns inside the filter element prevent that solids having passed the filter cloth at the begin of the filtration cycle during turbid filtrate recycling can deposit at the bottom of the filter element. Deposits of solids at the bottom of the filter elements often lead to increasing weight of the filter elements and cloth destruction. Furthermore, deposits of solids form protuberances at the bottom of the filter bag reducing the open sedimentation channel for the discharged filter cake between the filter elements.

![Image](image_url)

Figure 9: View of BOKELA Backflush Filters with backwash tanks (left), view into the filter with star-shape arranged filter elements (right)

The main performance data of the BOKELA Backflush Filter can be listed as:

• filter sizes: up to 500 m² filter area
• filter area per volume: up to 8 m²/m³
• cycle time: ca. 1 h, online time 50 - 55 minutes
• throughput capacity: 1.4 - 2.0 m³/m²h
• solids in filtrate: ≤ 15 mg/l
• concentration of discharged sludge: 150 g/l
• lifetime of filter cloth: 90 days

Numerous reference applications of the BOKELA Backflush Filter can be found in pregnant liquor purification in the Bayer process, Aluminate liquor in the Sinter process, spent liquor recovery (seed disc filter filtrate), fine hydrate reclaiming and in filter aid production.
Filter Revamping – New Filtration Capacities by Retrofitting

Filter revamping is an economic and fast way to eliminate bottlenecks in production plants and to make running filtration plants suitable for new production targets – provided that the revamping is carried out with the necessary know how and experience in filtration processes and filter operation.

With our well-proved filter optimization programme we upgrade running filter plants in Alumina refineries with great success. We modernised seed, product, oxalate and red mud filters of nearly all suppliers with considerable improvements. Our optimisation program is split in a

- diagnostic step,
- engineering step
- realization step.

This method allows a maximum of cost control and a minimum risk. The benefits are:

- capacity increases of 50 % up to 150 %
- improved profitability and product quality by better cake washing, cake dewatering and cake discharge, longer filter cloth lifetime, reduced energy consumption etc.
- short-termed and fast realisation
- usage of the well known and operator-accepted equipment
- minimal costs for peripheral & supplementary equipment
- cost coverage by the maintenance budget
- pay-back period of less than 1 year

Our reference list comprises a comprehensive variety of filter types disc filters, drum filters, pan filters, belt filters, filter presses, Kelly filters, Niagara filters etc.

Meanwhile BOKELA is the No. 1 expert in filter revamping world-wide.

Figure 10: Red mud drum filter – roller discharge before and after modification

BOKELA Leadership in Filtration Technology
Figure 11: Perfect cake discharge from an Al-Hydrate disc filter revamped by BOKELA