Drivers Toward Filtered Tailings

- Water Reclamation and Makeup Water Minimization – Saving Money
  - Water can cost > $4/m³
- Minimizing Tailings Storage Facility (TSF) Footprint – Saving Money
  - Footprint is < 50% of a conventional TSF
- Reduction in closure costs at end of mine life – Saving Money
  - Progressive closure possible
- Providing a social license to the mine
  - Quicker permitting possible
- Reduced Tailings Risk – Improving Safety
  - Removal of water pool prior to failure
Demonstration Plant

FLSmidth is installing a filtration demonstration plant at a major copper concentrator in the Atacama region of Chile.

FLSmidth’s Goals

- **Prove Technology at Scale**
  - Build a large format filter to provide consistent and reliable service
  - Obtain operational and performance data from the machine
  - Develop a discharge conveyor capable of handling the filter’s load
  - To meet the throughput and moisture requirements set by the client
  - Perform Geotechnical studies to determine optimal design parameters for the dry stack TSF and upstream dewatering equipment

Clients Goals:

- **Reduce Risk**
  - Complete a full scale test program, dewatering the actual tailings stream, to determine design requirements for a full scale plant
  - Complete a Cost/Benefit analysis to compare the filtered tailings plant with alternatives
Water Reclamation Saving Money

Using the ~10,000 mtpd demonstration plant mass balance, the following table was developed to illustrate the potential water recovery:

- Thickener: 14,103 m³/day
- Filter: 6,961 m³/day

or

- An additional 290 m³/Hr

- Water Recovery
  - 6,900 m³/day/filter
  - 2,540,400 m³/year/filter
  - ~$10 MUSD/year/filter
TSF Footprint – Saving Money

By reducing the volume of tailings through filtration, the TSF footprint can be significantly reduced. The illustration below provides an example of the area required for a wet impoundment versus a dry stack arrangement for the same concentrator.
The Water Pool causes the Damage
Improving Safety

The TVA Kingston Fossil Plant coal fly ash slurry spill occurred just before 1 a.m. on Monday December 22, 2008, when an ash dike ruptured at an 84-acre (0.34 km²) solid waste containment area at the Tennessee Valley Authority’s Kingston Fossil Plant in Roane County, Tennessee, USA. 1.1 billion gallons (4.2 million m³) of coal fly ash slurry was released.

Samarco Tailings dam failure, Brazil 2015
A tailings dam, holding back more than 50 million cubic meters of mining waste collapsed, unleashing a wave of mud several meters high. BHP and Vale have reserved more than 5 billion USD due to the dam disaster.

Cerro Negro near Santiago Chile 2003
Wet tailings

Mount Polley dam failure 2014, releasing 10 million cubic meters of water and 4.5 million cubic meters of slurry into Polley Lake

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No Pool with Filtered Tailings
Improving Safety

Filtered Tailings at a mine in Canada
Filtration Technologies

When dewatering tailings the material properties and geotechnical requirements at the TSF have a great influence on the type of filter used. Some examples of filters that have been traditionally used for tailings dewatering are:

- Horizontal Belt Filter- Vacuum
- Belt Press
- Filter Press
Filter Press - Tailings

Goldcorp Eleonore

- (2+1 spare) M2020 AFP – 96 Chambers
- Slurry SG: 1.76
- Cake Dryness: 15 wt%
- Throughput: 6900 - 7700 mtpd
- Availability: 90%
- Cycles Operated: >20,000 per filter
Challenges of Going Bigger

The following are a few of the challenges were identified:

- A filter larger than ever built previously would need to be developed to process the required throughput tonnage.
- Filter Plates larger than commercially available would be required.
- A robust plate shifting mechanism would need to be developed to enable reliable movement of the larger plate format.
- With a filter volume of approximately 40m$^3$ (70 mt) of wet cake, a suitable discharge conveyor would need to be designed to meter and convey the material from under the filter.

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2x2 AFP Operation
Solutions - The “Colossal” Filter

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate Dimension (mm):</td>
<td>2000 x 4000</td>
</tr>
<tr>
<td>Maximum Qty of Chambers:</td>
<td>152</td>
</tr>
<tr>
<td>Filtration Area Max. per Filter (m²):</td>
<td>&gt;2000</td>
</tr>
<tr>
<td>Filter Volume (m³):</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Filter Opening Time (seconds):</td>
<td>&lt;60</td>
</tr>
<tr>
<td>Filter Closing Time (seconds):</td>
<td>&lt;60</td>
</tr>
<tr>
<td>Feed Pressure Rating (bar):</td>
<td>15</td>
</tr>
</tbody>
</table>

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Demonstration Plant Criteria

When FLSmidth and the Chilean mining company began engineering the filtered tailings demonstration plant, the design was based around the following parameters:

- ~10,000 mtpd throughput capacity
- Cake solids content of 81.5wt%
Solutions- Plate Links

Filter Plate Link Development

Links are used to connect every plate in the filter, allowing all filter cakes to be discharged in less than 1 minute. The links on the colossal filter needed to be:

- Strong enough to withstand the load of a large format plate stack
- Fit into a small space
- Corrosion resistant

Solution: Links were manufactured from carbon composite materials and provide an ultra light weight, corrosion resistant system, with a strength >7x that of hardened steel.
Solutions- Filter Plate Design

Filter Plate Development
Filter plate suppliers are developing their machines to enable larger filter plates to be manufactured, however these machines are few. FLSmidth overcame this supply chain issue by completing the following:

- Develop welding procedure to join two readily available 2000mm x 2000mm plates
- Designed plates to fit within shipping container

Other Advantages
- Known slurry distribution
- Standard filter media supply
Solutions- HAB Feeder

**FLSmidth HAB Feeder:**
- 4.5 m wide by 25 m long
- Hybrid, low profile style feeder conveyor.
- The HAB takes the concept of using flights from an apron feeder, and combines it with the belt from a traditional conveyor.
- Designed to handle the impact of 40 m³ (70 mt) of filter cake in <1 min

DEM Bulk Material Flow Simulation results.
Right-to-Left conveyor flow
Solutions - HAB Feeder

Phase One
- Batch Process - Dewatering
  - Thickeners
  - Filter Presses

Phase Two
- Continuous Process - Conveying & Stacking
  - Feeder Conveyors
  - Transfer conveyor
  - Single system
  - Dual system
  - Secondary stacking
  - Shiftable conveyor
  - Stacking spreaders

Critical Interface
Solutions - HAB Feeder
Solutions- Optimum Water Recovery

- The Demo Plant and Filter Press does not require any plant water for wash functions as **water is recycled**
- A Delta-Stak clarifier processes all filtrate and provides the filter with the water required for washing. This process step would be performed in the filter feed thickener on a full scale facility.
- The solids from the Delta-Stak are sent to the tailings impoundment. In a full scale plant, the solids from the thickener will be fed to the filter.
Options for Full Scale Production

- Mantos de Oro La Coipa, Chile
- Capacity 1,200 tph
- Commissioned 1990
How to Combine Mine Waste

Concentrator → Coarse underflow to belt → Water recycling

Dry tails underflow to belt → Transfer conveyor 500-5,000m → Transfer chutes

Chute Mixing
- Blending of various particles through chutes
- Comparative test i.e. no. of revolutions in the cement mixer and based on no. of chutes
- Impact of ‘cross conveyor’ on mixing

Stack
- Extent of final blending on discharge
- Measurement of compaction in stack
- Ground bearing pressure
- Define stacking height

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Conclusion

- Numerous design improvements have been implemented to overcome limitations of existing designs

- A new **high capacity filter press** has been developed, suitable for high tonnage tailings dewatering

- A new style of **feeder conveyor – HAB** - has been developed to overcome the high tonnages that result from an increase in filter size

- The demonstration plant will provide the customer and industry with an accurate set of data, allowing them to enter the second phase of the project with **reduced risk** and confidence in their full scale system design
FLSmidth Tailings Systems
Saving Money and Improving Safety