FLSmidth Filtration for Tailings Management

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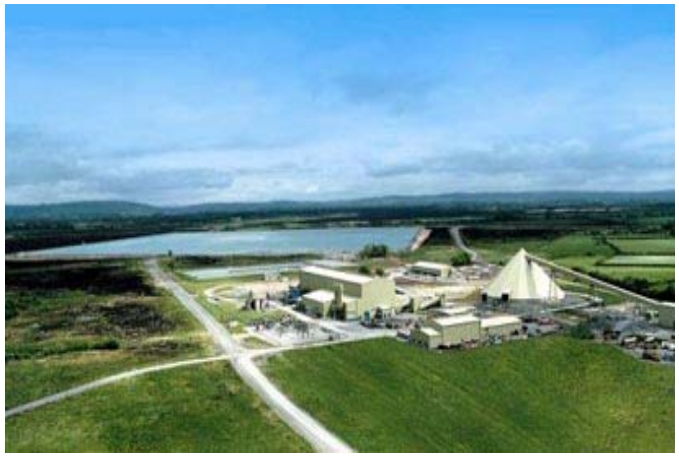
One Source

Wet Tailings Solutions



Lisheen mine tailings pond (Vedanta) in Ireland

The L-L embankment of the Valley impoundment
The Highland Valley Copper Mine is located just outside the town of Kamloops in British Columbia, Canada. The mine produces copper (435,000 tones in 2003) and molybdenum (6405 tones in 2003) concentrates. The tailings pumped to the Valley Impoundment in 2003 were 48.5 million tons.

River and sea disposal Submarine Tailings Disposal (STD) is perhaps the most common offshore disposal technique and involves the deep water discharge of tailings to the sea

Facts about Tailings and the handling processes

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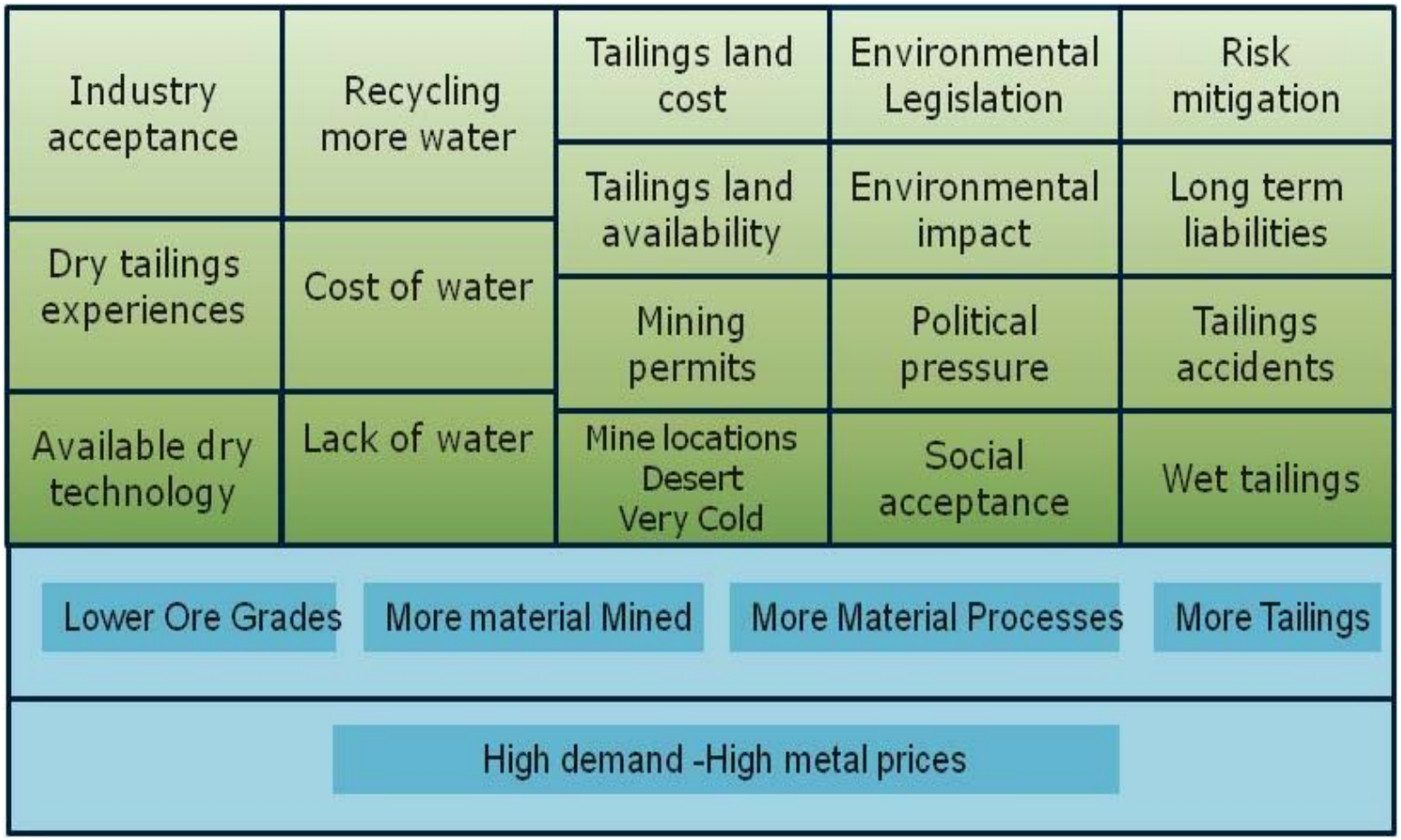
Facts about Tailings and the handling processes

- *Depending on the type of mineral the tailings can represent anywhere from 30% to 99% of the solids mined*
- *Most minerals tailings currently are handled with wet tailings process and stored in tailings impoundments*
- *These need careful construction, maintenance and monitoring, and also suffer from high evaporation/loss rates*
- *Several drivers towards dry tailings, including:*
  - *lack and cost of water*
  - *Suitable tailing pond lands,*
  - *reclamation responsibilities,*
  - *environmental legislation and,*
  - *wet tailings storage risks*

Dry Stacking Drivers



Tailings Solutions Options

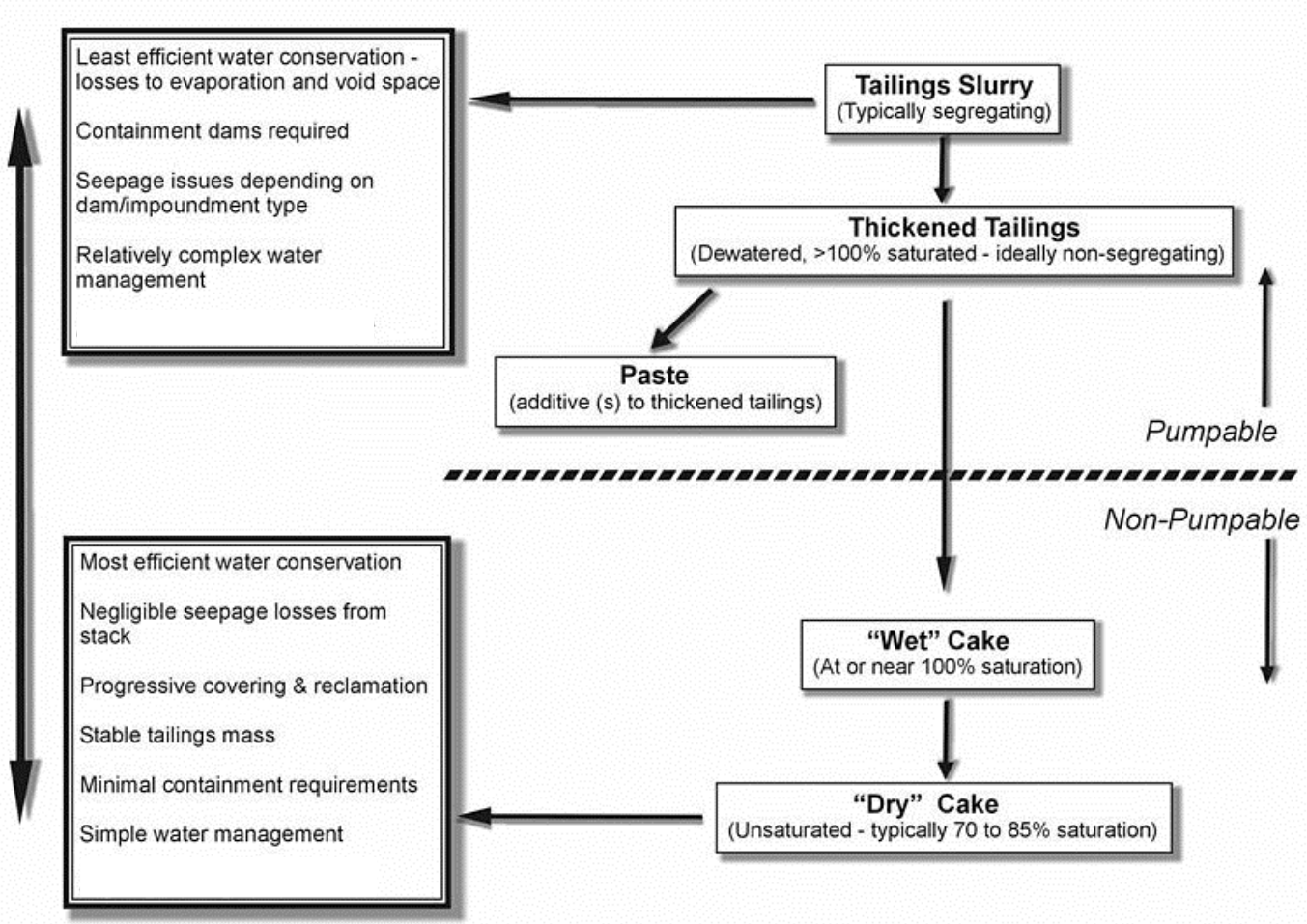
Dry stacking-La Coipa Mine (Anglo American, Chile)

Surface paste disposal at Myra Falls Mine, Vancouver Island, Canada

Surface thickened
Thickened discharge at Kidd Creek, ON, Canada (left) and at Mt Keith, Western Australia (right)

Fresh paste depositing over a desiccated layer (left) and one of the risers at the Bulyanhulu Mine (Barrick), Tanzania (Courtesy Golder Associates)

Wet or Dry Tailings?

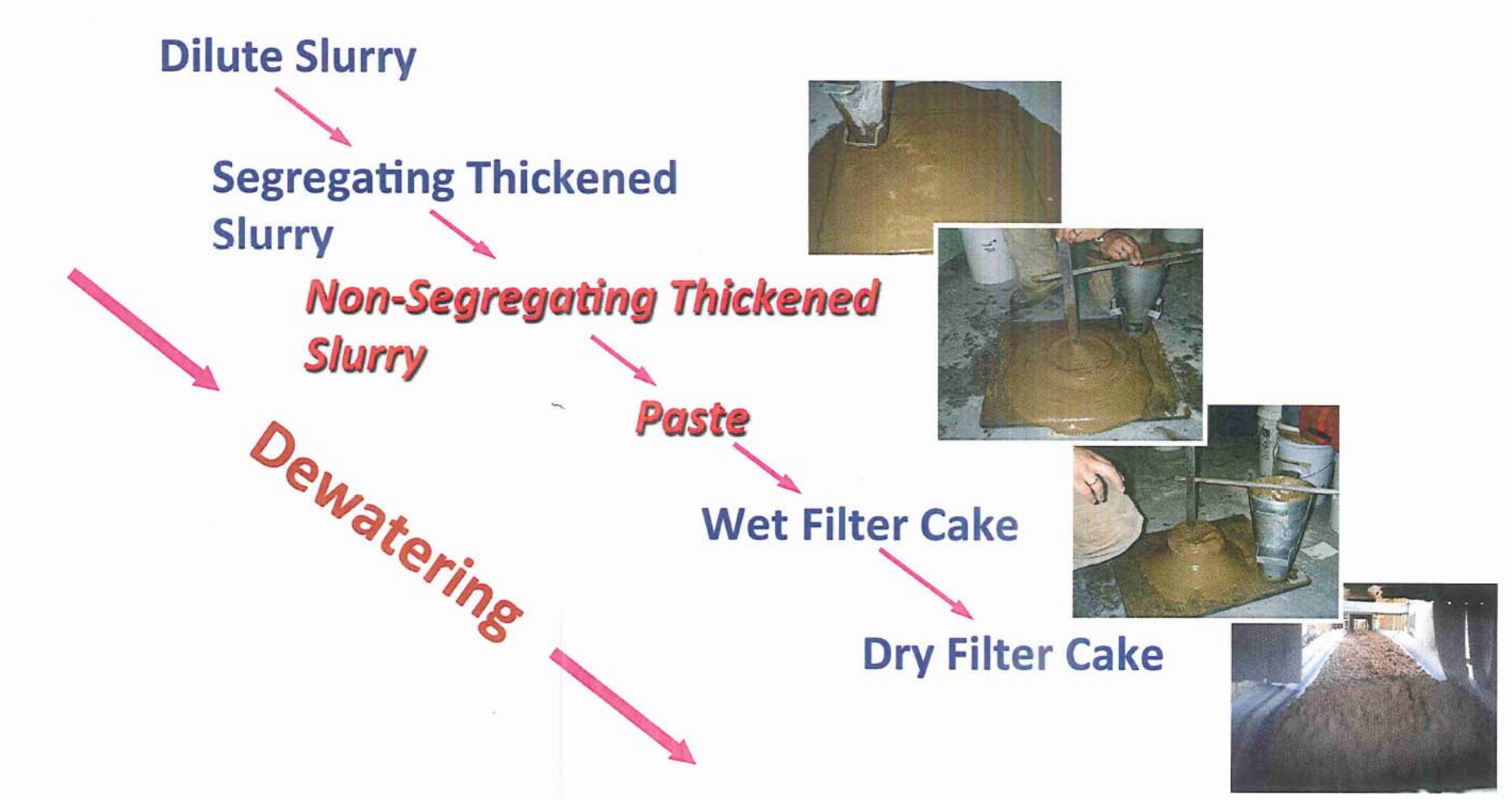


Water ratio's for typical granular tailings

Slurry % solids	H_2O vol. / mt Tailings (m^3/mt)	Description
20	4.0	Ore processing
30	2.3	Plant tailings
50	1.0	Thickened slurry
60	0.67	High Density slurry
75	0.33	Thickened to paste
82	0.21	Vacuum filter
88	0.13	Pressure filter

COURTESY MINE PASTE ENGINEERING LTD.

Slurry Material Continuum



COURTESY MINE PASTE ENGINEERING LTD.

Facts about Tailings and the handling processes

- *The dry tailings process will increase with new operations, especially those situated in deserts environments and areas where tailings land availability is a constraining factor*
- *Solids content in thickened tailings is between 40% and 70%.*
- *Dry cake tailings solutions can increase the solids content to as high as 85%, which represents substantial water savings for the mine*
- *Dry tailings are also easier to reclaim and have lower environmental impact risks during operation and after the closure*
- *Dry Tailings provide the lowest risk profile with respect to failures and the costs associated with cleaning up those failures.*

Tailings accidents

The majority of historical tailings related incidents have been influenced by poor day to day management.

Accident in Stava Trento Italy, 1985
Cycloned sand tailings
Along its path, the mud killed 268 people and completely destroyed 3 hotels, 53 homes, and six industrial buildings; 8 bridges were demolished and 9 buildings were seriously damaged. A thick layer of mud measuring between 20 and 40 cm in thickness covered an overall 435,000 square m over 4.2 km. According to the subsequent inquiries, the collapse was caused by the chronic instability of the dams, especially in the upper one, which were below the minimum factor of safety required to avoid collapses.

Cerro Negro near Santiago Chile 2003
Wet tailings

Marriespruit South Africa 1994
Wet tailings

The TVA Kingston Fossil Plant coal in the USA 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.

Tailings accidents

The Ajka Timfoldgyar Alumina Plant Tailings Dam Accident October 4th 2010 in Hungary. Hungary's government estimated that it would cost more than US$51 million and take at least a year to clean up the damage. Hungarian state news service MTI estimated at the time of the accident that Hungary stores about 50 million tons of the red tailings with about 800,000 tons generated annually.

World Market for Dry Tailings

Expected high global growth

Dry Tailings Global Market Outlook & FLSmidth Strategy

FLSmidth's Tailings Strategy

2011

- ✓ One of the leading suppliers of tailings equipment and bundled products.

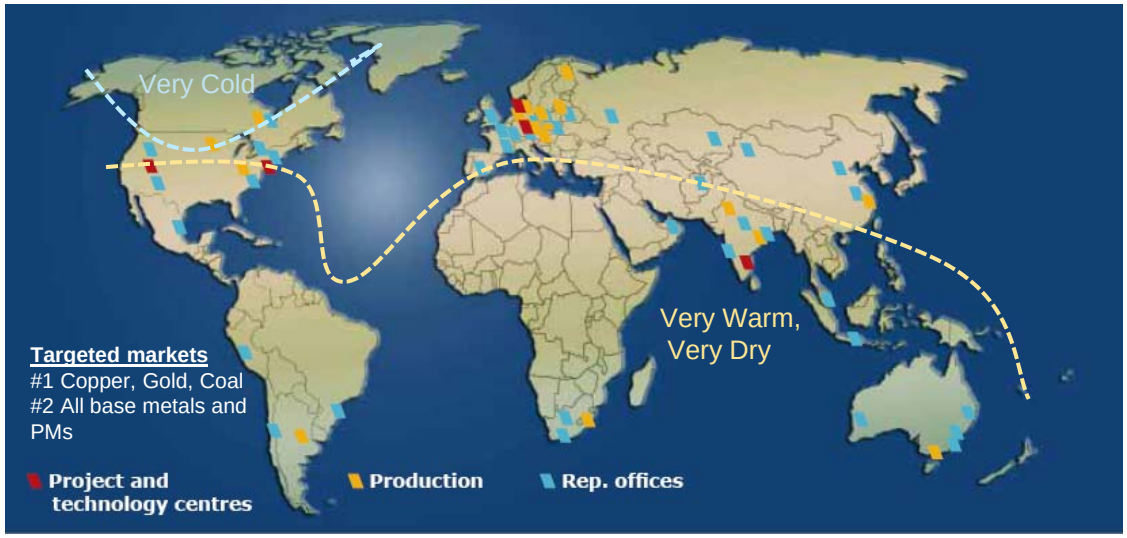
Near Future

- ✓ The leading supplier of dry tailings islands solutions.

Long Term

- ✓ The Leading supplier of dry tailings management solutions

Dry Tailings Opportunities & FLSmidth Locations

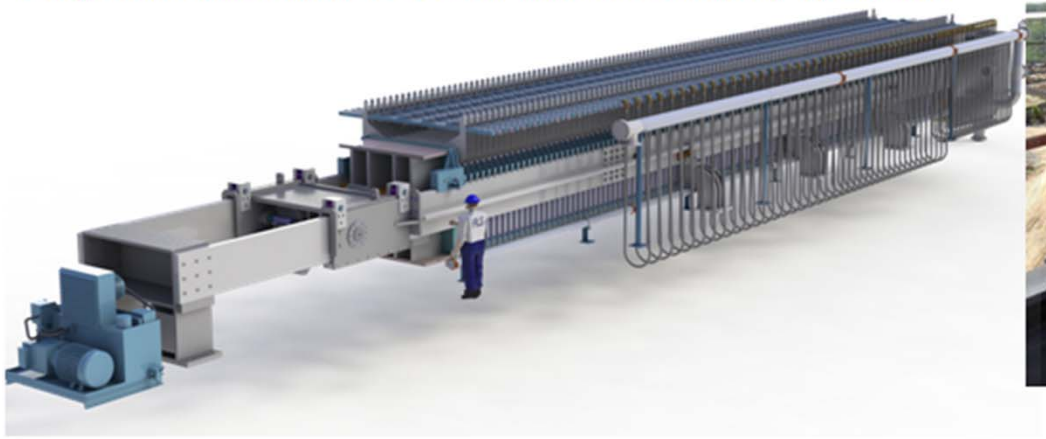


Dry Tailings

- ➢ Dry, desert areas, lack of water. Southern Hemisphere in specific
- ➢ Water issues and TSF type guided by strong environmental legislation
- ➢ Very cold climates, freezing temperatures, permafrost

FLS Dry Tailings Solutions

Largest Minerals Filter Press for 100 000 tons/day operation



FLS Values for Tailings Solutions

- **Sustainable solutions**
  - Dry tailings solutions
    - Recycling of water
    - Environmentally sound
    - Lower cost

- **Peace of mind**
  - Our solutions combine technical and operational reliability
    - Reliability of operations
    - Proven results
    - Proven technology
    - Experience
    - References
    - Process knowledge
    - One source for solutions or individual equipment
    - Tailings islands
    - Customer Service
    - Maintenance contracts

- **Low TCO**
  - Our approach is holistic concentrating in effective tailings solution for the life of the mine
  - Cost of water
  - Our industry presence, customer contacts and large reference give basis for continuous innovation
    - Productivity of the equipment
    - Leading technical solutions
    - Parts, spares, wear materials
    - Automation and monitoring
    - New methods
    - System integrations

- **Customized solutions**
  - We provide individualized solutions which meets the specific customer tailings management requirements
    - Wet or Dry
    - Different minerals and materials
    - Different conditions
      Different production requirements

FLSmidth Filtration

Key filter lines

Vacuum Filters

- Horizontal
  - Belt Filters and Pan Filters up to 250m^2
  - High Performance and Flexible
- Vertical
  - Drum Filters and Disc Filters up to 310m^2
  - Simple, Robust and Reliable

Pressure Filters

- Horizontal
  - Filter Press up to 24m^2 volume, 960m^2 area
  - Simple, Robust and Reliable
- Vertical
  - Pheumapress up to 100m^2 area
  - High Performance and Flexible

Installed Base +30,000

Global Clients

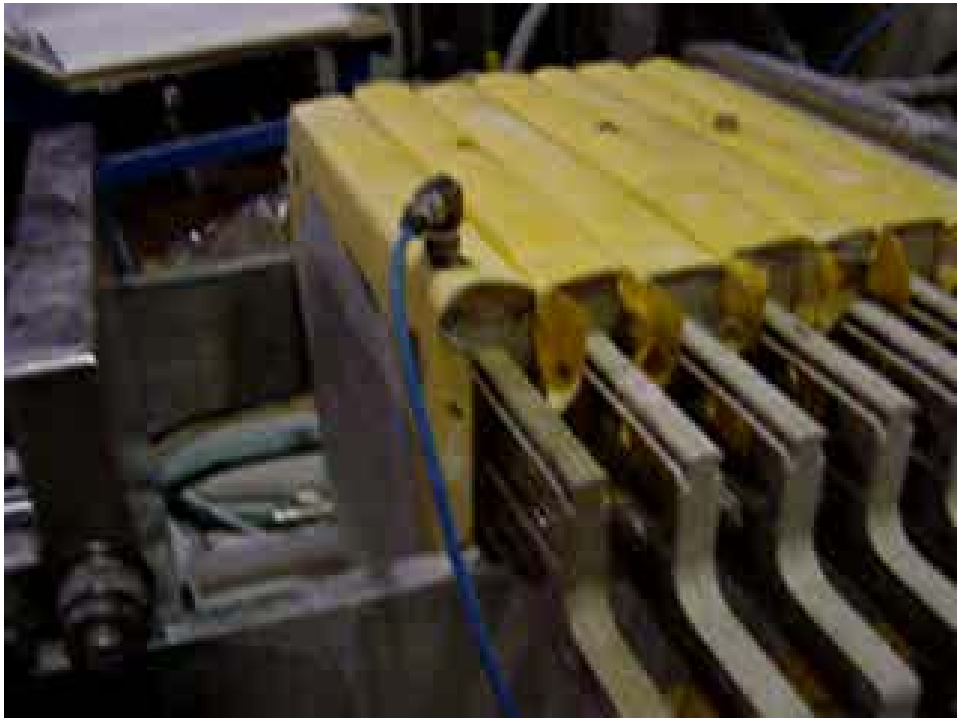
bhpbilliton

ANGLO AMERICAN

CODELCO

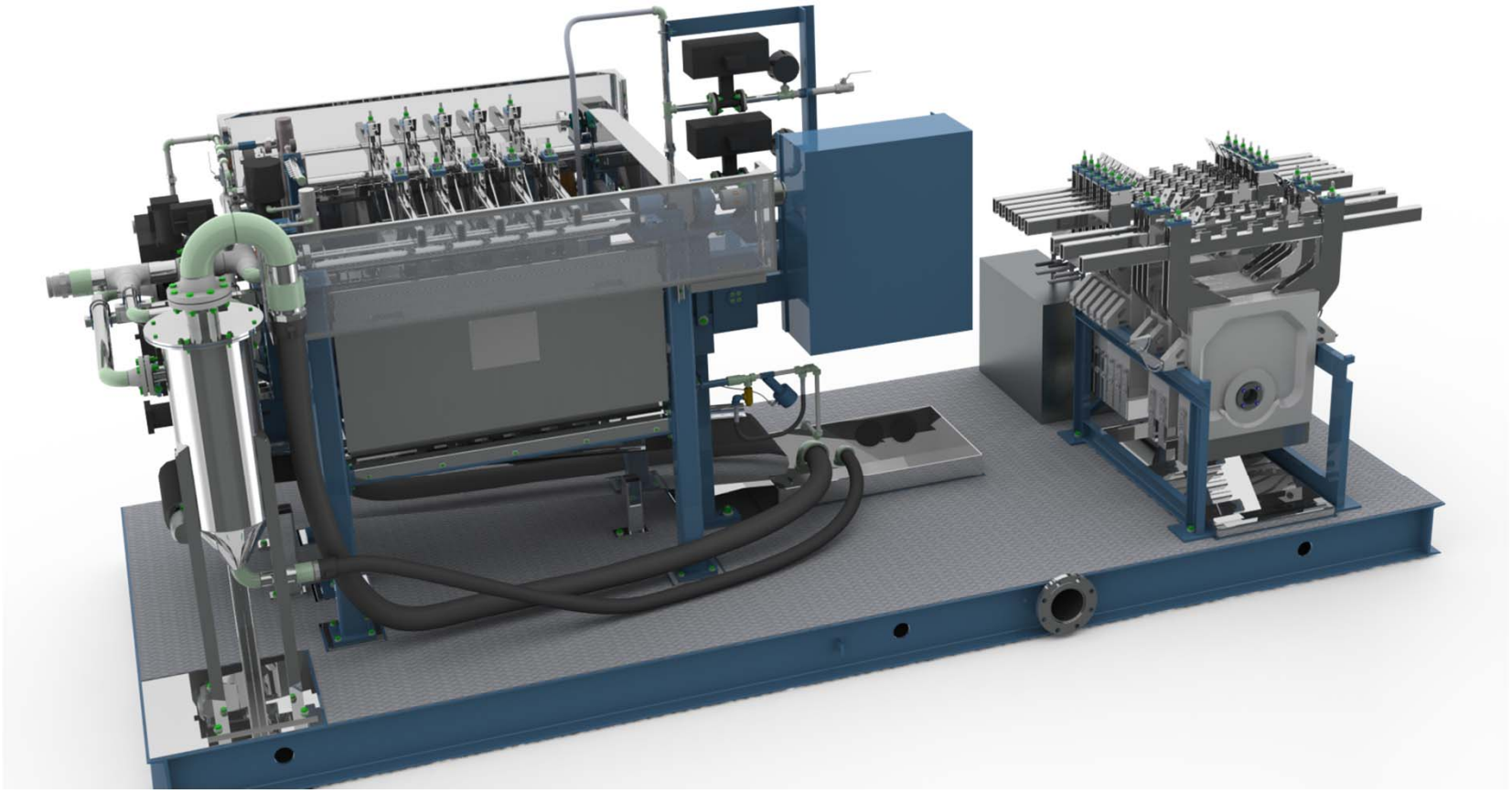
VALE

Lab and Pilot Testing

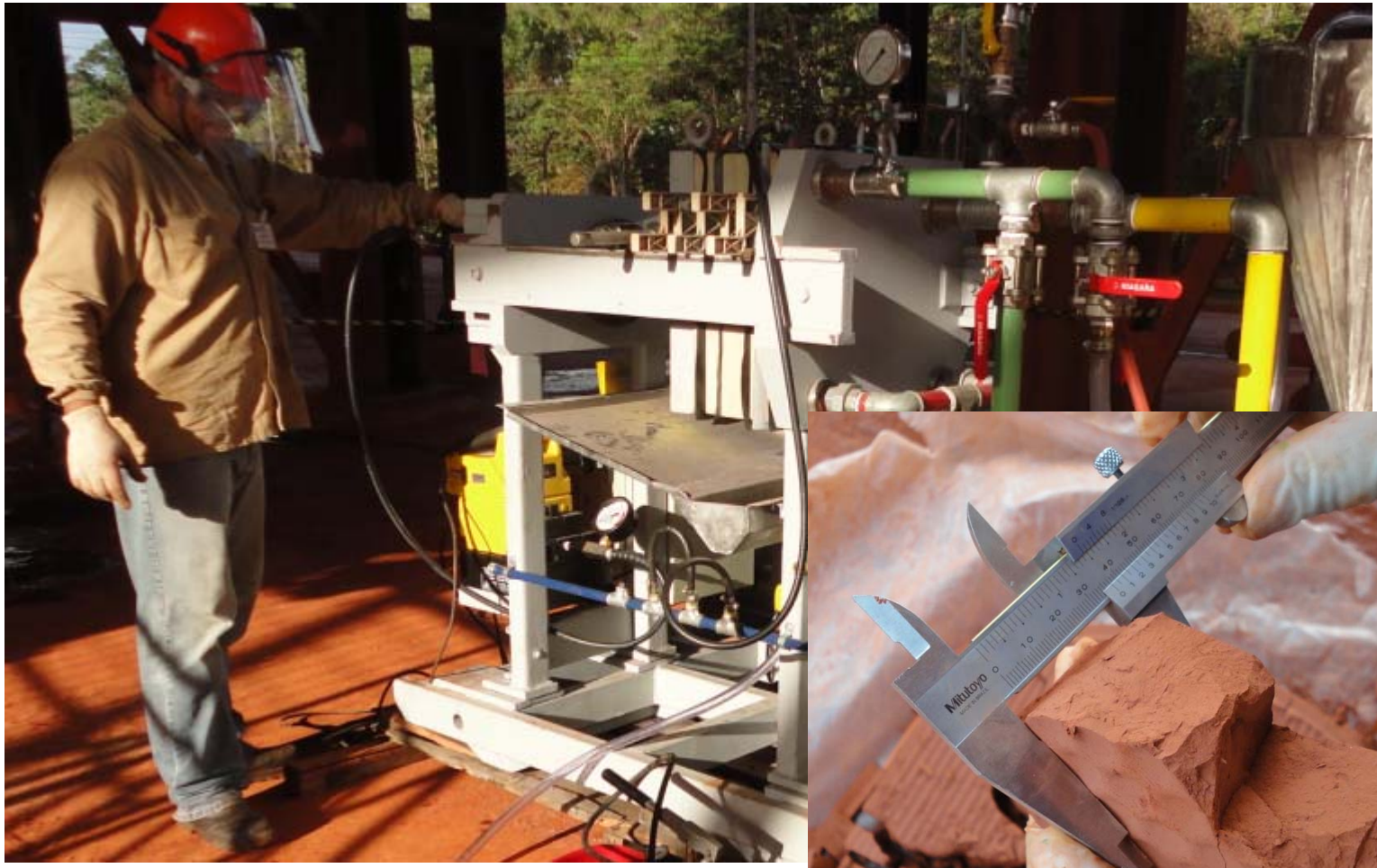


Bench-Scale and/or Pilot Testing are used to determine material filtration characteristics For equipment proper selection and sizing.

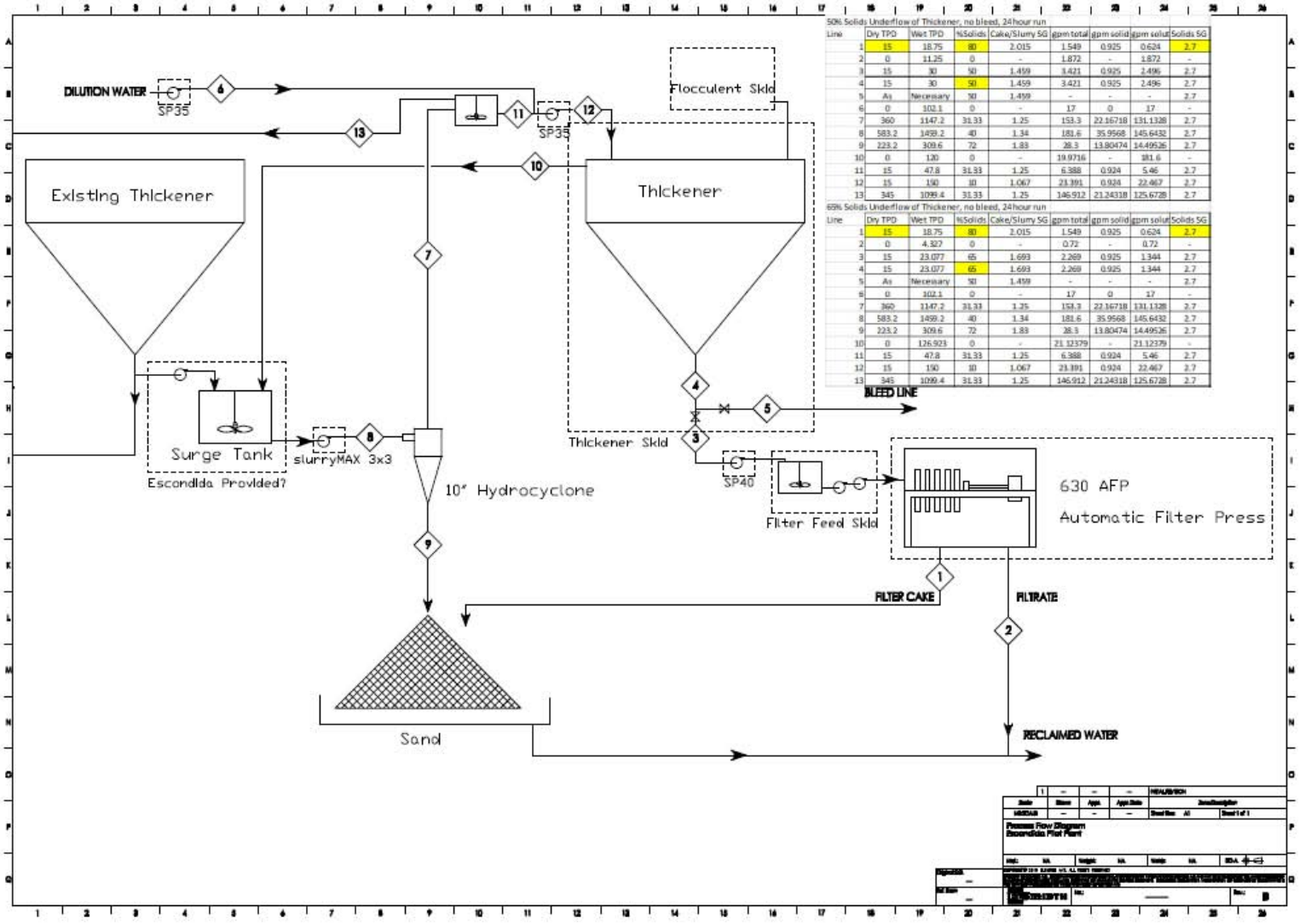
AFP Pilot Unit



FLSmidth Pilot Filter Press
500mm Membrane Mixed-Pack Plate Stack



Tailings Dewatering Options Tested



50% Solids Underflow of Thickener, no bleed, 24hour run

Line	Dry TPD	Wet TPD	%Solids	Cake/Slurry SG	gpm total	gpm solid	gpm solut	Solids SG
1	15	18.75	80	2.015	1.549	0.925	0.624	2.7
2	0	11.25	0	-	1.872	-	1.872	-
3	15	30	50	1.459	3.421	0.925	2.496	2.7
4	15	30	50	1.459	3.421	0.925	2.496	2.7
5	As	Necessary	50	1.459	-	-	-	2.7
6	0	102.1	0	-	17	0	17	-
7	360	1147.2	31.33	1.25	153.3	22.16718	131.1328	2.7
8	583.2	1458.2	40	1.34	181.6	35.9568	145.6432	2.7
9	223.2	309.6	72	1.83	28.3	13.80474	14.49526	2.7
10	0	120	0	-	19.9716	-	181.6	-
11	15	47.8	31.33	1.25	6.388	0.924	5.46	2.7
12	15	150	10	1.067	23.391	0.924	22.467	2.7
13	345	1099.4	31.33	1.25	146.912	21.24318	125.6728	2.7

65% Solids Underflow of Thickener, no bleed, 24hour run

Line	Dry TPD	Wet TPD	%Solids	Cake/Slurry SG	gpm total	gpm solid	gpm solut	Solids SG
1	15	18.75	80	2.015	1.549	0.925	0.624	2.7
2	0	4.327	0	-	0.72	-	0.72	-
3	15	23.077	65	1.693	2.269	0.925	1.344	2.7
4	15	23.077	65	1.693	2.269	0.925	1.344	2.7
5	As	Necessary	50	1.459	-	-	-	2.7
6	0	102.1	0	-	17	0	17	-
7	360	1147.2	31.33	1.25	153.3	22.16718	131.1328	2.7
8	583.2	1459.2	40	1.34	181.6	35.9568	145.6432	2.7
9	223.2	309.6	72	1.83	28.3	13.80474	14.49526	2.7
10	0	126.923	0	-	21.12379	-	21.12379	-
11	15	47.8	31.33	1.25	6.388	0.924	5.46	2.7
12	15	150	10	1.067	23.391	0.924	22.467	2.7
13	345	1099.4	31.33	1.25	146.912	21.24318	125.6728	2.7

Options for Tailings Dewatering

FILTRATION CYCLE TIMES	
(Minutes)	
Fill Empty Filter	1.48
Filtration to Solids Consolidation	5.51
Wash Solids	0.00
Inflate + Hold + Deflate Membranes	0.00
Cake Blow	0.25
Core Wash/Blow	0.50
Shake Cloth	0.50
Filter Cloth Wash & Purge	0.50
Open & Close Filter	1.89
Total Cycle Time	10.63

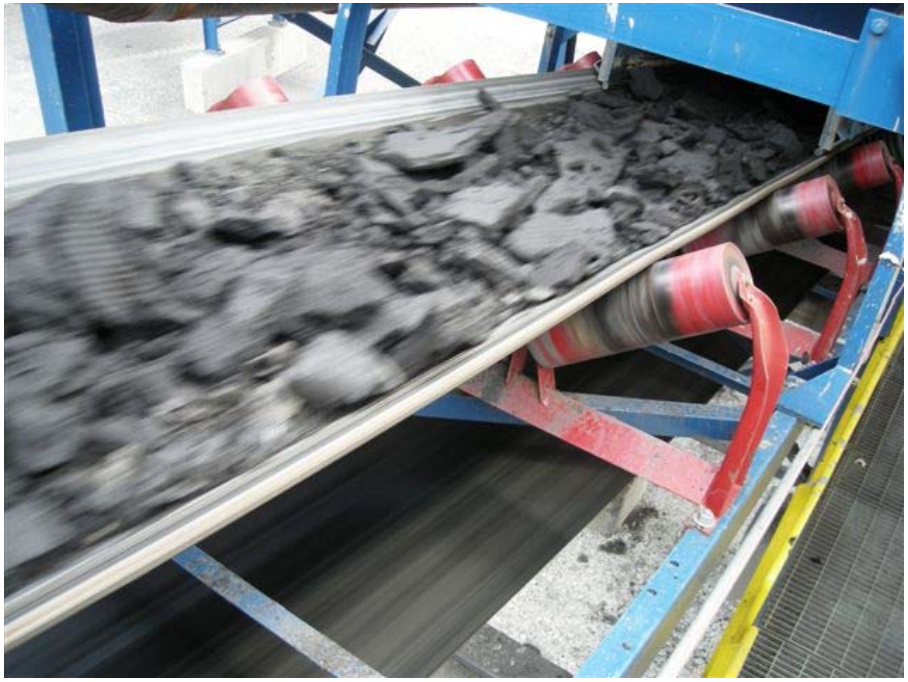
Fine Tails – Cyclone Overflow
26% Cake
P80 - 30.5

FILTRATION CYCLE TIMES	
(Minutes)	
Fill Empty Filter	0.81
Filtration to Solids Consolidation	5.38
Wash Solids	0.00
Inflate + Hold + Deflate Membranes	0.00
Cake Blow	0.25
Core Wash/Blow	0.50
Shake Cloth	0.50
Filter Cloth Wash & Purge	0.50
Open & Close Filter	1.50
Total Cycle Time	9.44

Total Tails
18 % Cake
P80 – 204

Most Effective Solution – Filter Cake

Filter Press Technology Produce Consistent Dry Cake w/o the Need for Expensive Polymers



Refuse Belt

Coal Refuse Filter Cake

Full Range of Filter Press Products

Low Cost Standard Products

- Filter Presses from small to large / Fully and Fully Automatic to Fully Manual

High Performance Advanced Products

- Worlds Largest Minerals Filter Press → 10% capital cost saving
  - 120 Chambers – twice the size of Competitors
  - 2x2 lower feed eye filter plates

Key Elements for Cost Effective Filter Design

- *TCO must be competitive with traditional solutions*
  - *High Initial Costs > $100,000,000 USD*
  - *Low Operating Costs > $0.75 USD/ton*

- *Minimize Filtration Capital Costs*
  - *Minimize Cycle time*
  - *Maximum Filter Size*

- *Minimize Filtration Operational Costs*
  - *Minimize energy usage*
  - *Eliminate wasted energy*
  - *Minimize Cloth Consumption*
  - *Use cost effective design*

For High-Volume Production
Large-Scale Filters with 2M x 2M Plates

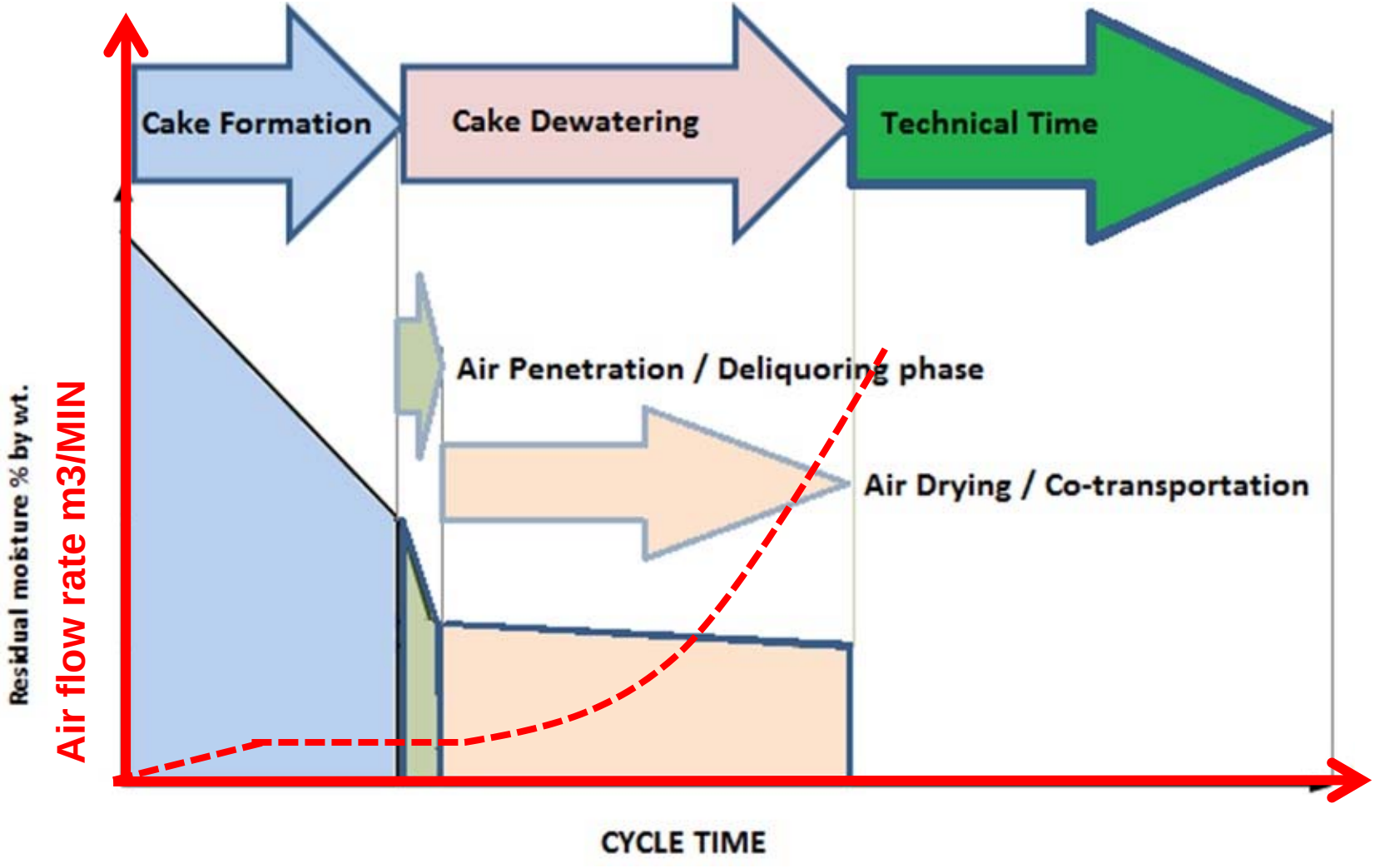
Filter Specifications:

- 2 x 2 Plates
- 16 bar rated
- Overhead Type
- 100 Bar Cloth Washer

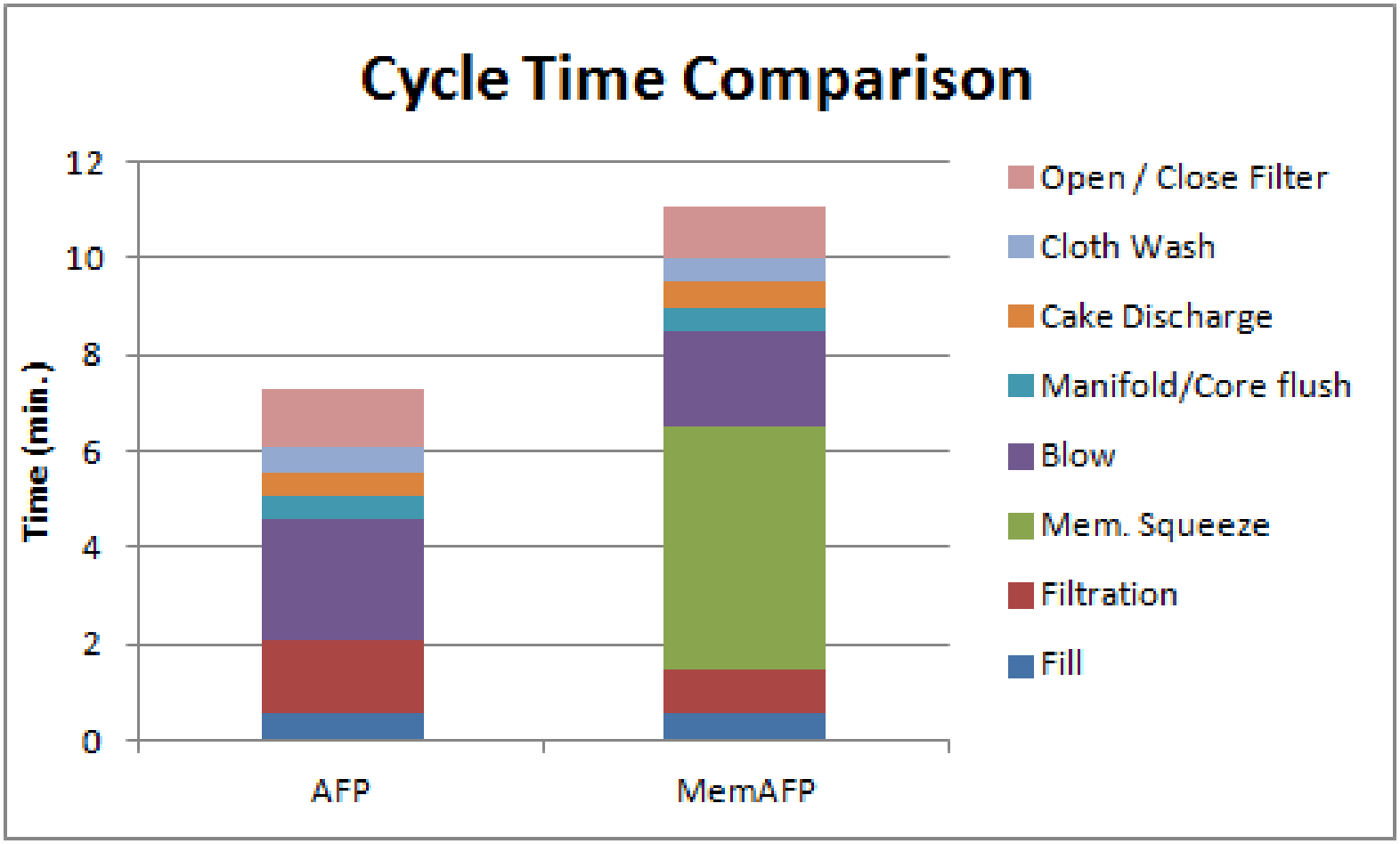
Single Plate Indexing – Discharge =10 min.

Shriver® Filter Press

Cake Filtration STAGES - Dewatering

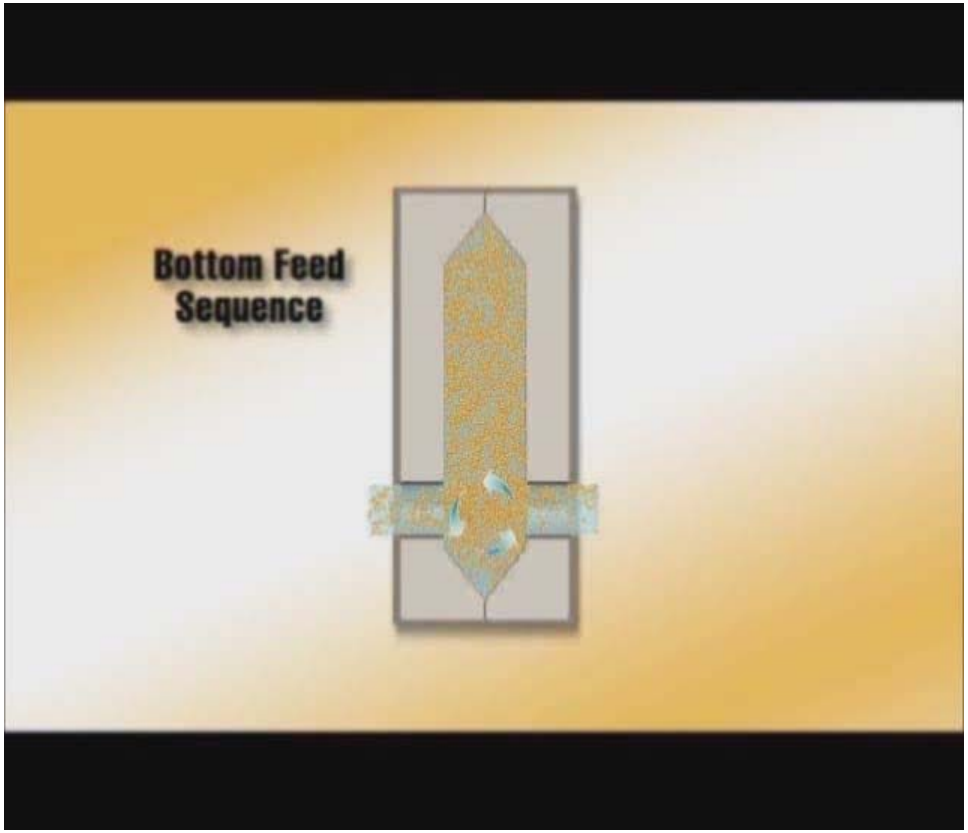


Typical Tailings Cycle Time

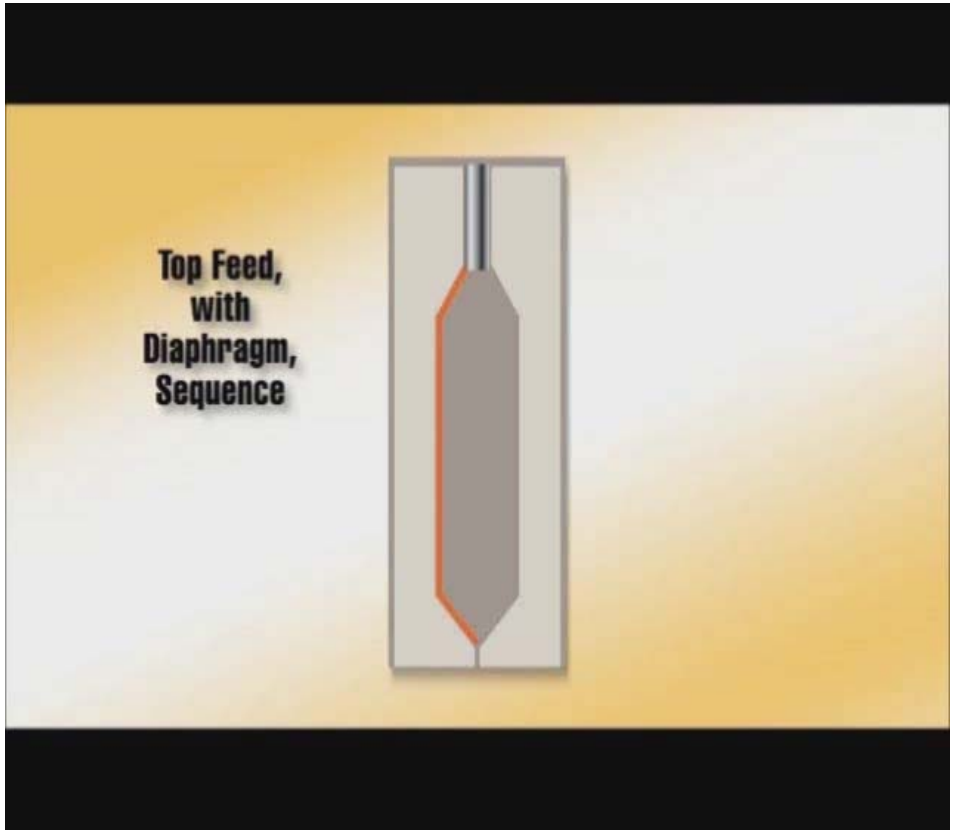


Minimize Cycle Time
Eliminate Membranes

Bottom Feed Recessed Chamber

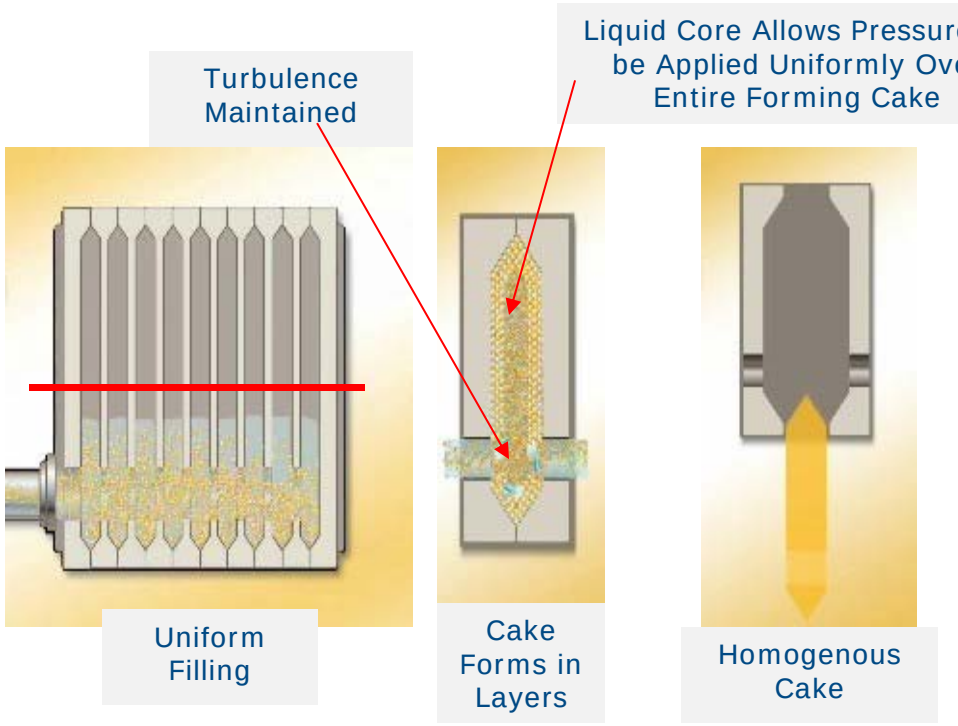


Top Feed Membrane

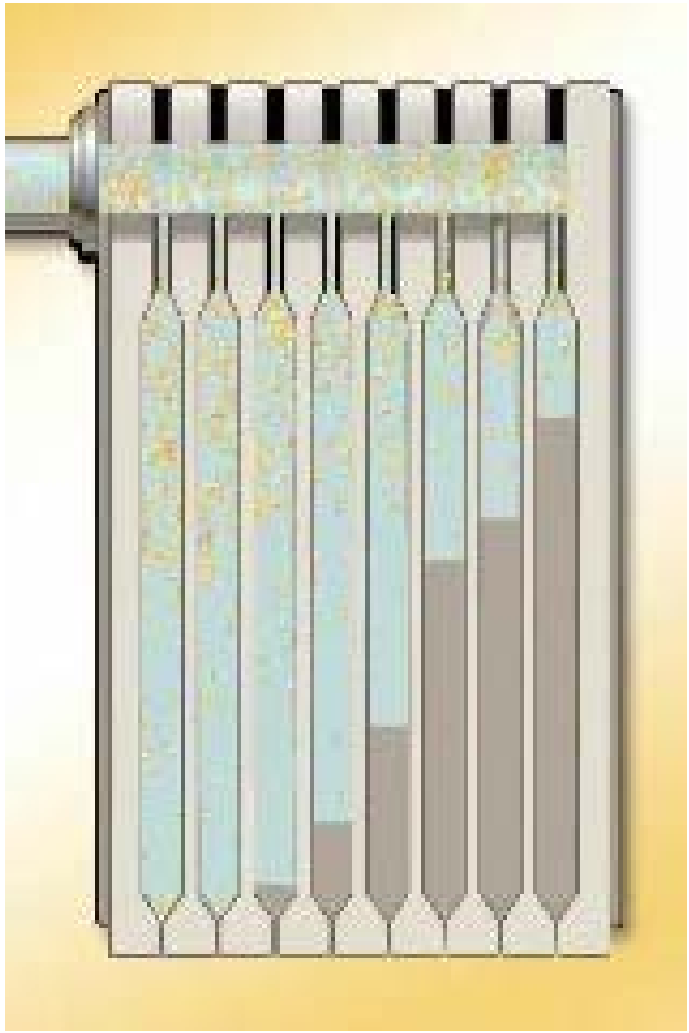


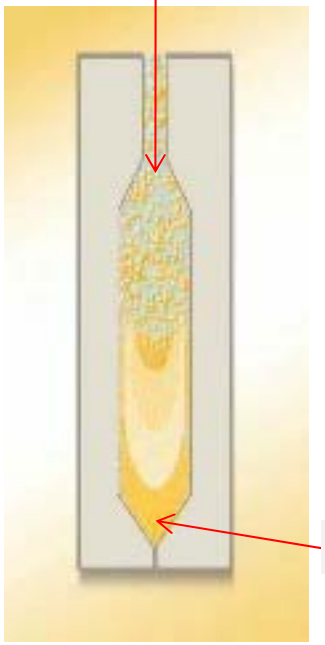
AFP IV™ FILTER
Filtration Pressure

- Slurry Pumps Are Used To Create The Filtration Flow and Pressure
- VFD control ensures pumps operate to required filtration curve.



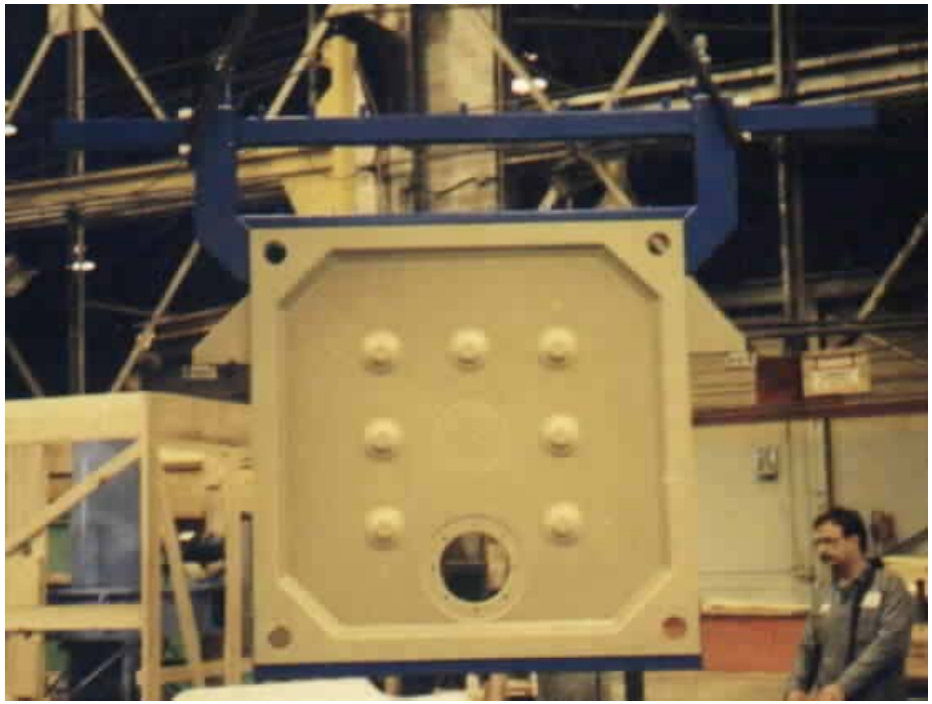
Competition
Upper Feed Eye

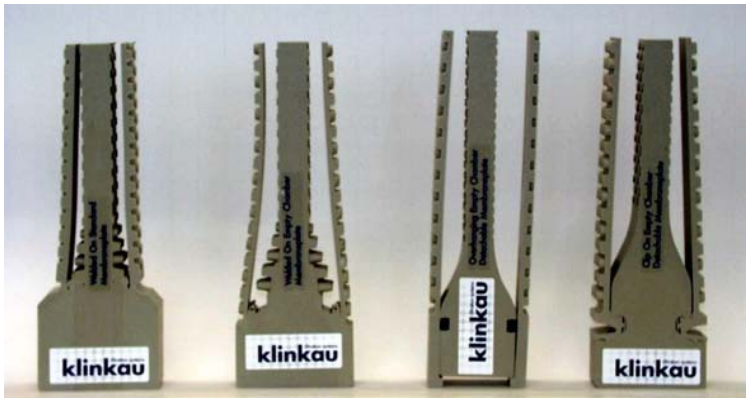




- Chambers fill in series, not in parallel
- Cakes are more consolidated at the bottom of the plate than at the top of the plate
- Membranes are required to consolidate into even cakes

PLATE DESIGN





Membrane Plate Section

Filter Plates Comparison

Top Feed

- Membranes required
- Plate removal not required for cloth change
- Plate life limited
- Cost up to US$ 20,000 each
- Membrane accessories needed – higher Opex
- Longer cycles for membrane squeeze means less production per cycle and more filter press area required

Bottom Feed – FLS Technology

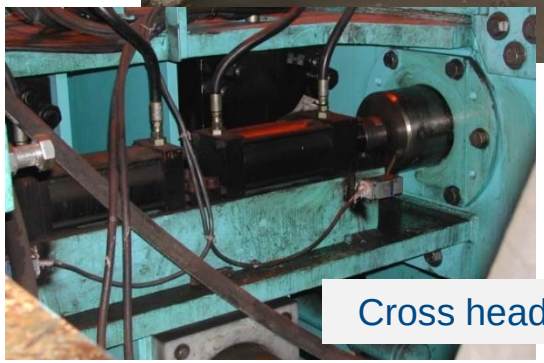
- No membranes required
- Remove plate for cloth change – Not significant
- Plate life extended
- Cost US$2,000 each

Minimize Cycle Time
Discharges In < 1 Min.

AFP IV™ Automatic Filter Press

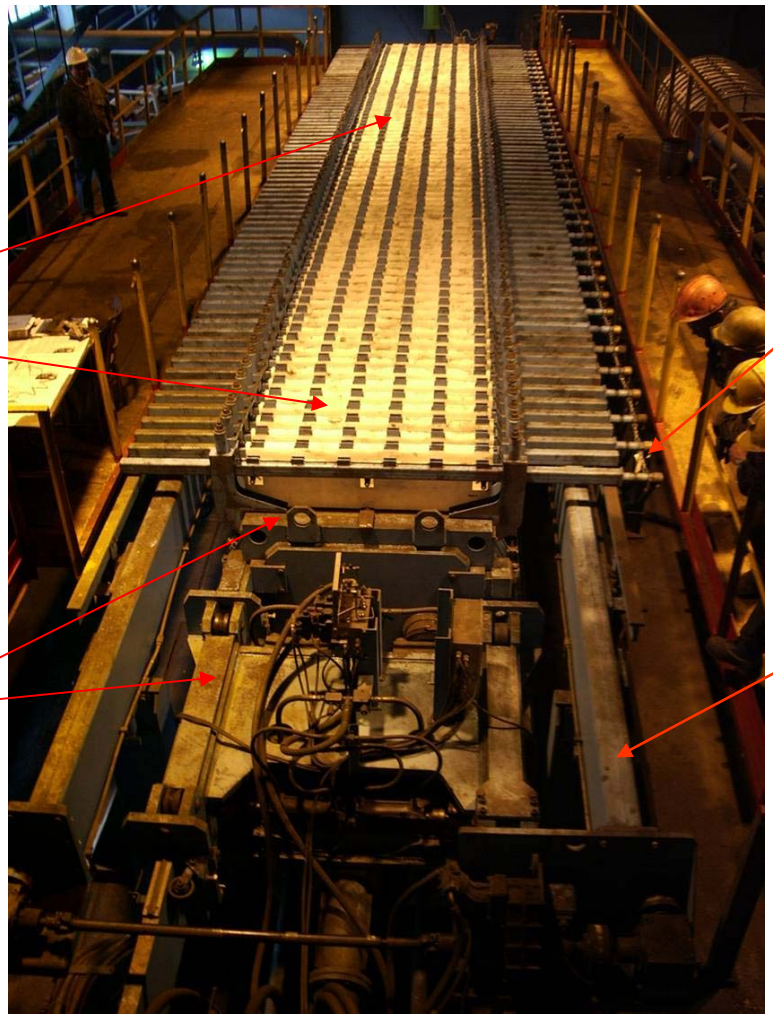
Cross Head System

Discharges 120 Chambers in < 1 Min.



Cross head system lock pins

Optimized Design



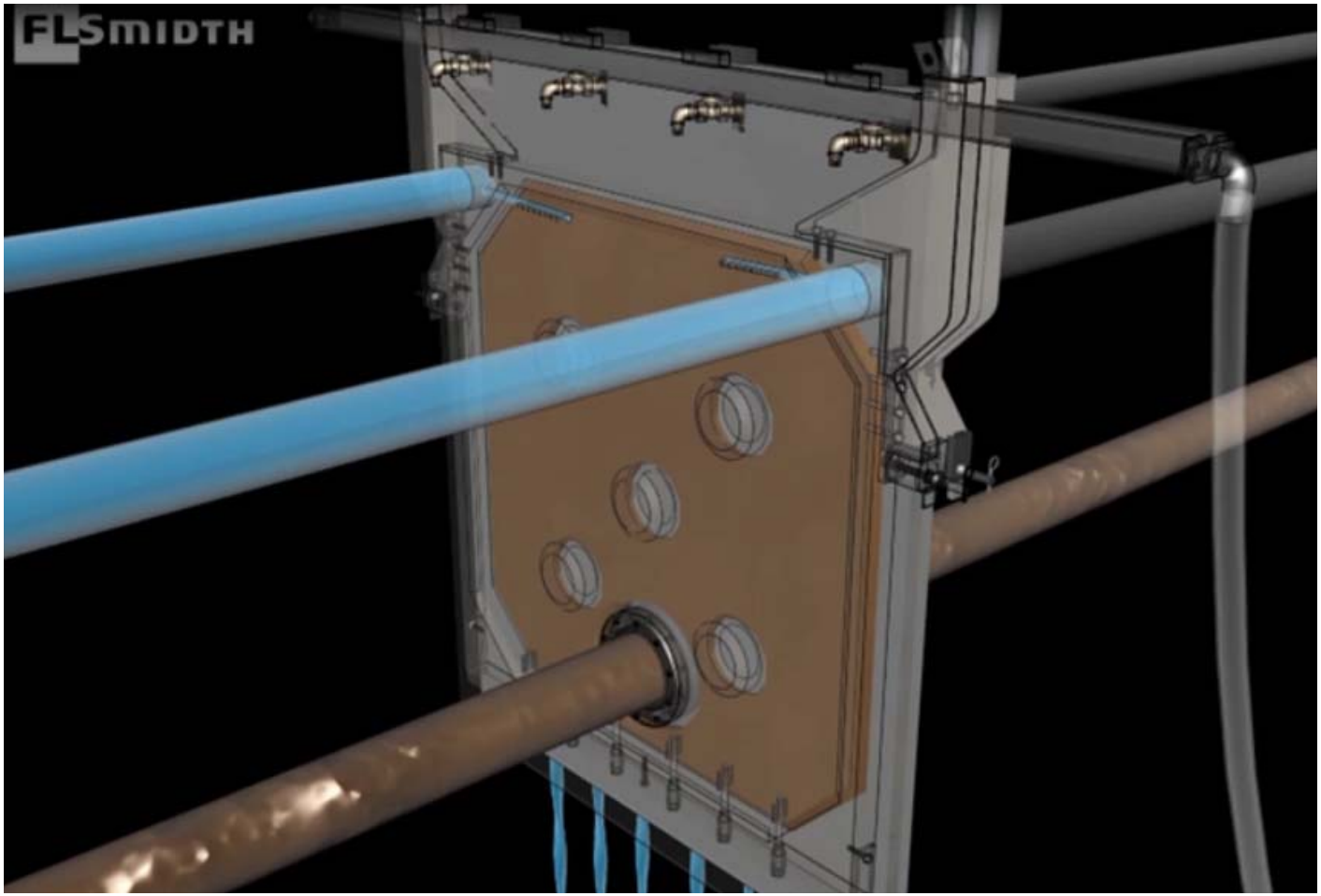
The Heart of Filtered Tailings
AFP IV™ Automatic Filter Press

Filter and Drip Tray on Assembly Floor

AFP IV™ Automatic Filter Press

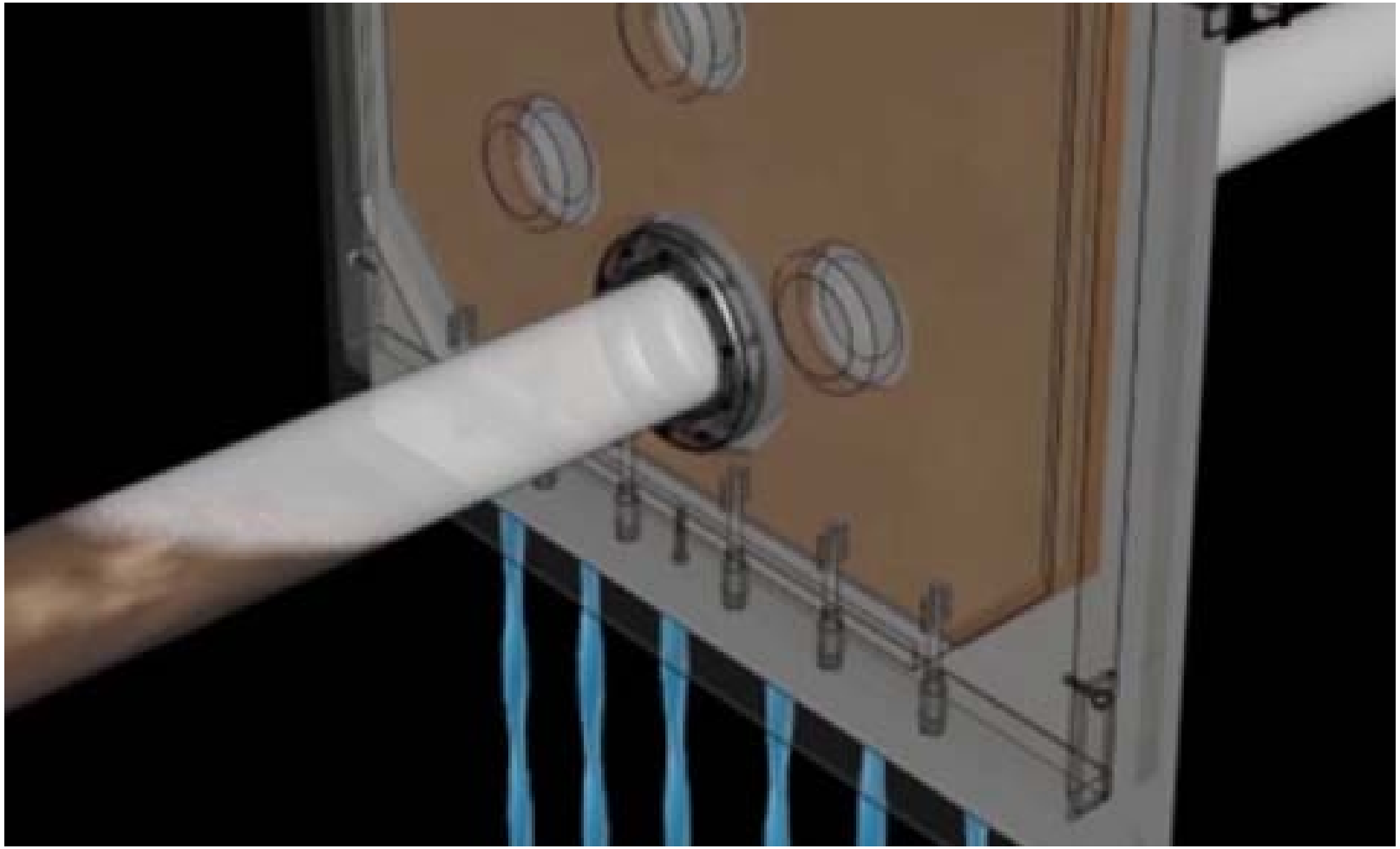
Automatic Filter Press

AFP Operation (without Cake Wash)



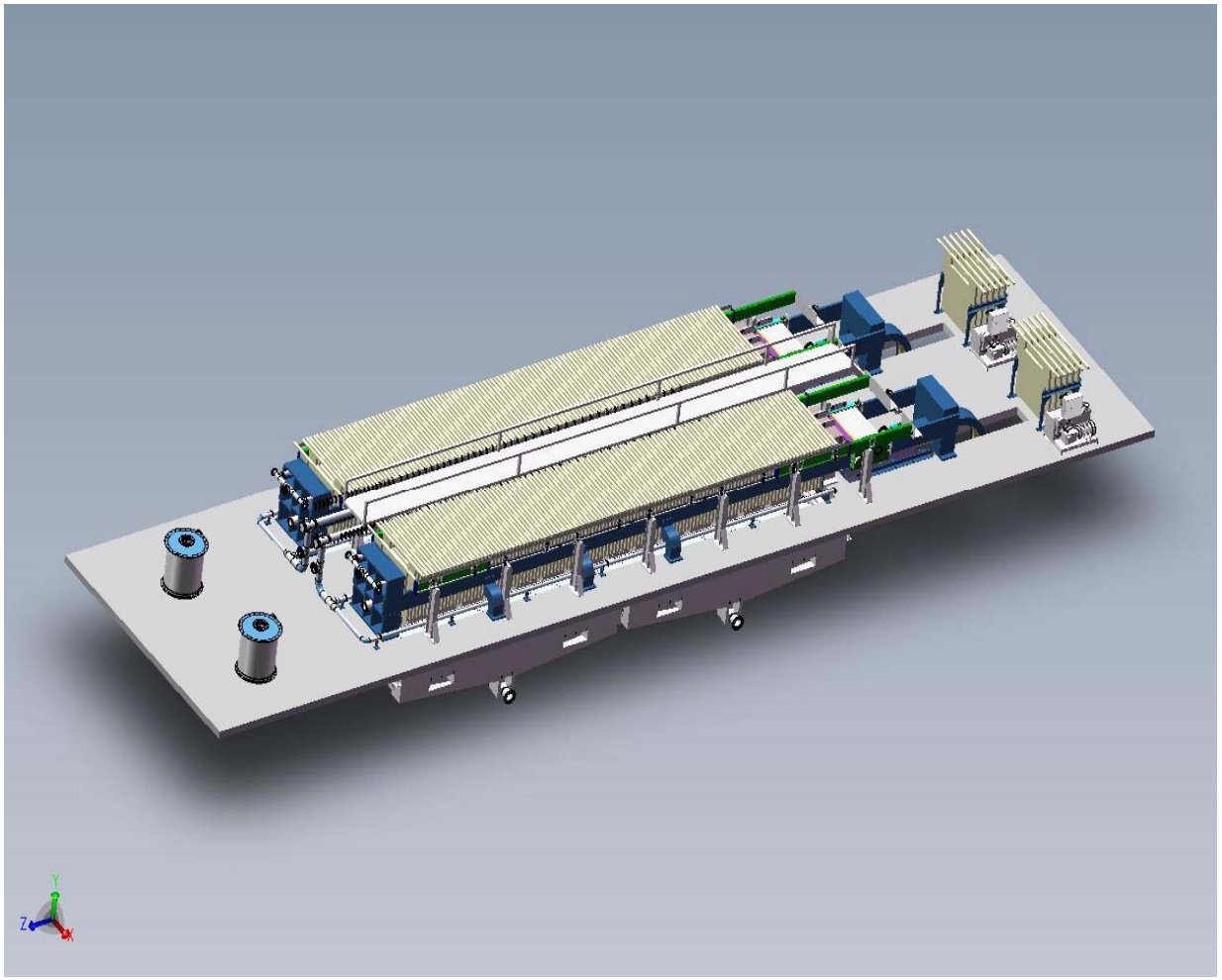
Automatic Filter Press

Core Blowing to Clear Feed Eye



For High-Volume Production

Large-Scale Filters with 2M x 2M Plates



Filter Specifications:

- 9,015 ft^2 (838 M^2)
- 475 ft^3 (13.5 M^3)
- 225 psi (16 bar)
- Dry Wgt: 165 tons

Typical Open Discharge Arrangement

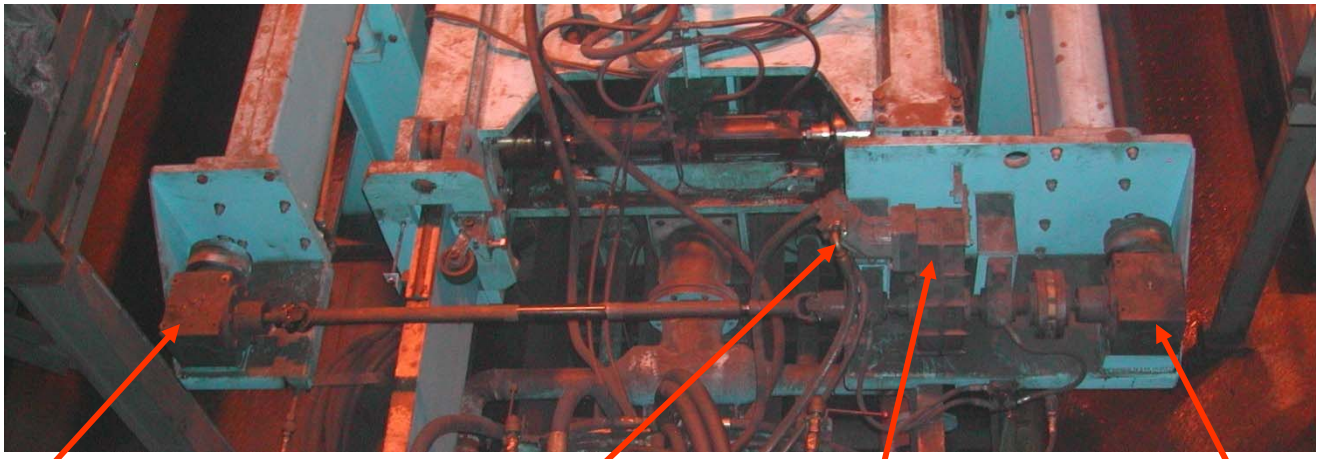
Filtrate is Discharged Directly to the Drip Tray or Launder

Flood Wash Arrangement

Water Connection

Bottom Wash Supply

Shaker System



Right Angle Gearbox

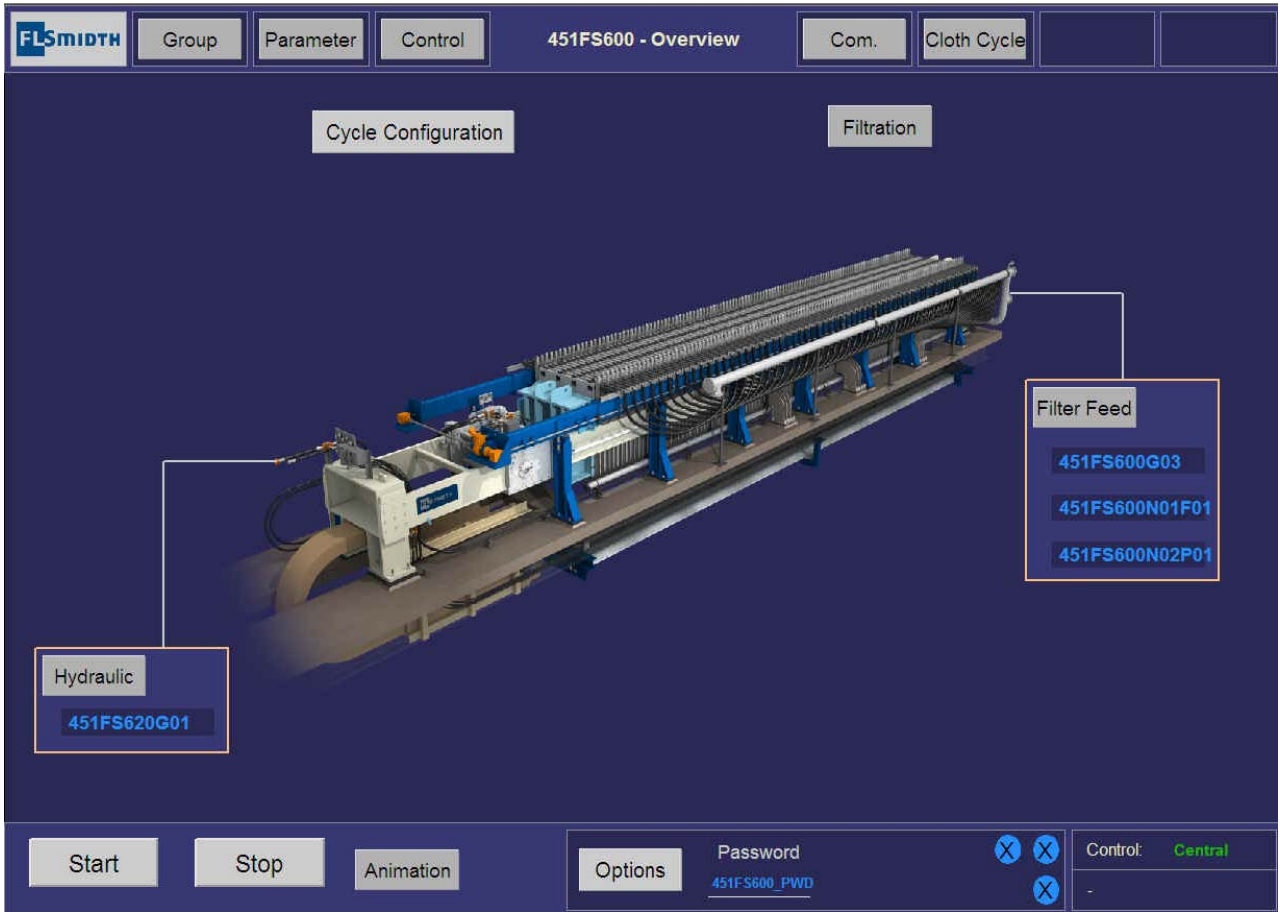
Hydraulic Motor

Gear Box

Right Angle Gearbox

Shaker Drive Configuration

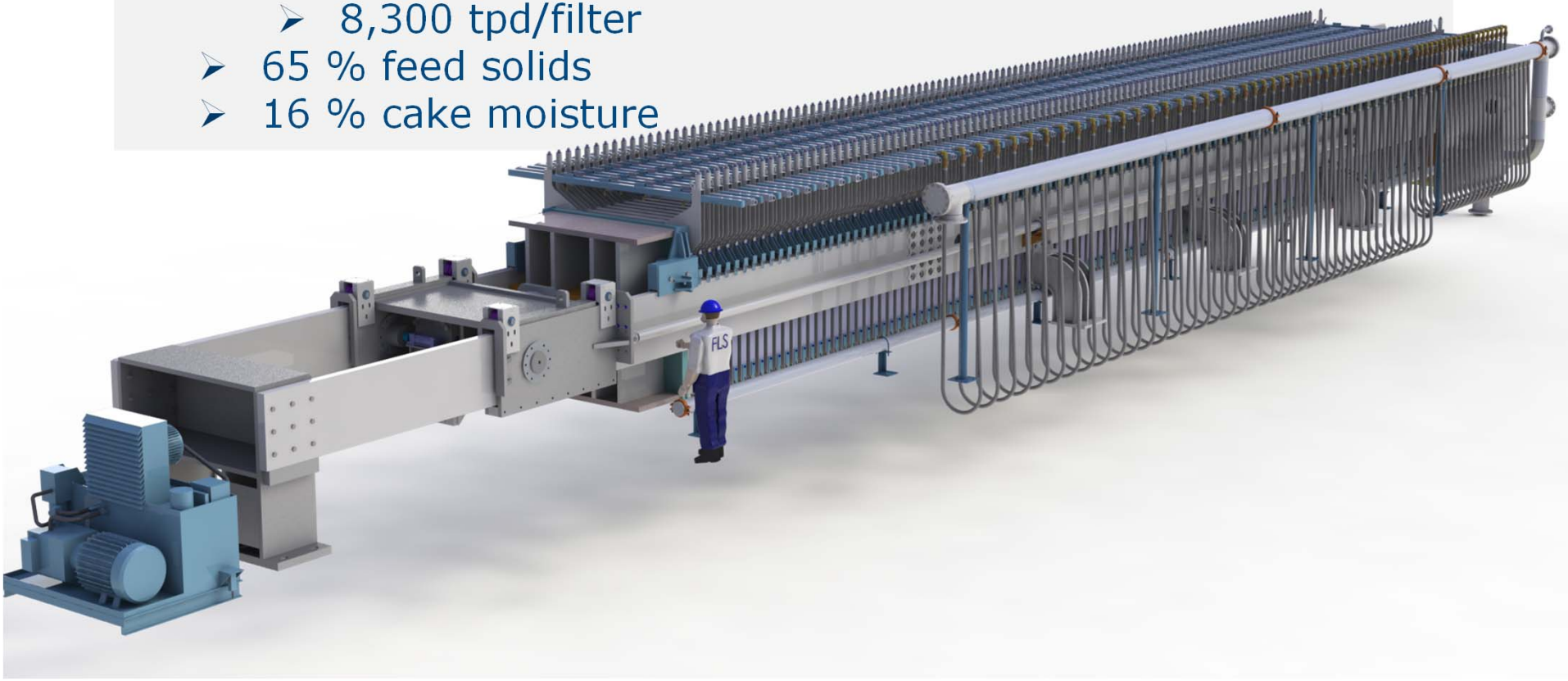
FLSmidth Automation Controls
w/Local PLC and DCS Connectivity



Copper Tailings Filtration

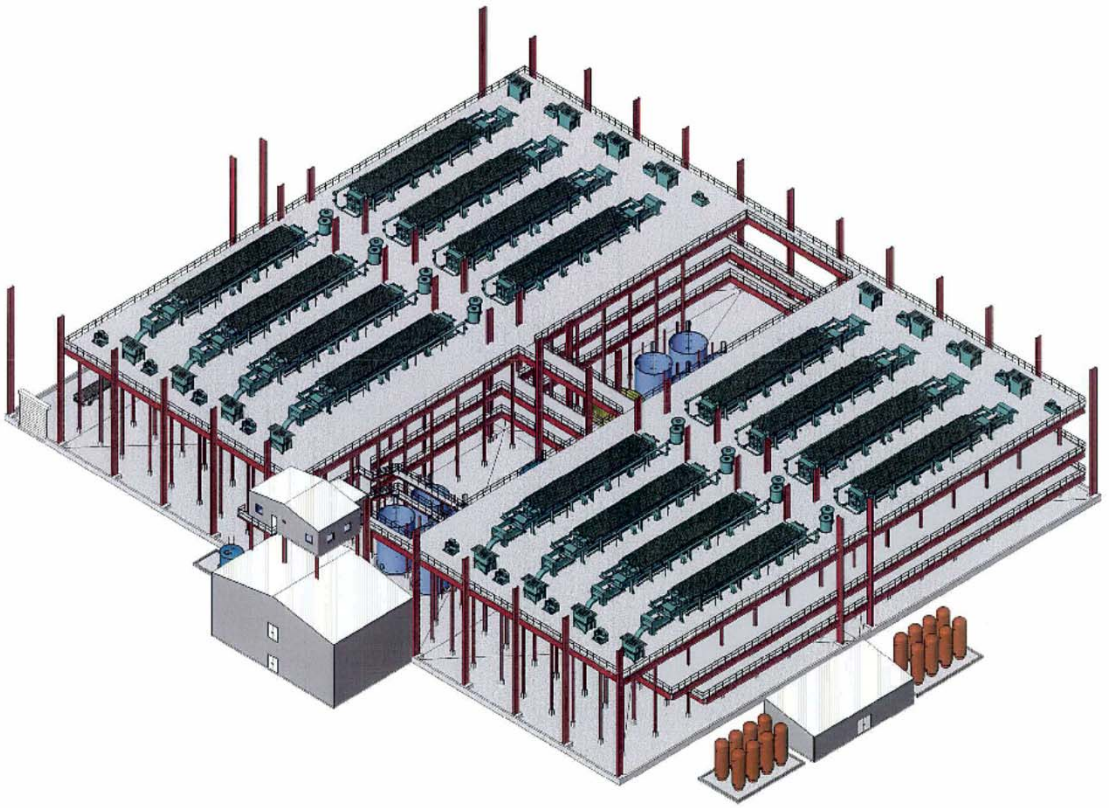
Largest Operating Minerals Filter Press

- (14) (12 operating 2 spare) 2x2 AFP Filters
- 120 Chambers
- Capable of 100,000 mt per day
  - 8,300 tpd/filter
- 65 % feed solids
- 16 % cake moisture



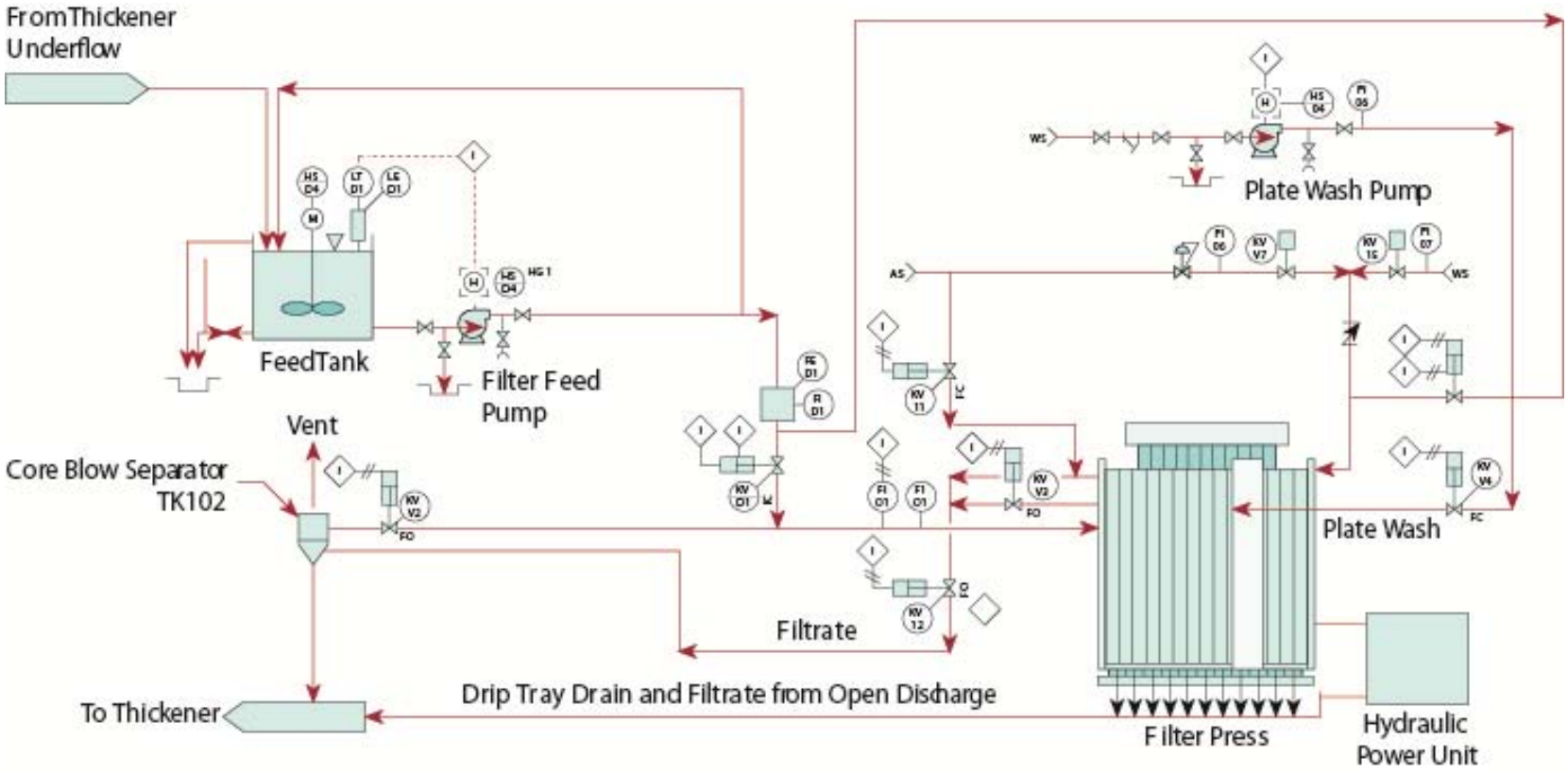
Rosemont Copper Tailings Filtration

Total Tailings Dewatering

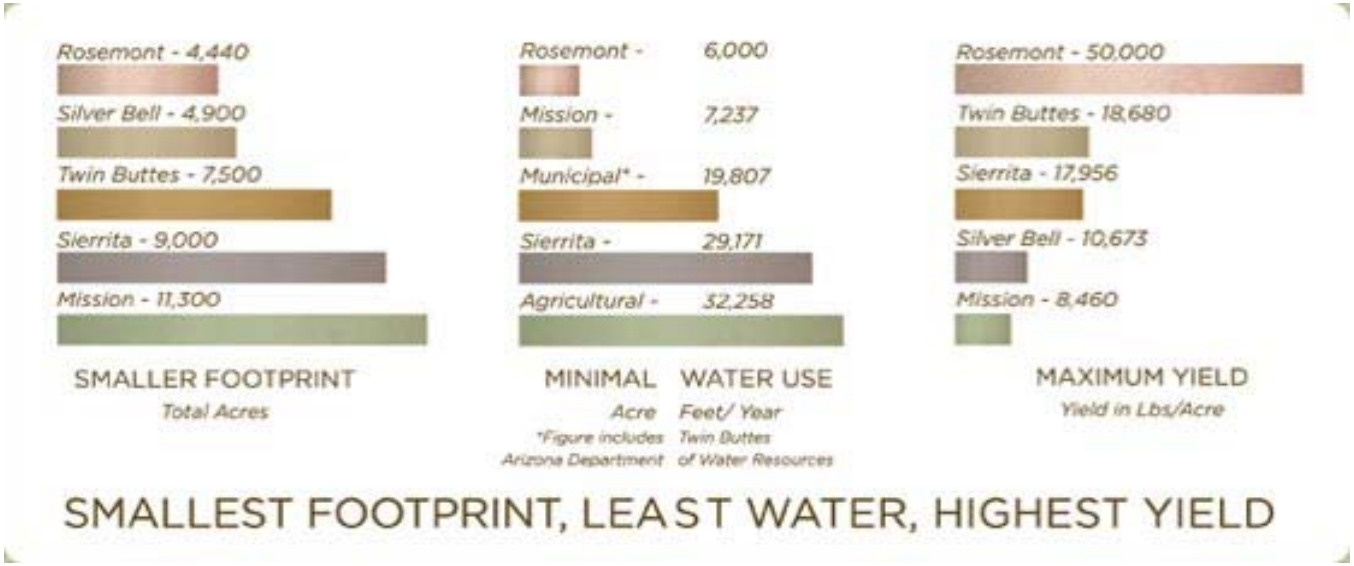


Filter Press with Surge Tank

Normally Used with Conventional Thickener Technology



Rosemont



Rosemont Tailings

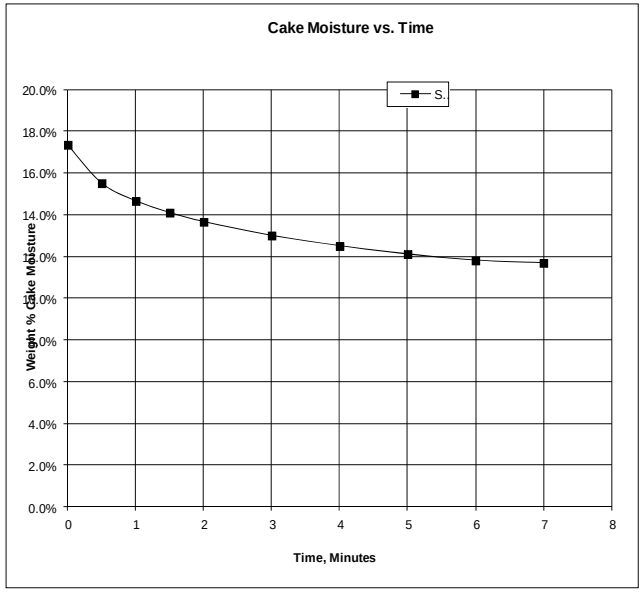
FILTRATION CYCLE TIMES

(Minutes)

Fill Empty Filter	**0.57**
Filtration to Solids Consolidation	**3.07**
Wash Solids	**0.00**
Cake Blow	4.00
Core Wash/Blow	0.50
Shake Cloth	0.50
Filter Cloth Wash & Purge	0.50
Open & Close Filter	1.50
Total Cycle Time	**10.64**

~ 8,500 tpd / filter
~ 350 tph / filter
~ 16 wt% cake moisture

P80 127 microns



M2020 in Operation

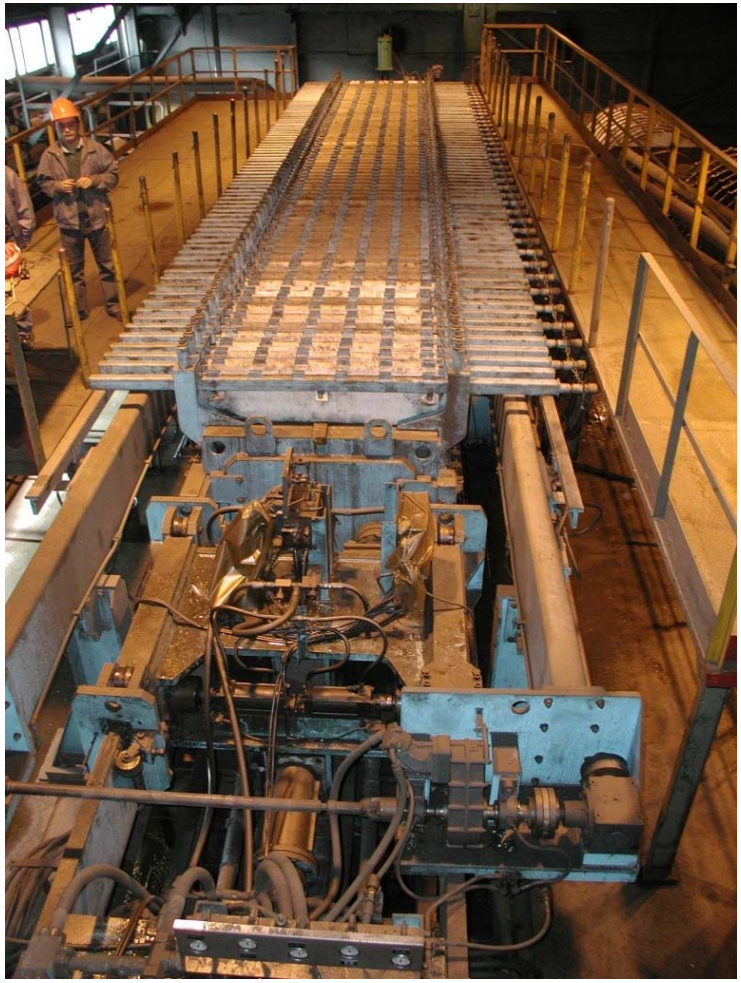
Copper Tailings Filtration Scenarios (Data From Testing)

Type	Combined Fine and Coarse	Fine
Solid Sg	2.73	2.73
Feed Wt% Solids	50	50
P80µm	204	30.5
Mtph	10570	5913
Cake Moisture Wt %	18.5	25.9
Cake Thickness mm	32	32
Filter Type	Recessed Chamber	Recessed Chamber
Total Cycle Time (min)	9.4	10.63
Filtration Rate kgh/m^2 (lb/h/ft^2)	183 (38)	146 (30)
Terminal Feed Pressure kg/cm^2 (psi)	9 (140)	9 (140)
Filter Size (ea) M2020 – Ch Qty/M^2/M^3	152/1018/19	152/1018/19
Qty Filter Required	57	40

Filter Press

Mongolian Copper Mine

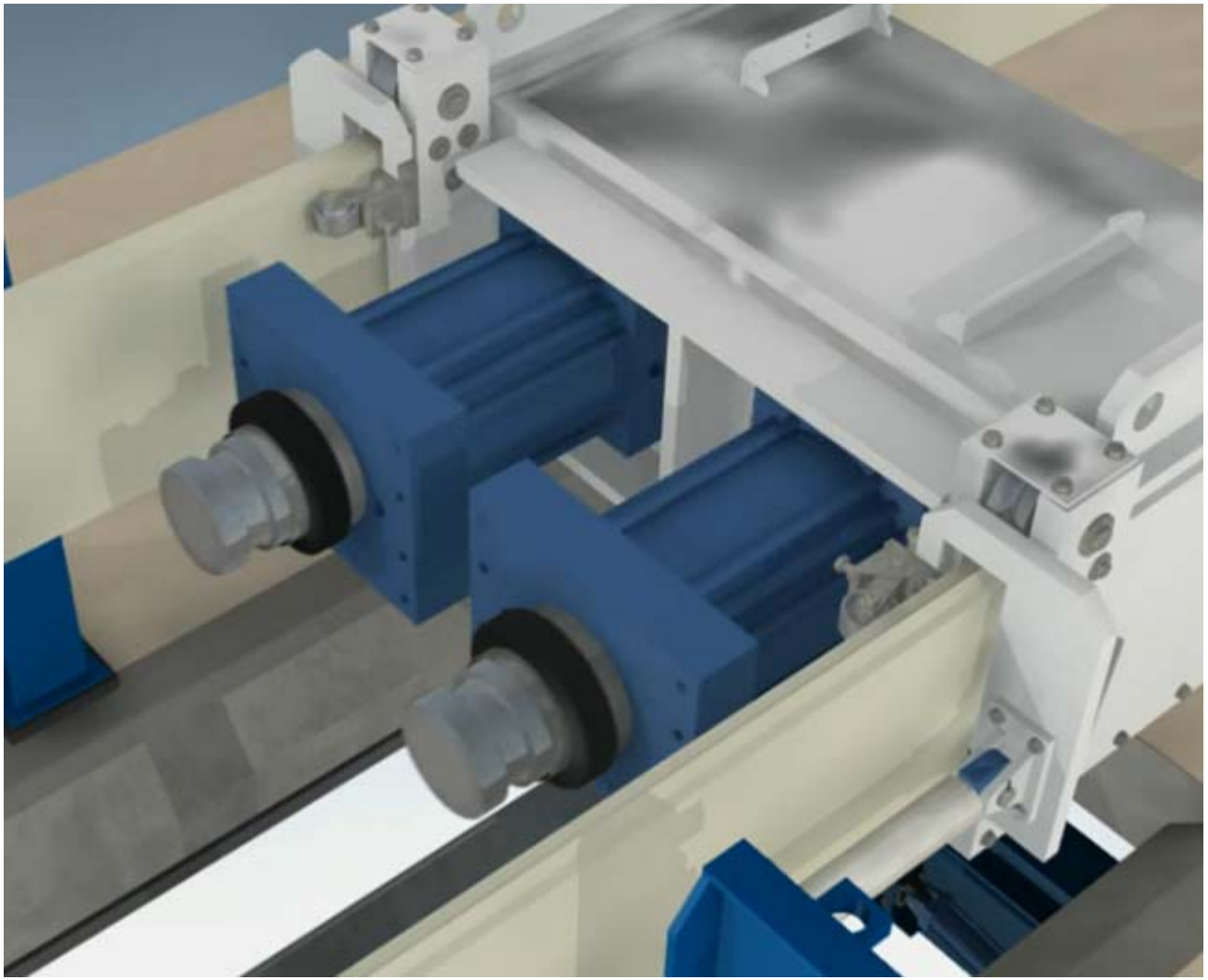
- M1500 – 77 Chambers
- Copper Concentrate
- Slurry Sg: 1.86
- Cake Dryness: 8-9 wt%
- Through put: 1200 mtpd
- Availability: >90%
- Cycles Operated: >100,000



FLSmidth Automatic Filter Installation

FLSmidth Automatic Filter Installation

FLSmidth Automatic Filter Installation



FLSmidth Automatic Filter Installation

Operating Costs

Copper Tailings

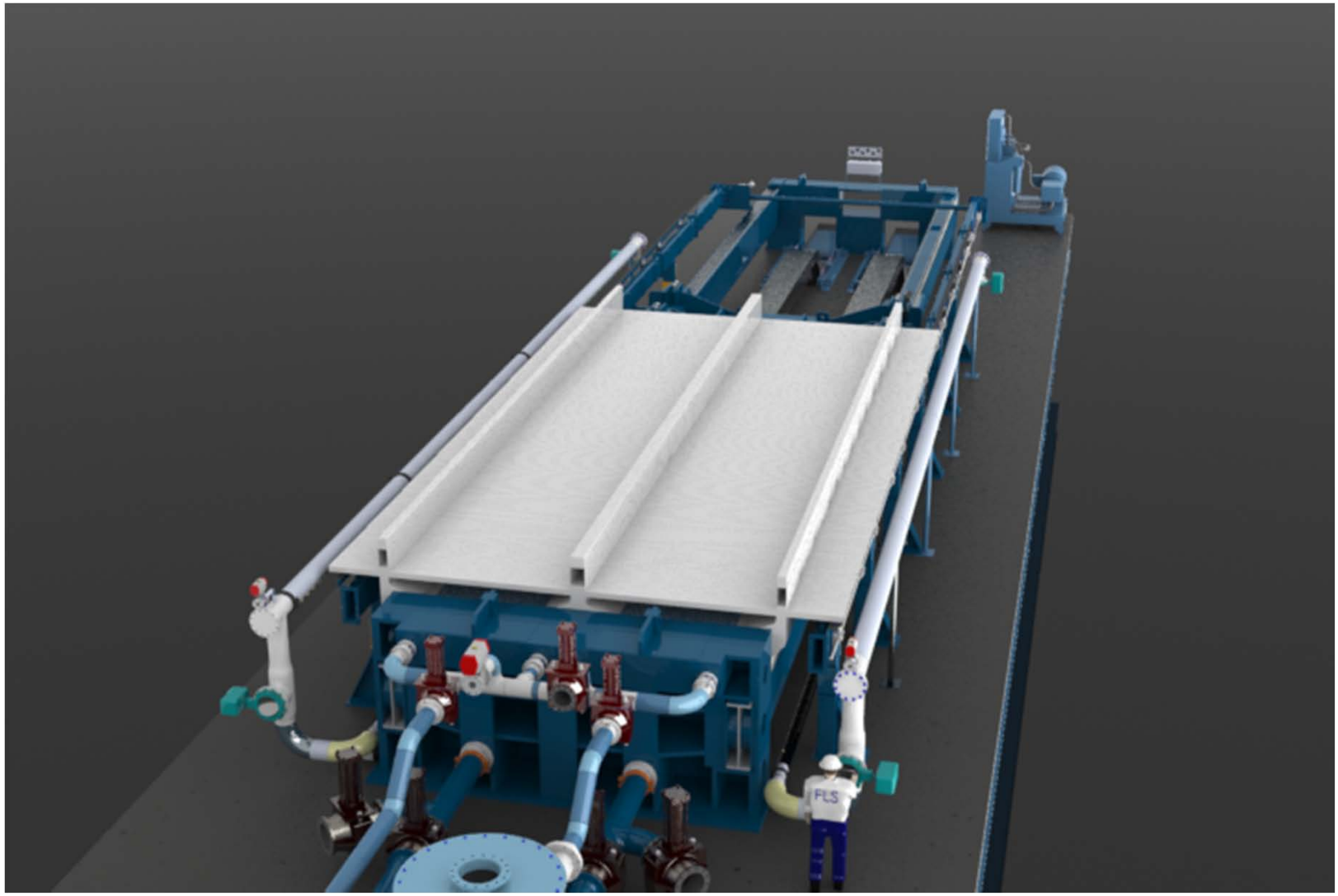
COST ANALYSIS OUTPUT

$/MT	%	Cost Items
$ 0.001	0.8%	Feed pump repairs
$ 0.000	0.1%	Compressor repairs first year
$ 0.000	0.2%	Hydraulic system
$ 0.000	0.2%	Cloth wash system
$ 0.001	0.5%	Filter plates @ 2%/yr
$ -	0.0%	Body plates @ 2%/yr
$ -	0.0%	Membranes @ 10%/yr
$ 0.000	0.2%	Filter Spare Parts
$ 0.013	6.5%	Valves (15000 cycle life)
$ 0.001	0.5%	Instrumentation
$ 0.002	1.0%	Rebuild Shaker every 3 years
$ 0.000	0.2%	Piping repairs from erosion
$ 0.001	0.7%	Maintenance labor
$ 0.000	0.1%	Operating labor
$ 0.060	31.2%	Electric Power
$ 0.018	9.2%	Water
$ 0.094	48.6%	Filter cloth @ 3000 cycle life
$ -	0.0%	Depreciation - Straight Line
$ 0.194		TOTAL

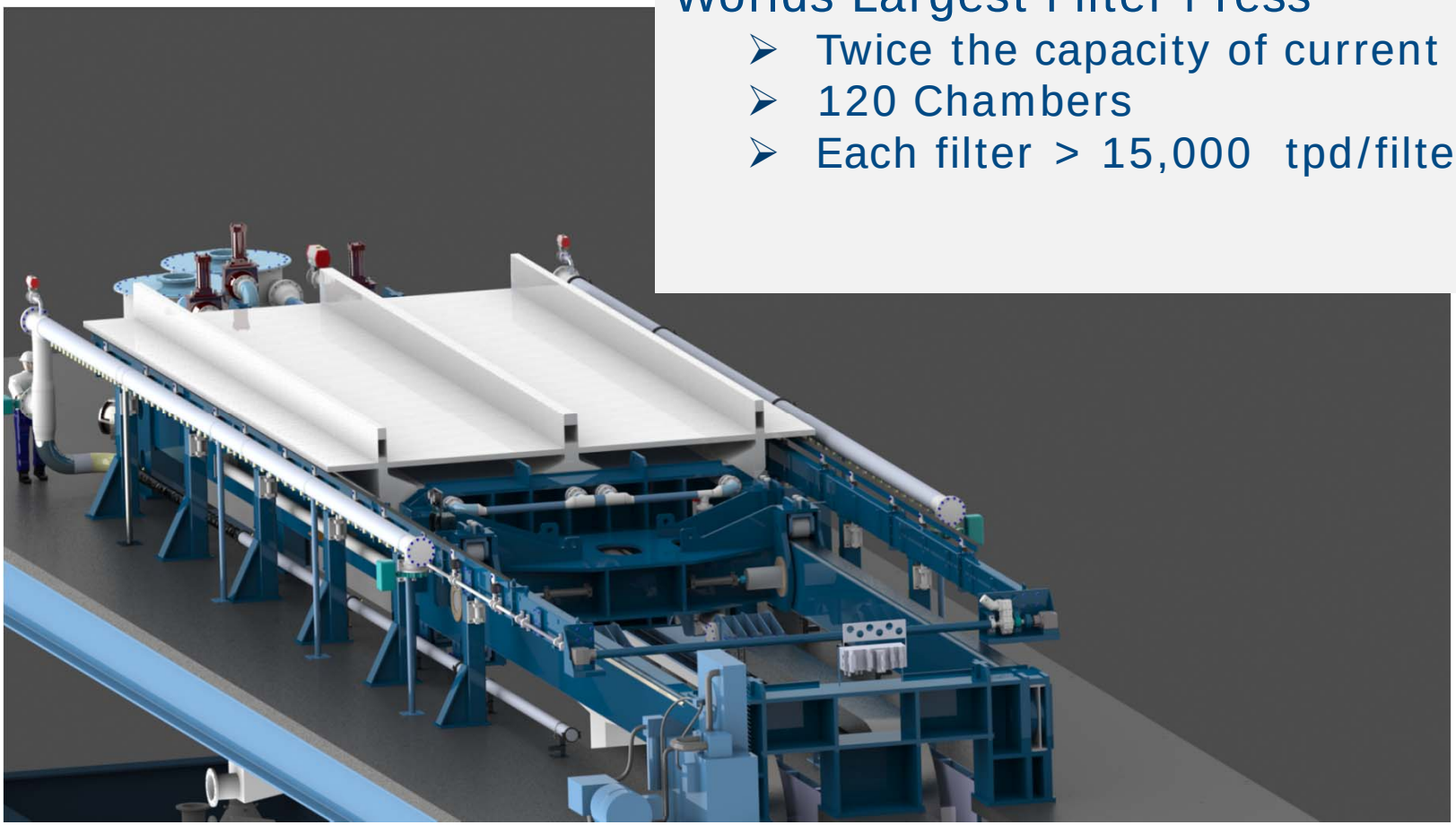
COST ANALYSIS INPUT DATA

12	Number of filters
120	Chambers per filter
238	Cycles per day per filter
365	Operation (Days/Year)
106437	Dry solids production rate (MTPD)
0.0%	Addition capacity (% of Design)
50.00	Operator labor rate ($/Hr)
0.025	Operators per shift
50.00	Maintenance labor rate ($/Hr)
0.010	Maintenance men per shift (different trades)
0.080	Power cost ($/kW-Hr)
0.8	Energy consumption (kW-Hr/MT)
0.04	Water cost ($/$M^3$)
0.4	Dewatering time (Minutes)
0.6	Compressed air rate (SCFM/FT^2)
2228	Compressed air consumed (SCF/Cycle/Filter)
2	Compressed air consumed (M3/MT/filter)
8668	Water consumption (GPM)
1968.5	Water consumption (M^3/Hr)
5.30	Water consumption (M^3/MT)
75	Filter cloth price, per chamber ($)
15	Filter cloth change time (Minutes)
1260	Filter plate with cloth support price ($)
0	Membrane Body plate with cloth support price ($)
0	Replaceable Membrane price ($)
	Capital investment ($)
20	Depreciation period (years)
	Salvage Value ($)
7	Valves Per Filter

Patent Pending Colossal AFP



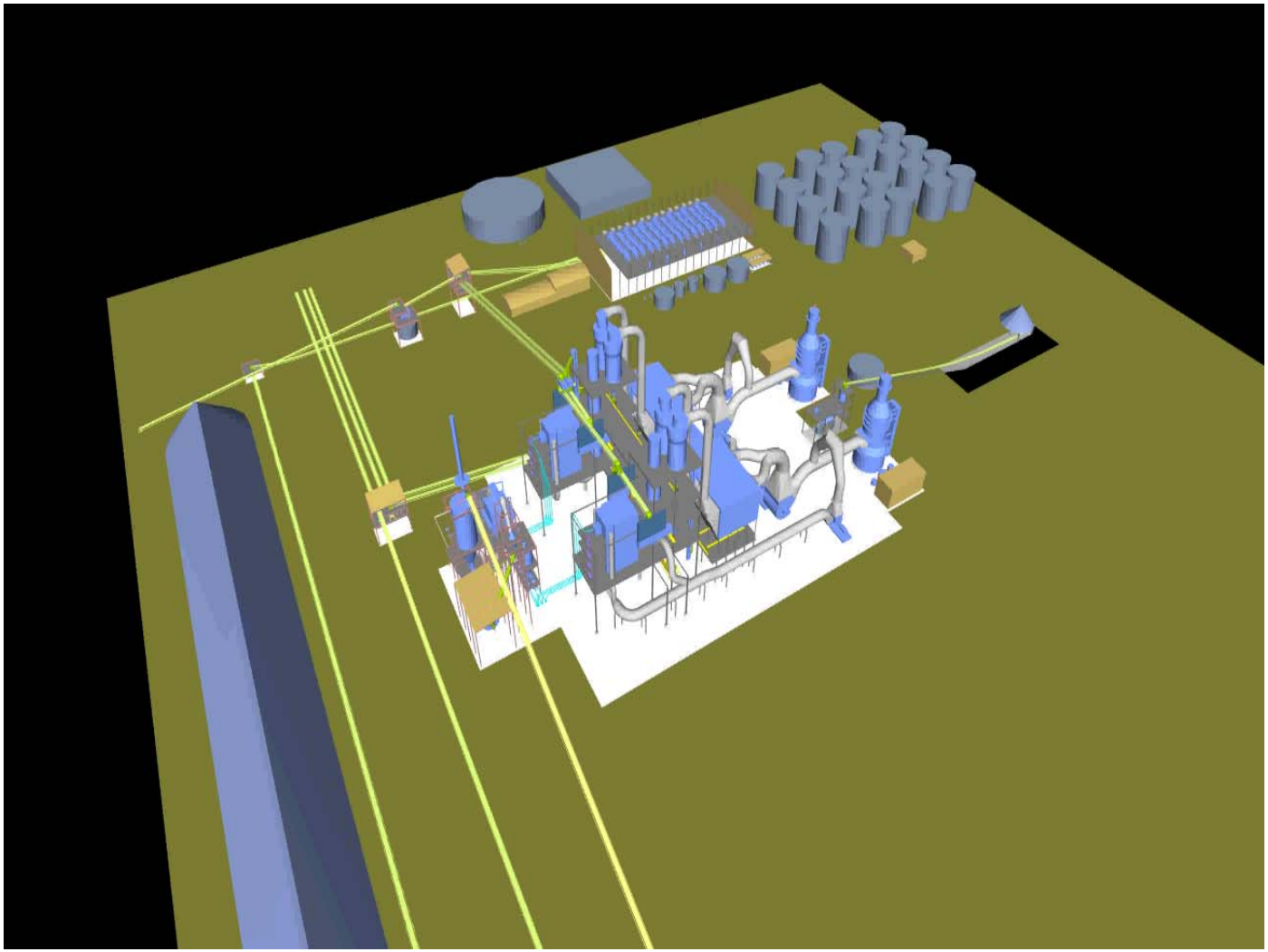
Copper Tailings Filtration



Worlds Largest Filter Press

- Twice the capacity of current filters
- 120 Chambers
- Each filter > 15,000 tpd/filter

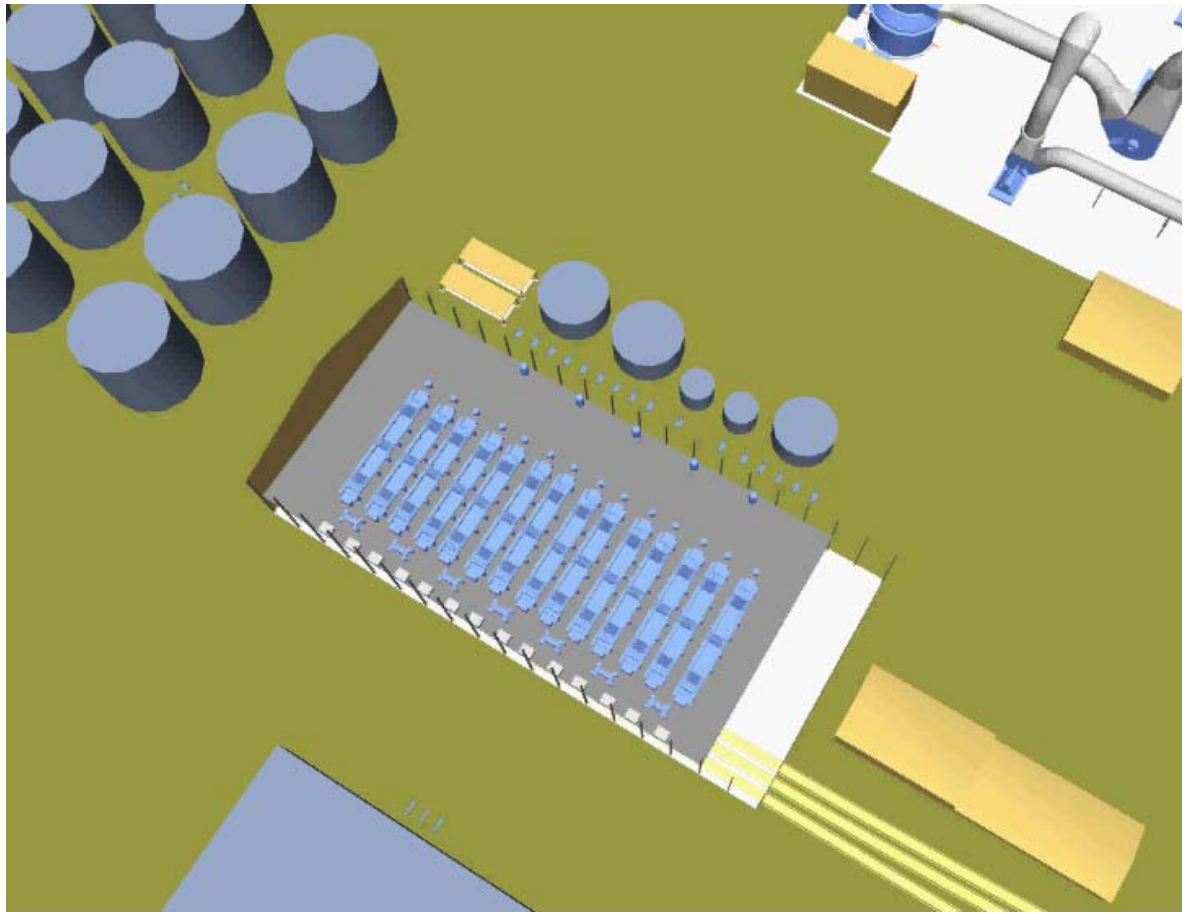
FLS Dewatering Plant



FLSmidth Plant Layout

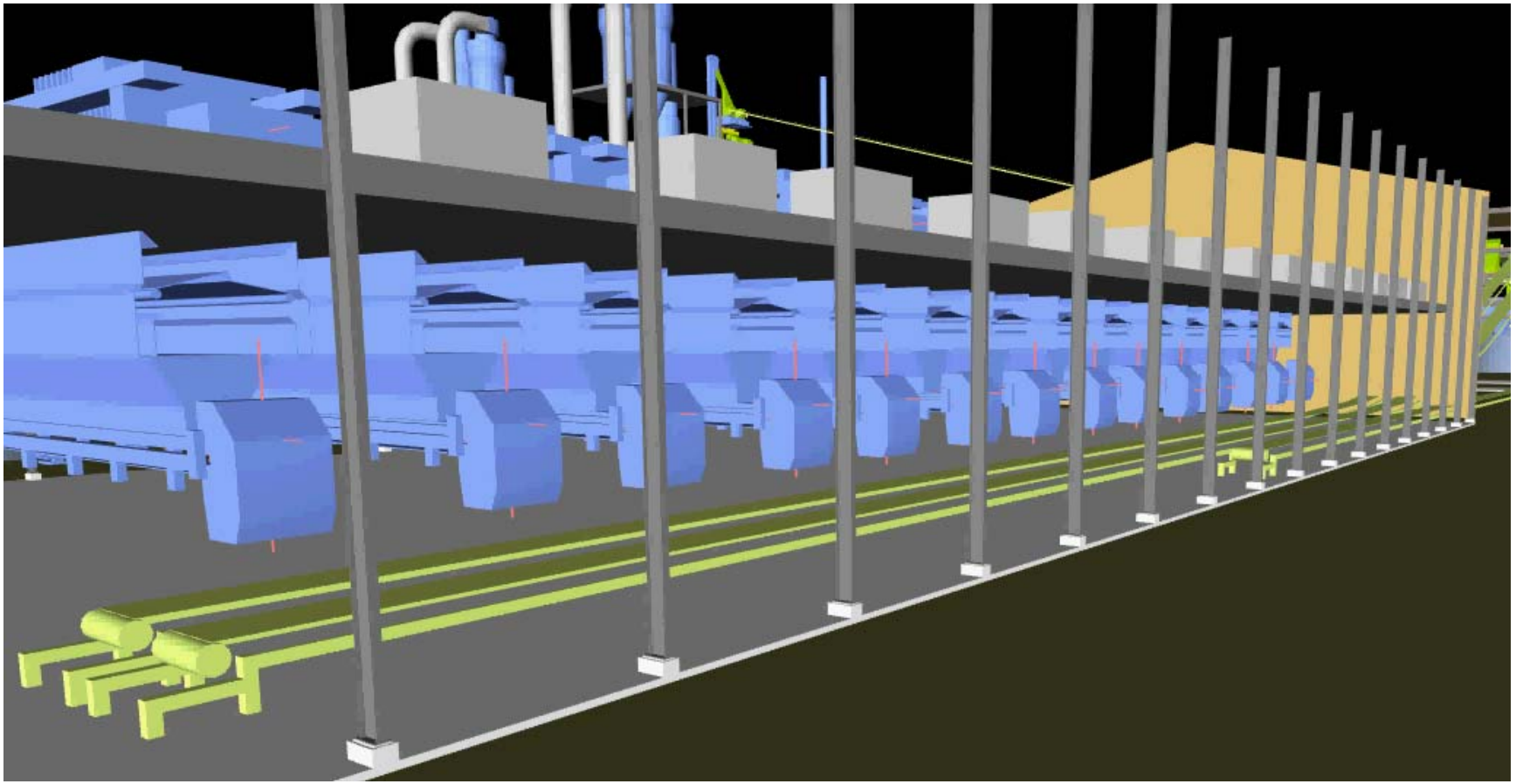
Fourteen (14) Automatic Pressure Filters

Total Filter Area 12,000 Sq M



FLS Plant Layout w/ 14 Pressure Filters

Filter Cake Collection System



Summary

FLS Filter Press Advantages:

- Largest Filter on the Market
- Lower Feed Eye = High Equipment Availability
- Heavy-duty = Less Down Time
- No diaphragms = Less maintenance
  - Inexpensive filter plates
- Short Cycles = High Throughput Per Area
  - Reduced number of filters
  - Low installed cost
- Low Cost sourcing available

Summary

Filtered Tailings Advantages:

- Maximum Water Recovery
- Minimum Fresh Water Needed
- Lowest Environmental Impact
- Co-current Land Reclimation
- Lowest Risk Profile
- Competitive Life Cycle Costs

FLSmidth Conveyor-Based Dry Tailings Stacking

Ted Wagner
Global Product Manager – Mobile Conveying

One Source