

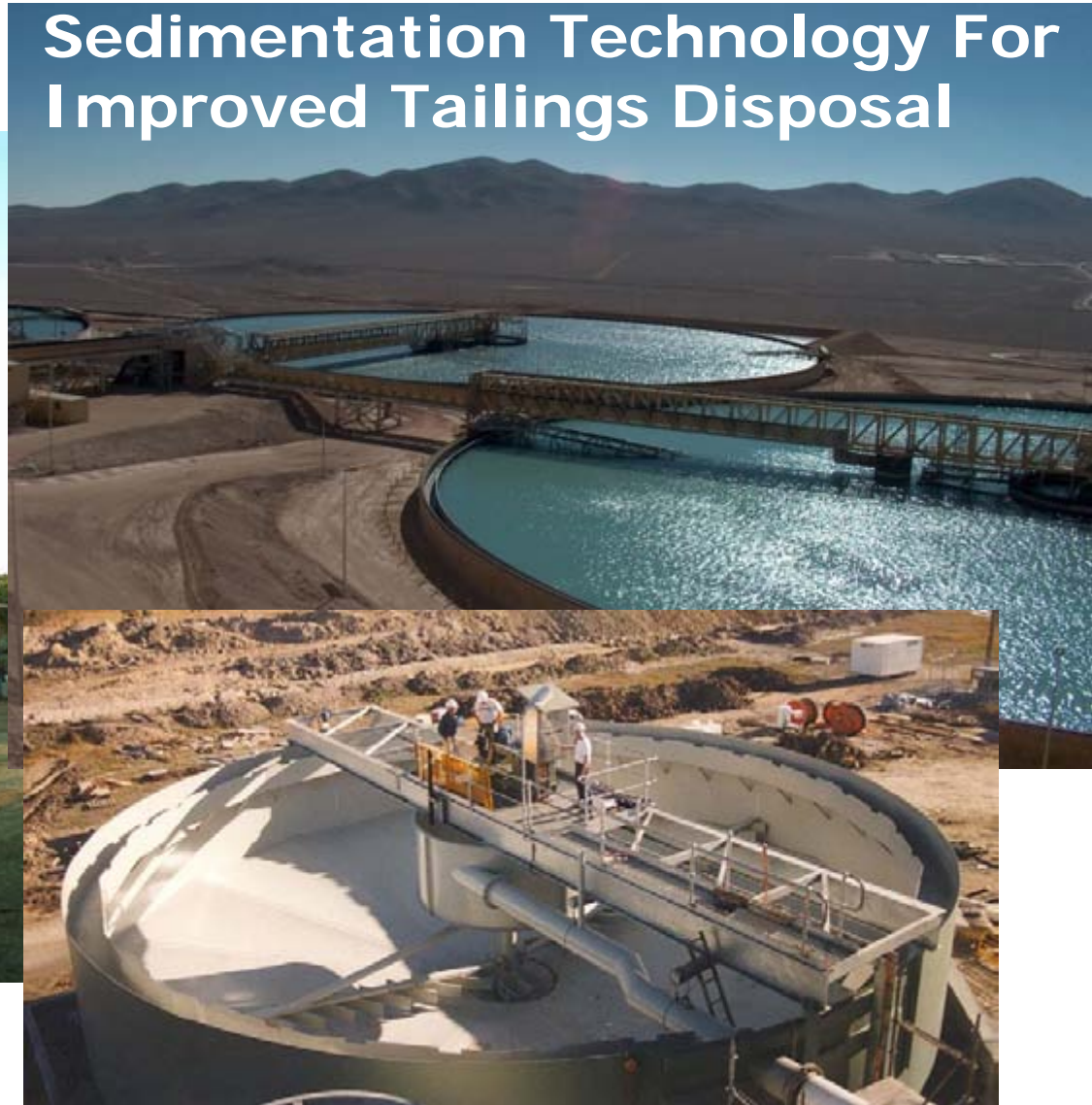
Tailings Disposal Seminar – Chile



Fred Schoenbrunn
Director - Thickeners



Sedimentation Technology For Improved Tailings Disposal



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Water ratio's for typical granular tailings

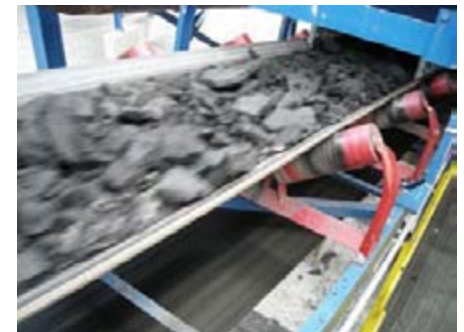
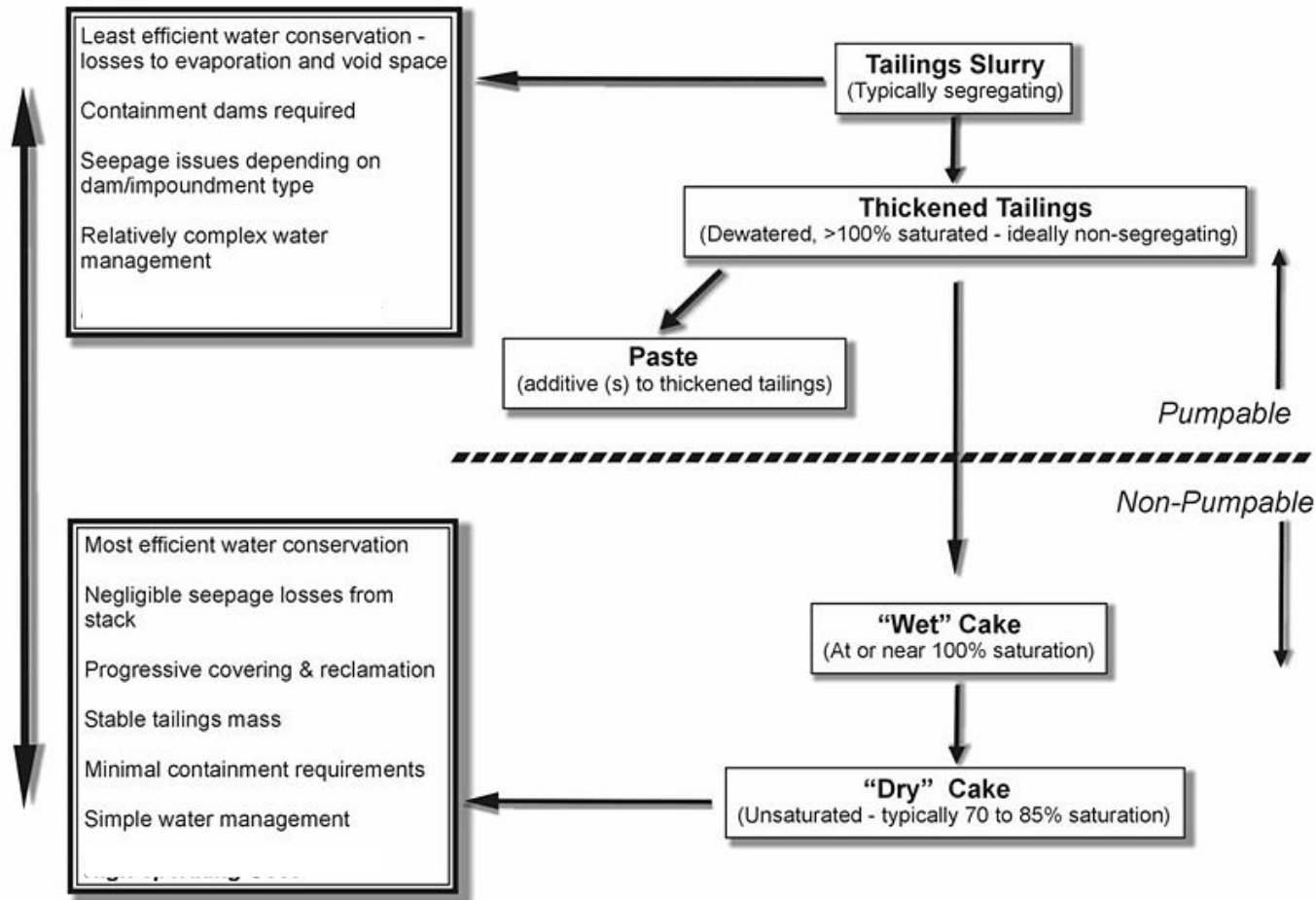


Slurry % solids	H ₂ O vol. / mt Tailings (m ³ /mt)	Description
20	4.0	Ore processing
30	2.3	Plant tailings
50	1.0	Thickened slurry
60	0.67	High Density slurry
75	0.33	Thickened to paste
82	0.21	Vacuum filter
88	0.13	Pressure filter

COURTESY MINE PASTE ENGINEERING LTD.

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Wet or Dry Tailings?



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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 tons in 2003) and molybdenum (6405 tons 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



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Tailings Solutions Options



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



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



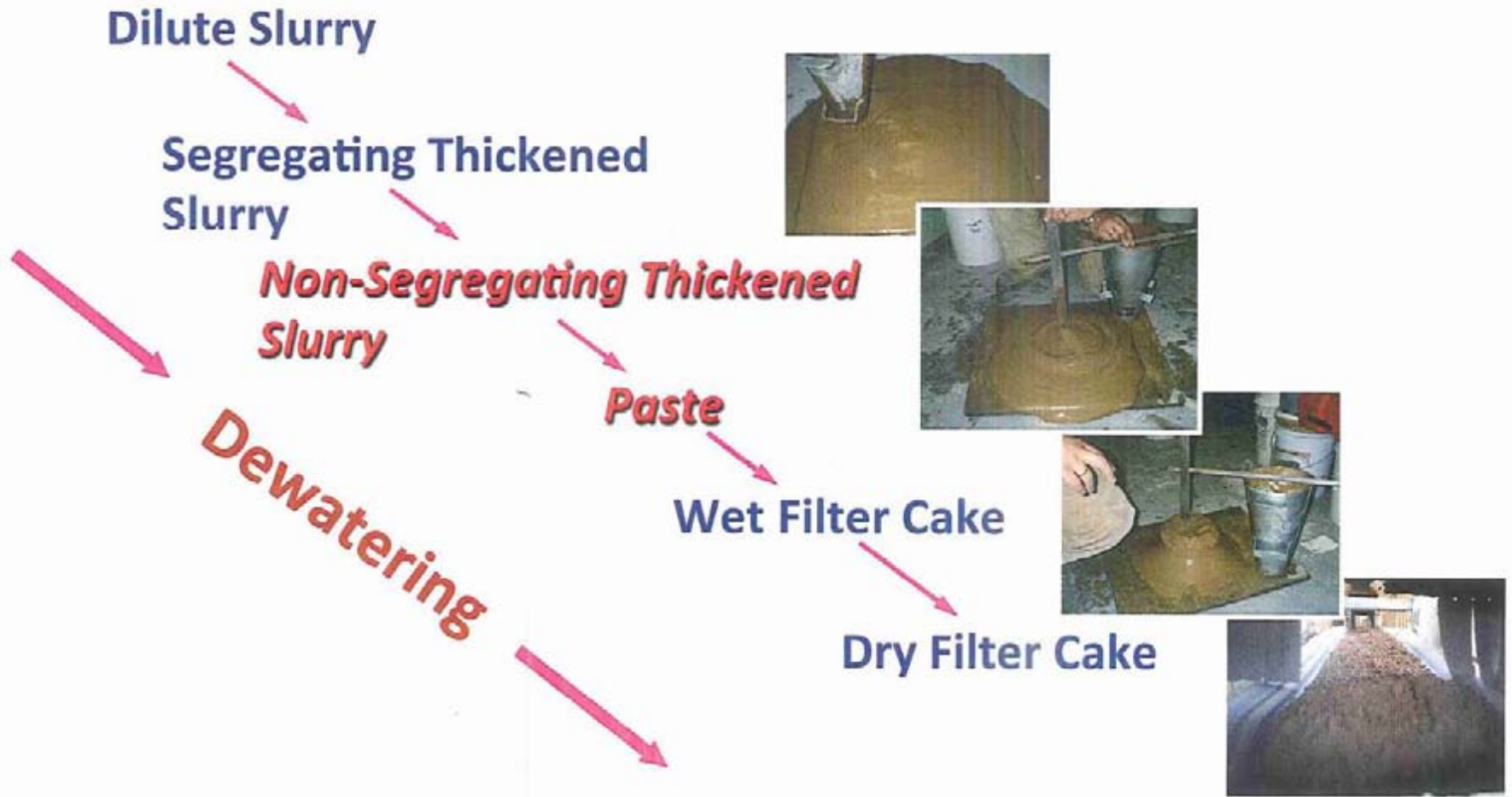
Surface thickened
Thickened discharge at Kidd Creek, ON, Canada (left)
and at Mt Keith, Western Australia (right)



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

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Slurry Material Continuum



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Sedimentation -Thickeners



125 m Center Drive



90m Traction Drive



24m Paste Assembled



E-Cat® Clarifier Thickeners

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Conventional / High Rate Tailings Thickeners; Pelambres



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Conventional / High Rate Tailings Thickeners; Escondida



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Conventional / High Rate Tailings Thickeners; Chuquicamata



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Conventional / High Rate Tailings Thickeners; Kennecott



cret laws.

Conventional / High Rate Tailings Thickeners; Andina



Conventional / High Rate Tailings Thickeners; Cerro Verde



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Underflow Slurry: Conventional / High Rate Thickener



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Conventional Containment



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Conventional Containment Failure



Thickening to Higher Densities

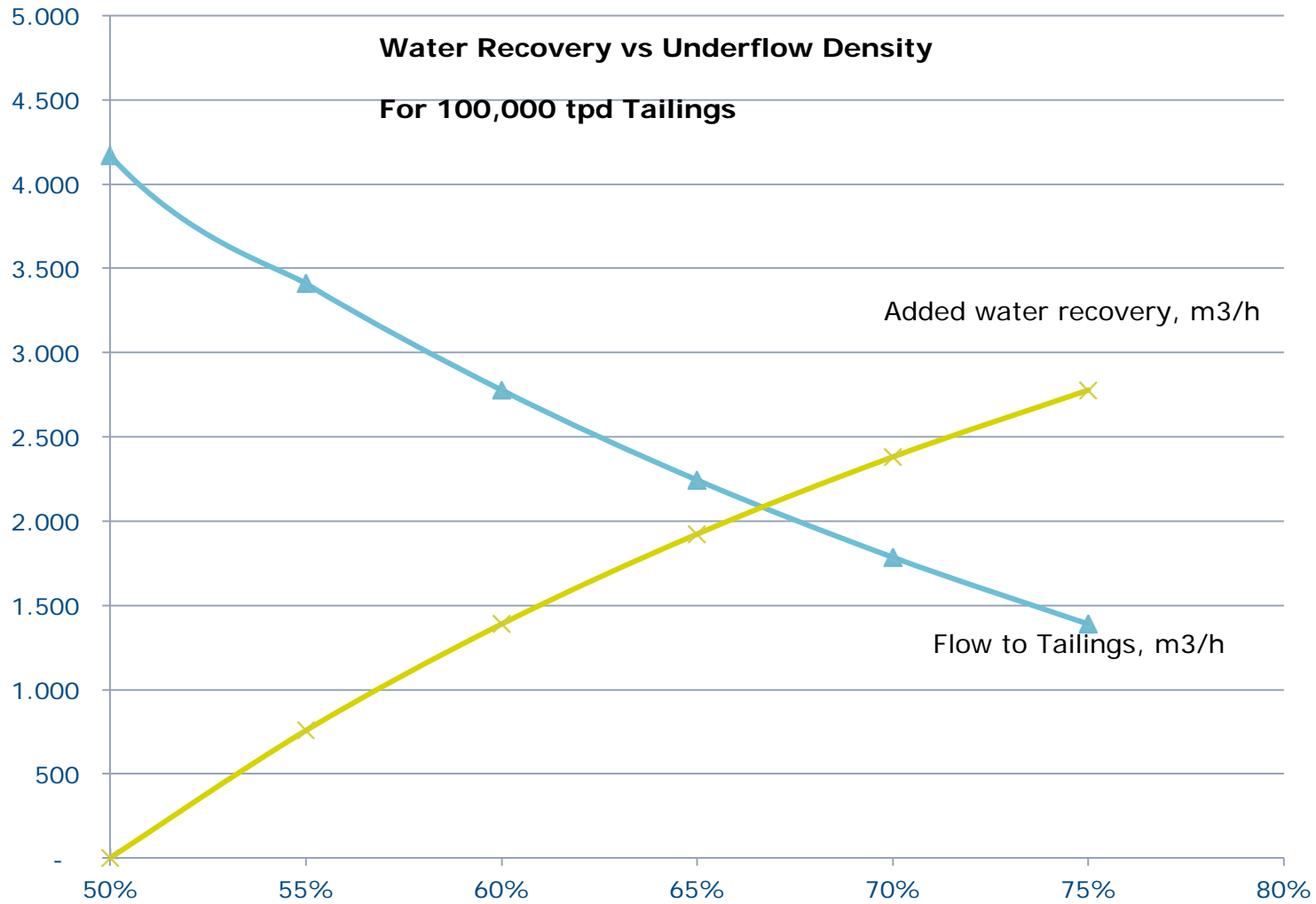


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Reduce risk of Failure

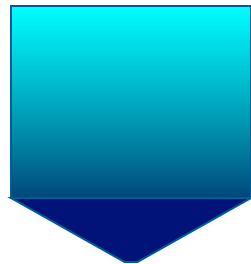
- ***Eliminate ponds of water on top of tailings***
 - *Water no longer available to transport tailings should the containment fail*
- ***Tails are deposited as a paste and not a slurry***
 - *Tailings can be stacked*
 - *Pond on tailings not required*
 - *Reduced segregation*

Tailings: Water Recovery Benefit



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Paste Thickening Technology



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THICKENING EQUIPMENT DESIGN



Deeper, Steeper, Stronger

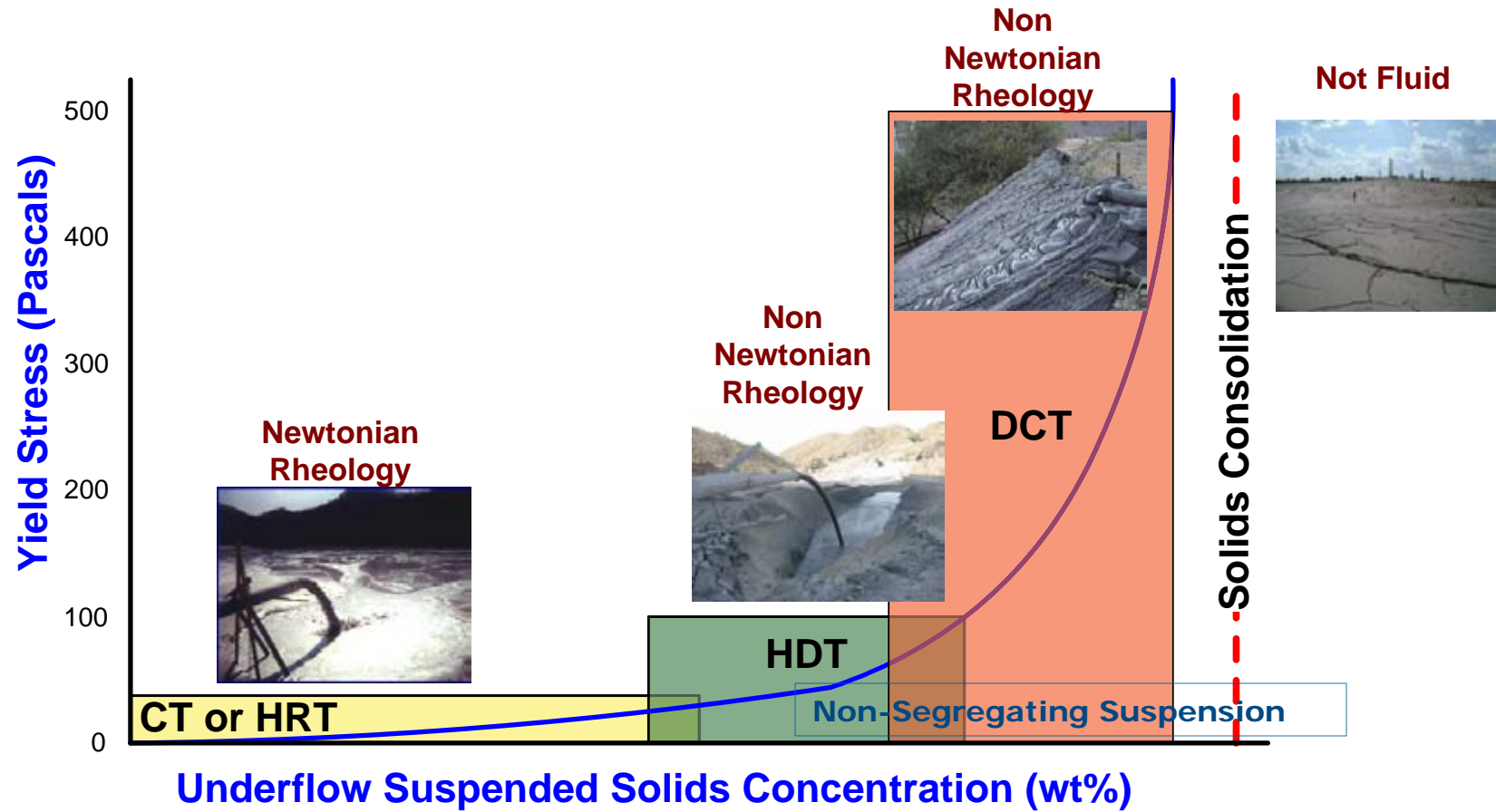


Thickener Type	Feedwell & Flocculation	Underflow Yield Stress	Avg Tank Slope	Torque
Conventional	Non-Diluting	< 50 Pa	0°- 9°	K <30
Hi-Rate	Diluting	< 50 Pa	8°- 10°	K >25
Hi-Density	Diluting	50 – 125 Pa	10°- 20°	K >75
Paste	Diluting	100 – 400 Pa	30°- 45°	K >200

$$\text{TORQUE} = K * \text{Diameter}^2$$

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Tailings: Mud Strength Benefit



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High Density Thickeners - Increasing Bed Depth



1998 Escondida



2008 Collahuasi



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Recent High Capacity/High Density Sizes



Site	Material	Tonnage	Dia, m	Qty	m2/tpd
Cerro Verde	Copper Tails	64,000	80	4	0.079
Coemin	Copper Tails	7700	22	1	0.046
Andina	Copper Tails	25,000	43	1	0.058
Tar Sands	Oil Sands	52,500	70	2	0.073
CP Mining	Iron Ore	105,000	90	2	0.061
Caserones	Copper Tails	17,000	45	3	0.096
Lihir	Gold	24,000	48	2	0.075
Rosemont	Copper Tails	38,000	50	2	0.054

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High Density Thickener



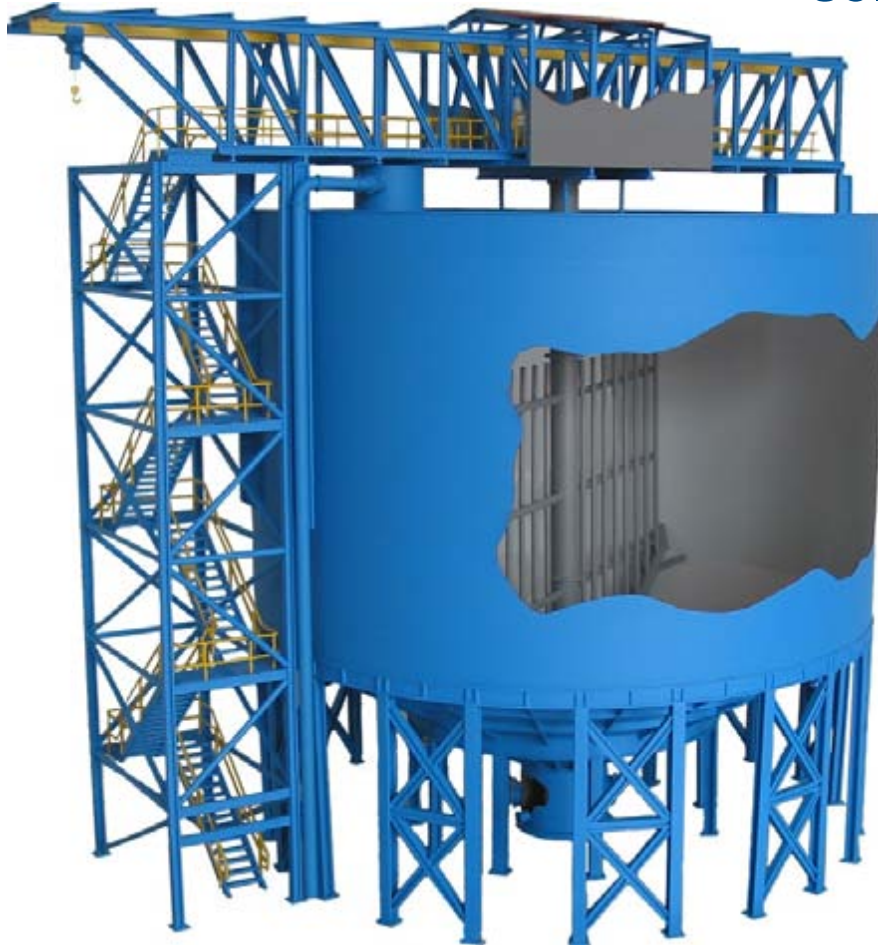
- 5 – 10 wt% higher underflow solids when compared to high rate thickeners

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Deep Cone[®] Paste Thickener



Maximum water and
soluble metal recovery

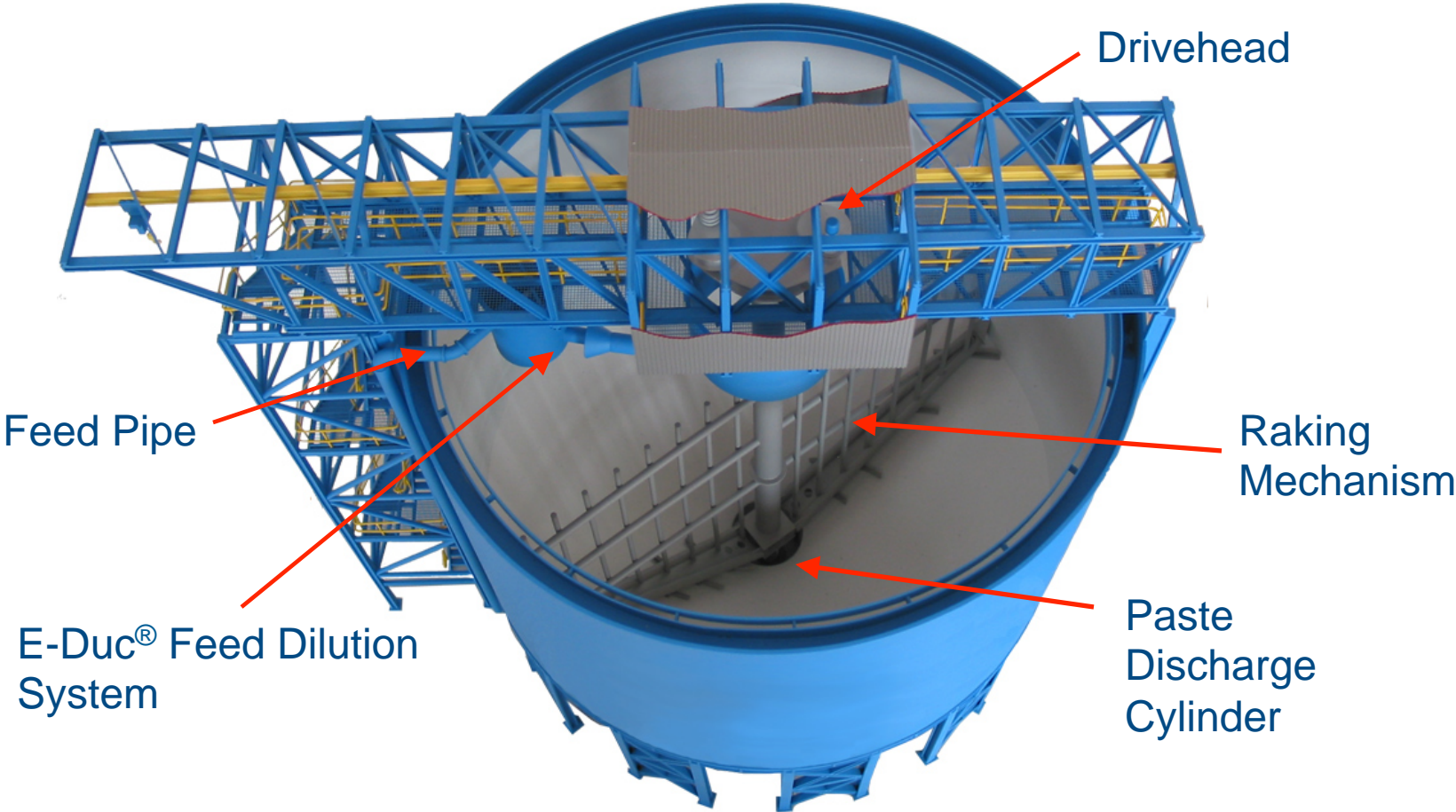


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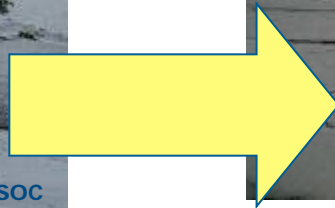
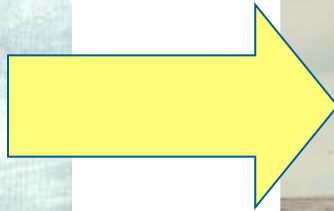
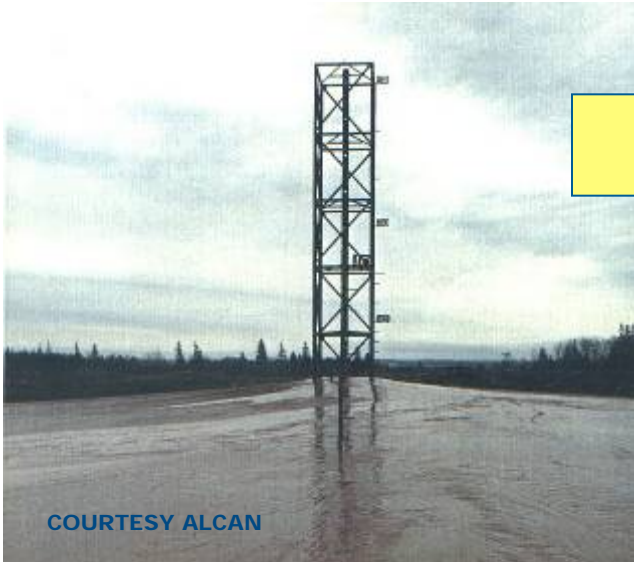


Deep Cone[®] Paste Thickener



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Tailings: Faster Drying Benefits



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Cobrizza Down-Slope Deposition



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Cobrizza Deposition Site – Containment Wall



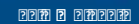
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Cobriza Deposit Strength - 4 Months



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Tailings: Faster Drying Benefits



CONVENTIONAL TAILINGS STRENGTH AFTER ???? MONTHS



COBRIZA TAILINGS STRENGTH AFTER 4 MONTHS

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Large Paste and High Density Development - More Torque, Bigger Drives



Torque Rating(s) (ft-lbs)

C120P-2	2,400,000
C120P-3	3,600,000
C120P-4	4,800,000
C120P-5	6,000,000
C120P-6	7,200,000
C140P-5	8,300,000
C140P-6	10,000,000

Drive Features:

Electric or hydraulic drive

Large main gear face – through hardened alloy steel gear and pinion

Fully supported one-piece pinion

Full oil bath lubrication for main gear and bearing set

Oil drains away from bearing seats

Fabricated steel cast base with dry well oil reservoir

No lip seals below oil level

Machined shoulder to preserve pinion/main gear alignment

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Full Range of Proven Drives and Lifts for both Bridge and Column Units

Elegant Design, Efficient Operation
Broadest Range of Torques in the Industry



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FLS Drives

- **FL Smidth Manufactured Parts**

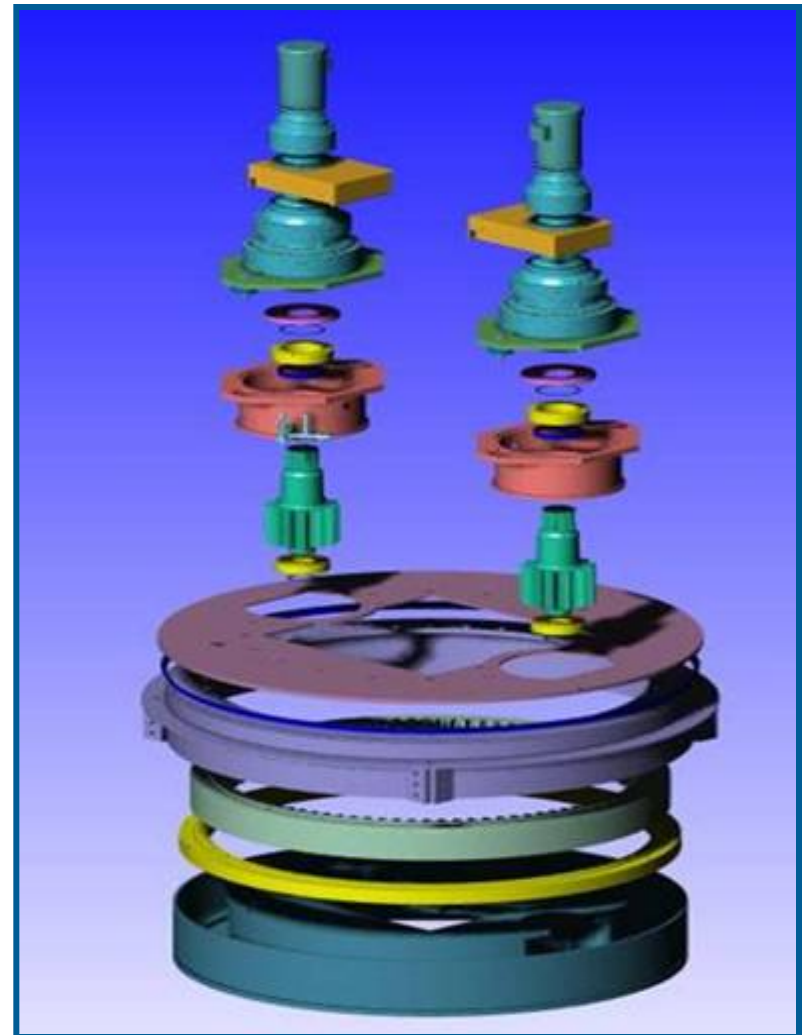
- Main Gear Housing
- Main Gear
- Cage Adapter
- Gear Cover
- Main Pinion
- Upper Bearing Housing

- **Purchased Parts**

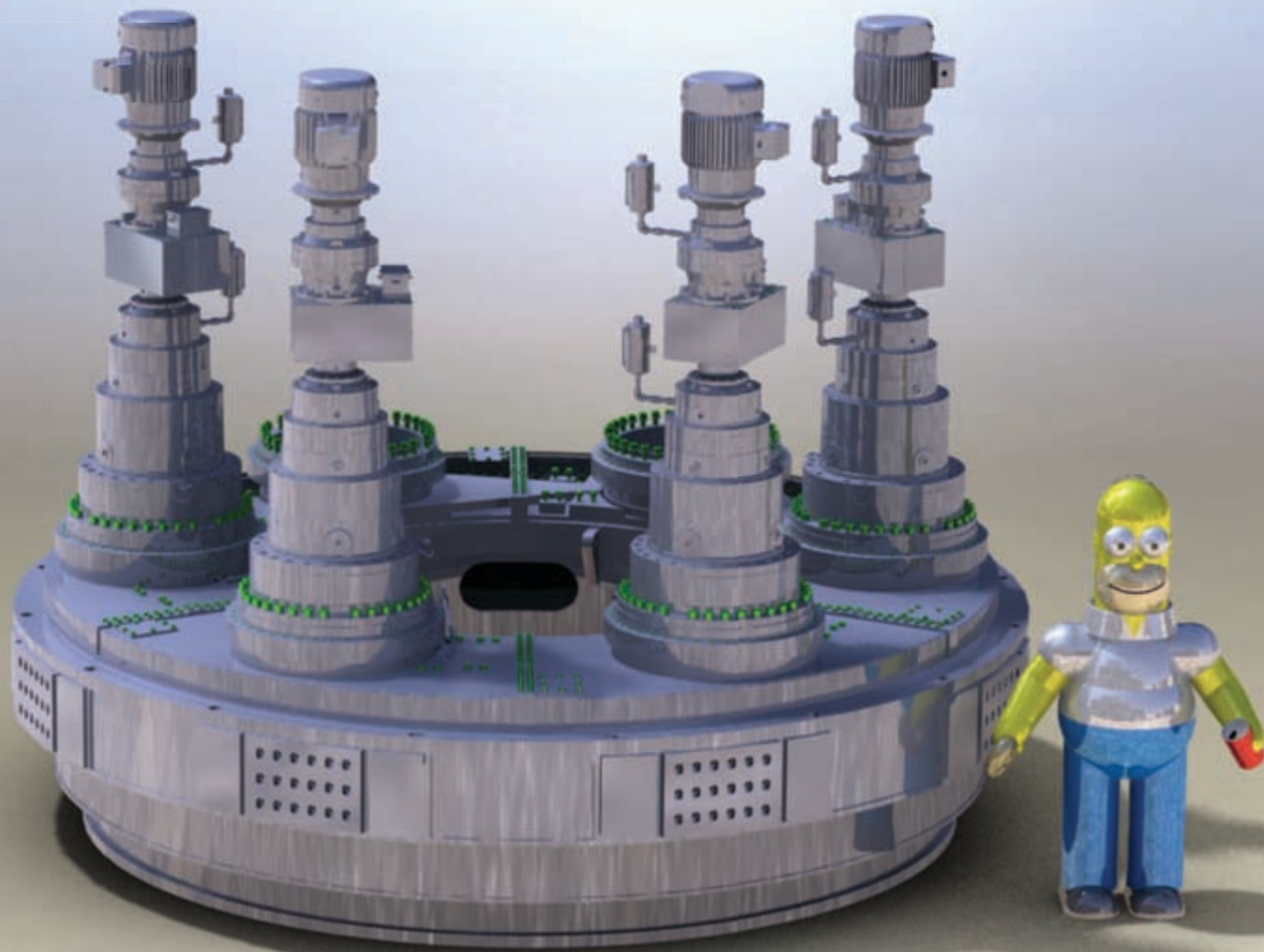
- Main Bearing
- Planetary Input Reducer

- **Drive Sizes**

- B45P, B60P, B90P Bridge
- C60P, C84P and C120P Column



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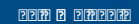


E-Duc Feed Dilution – Proven Performance for High Capacity Minerals Thickeners

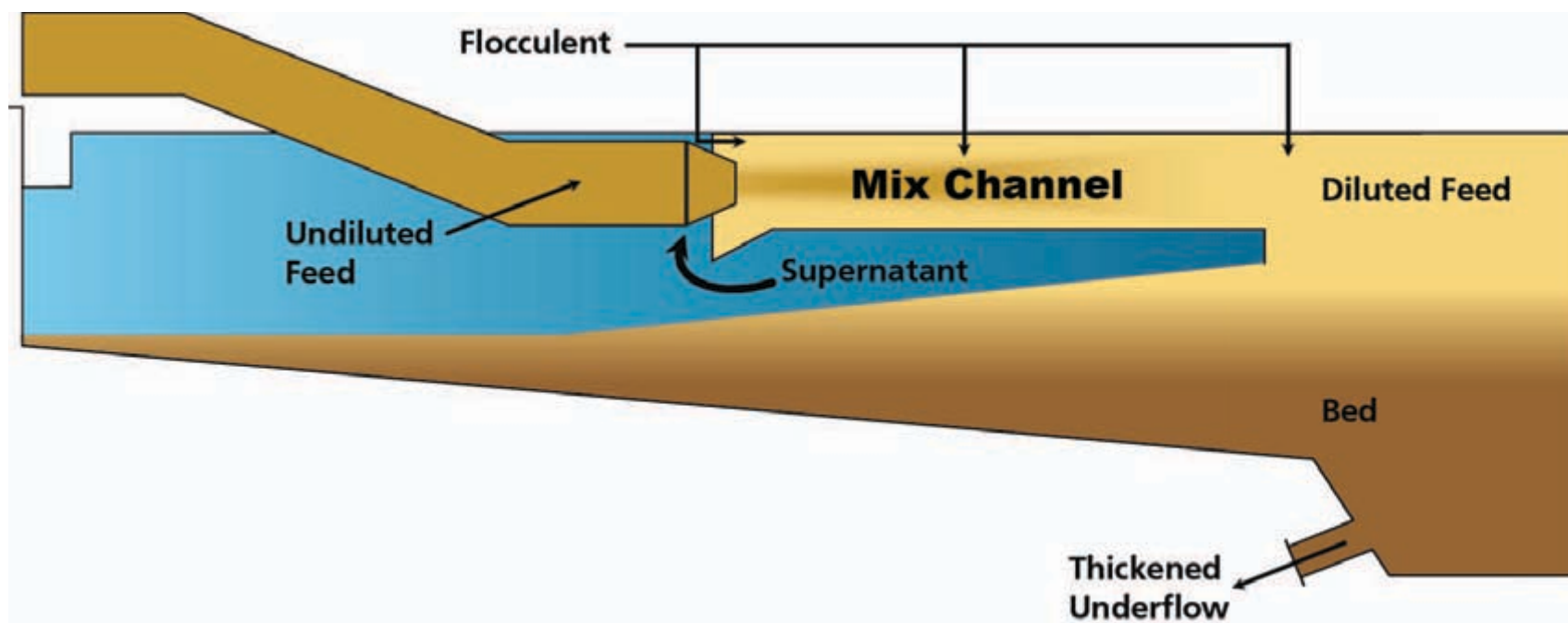


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E-Duc[®] Feedwell Dilution



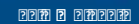
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Separates dilution, mixing, flocculation and distribution

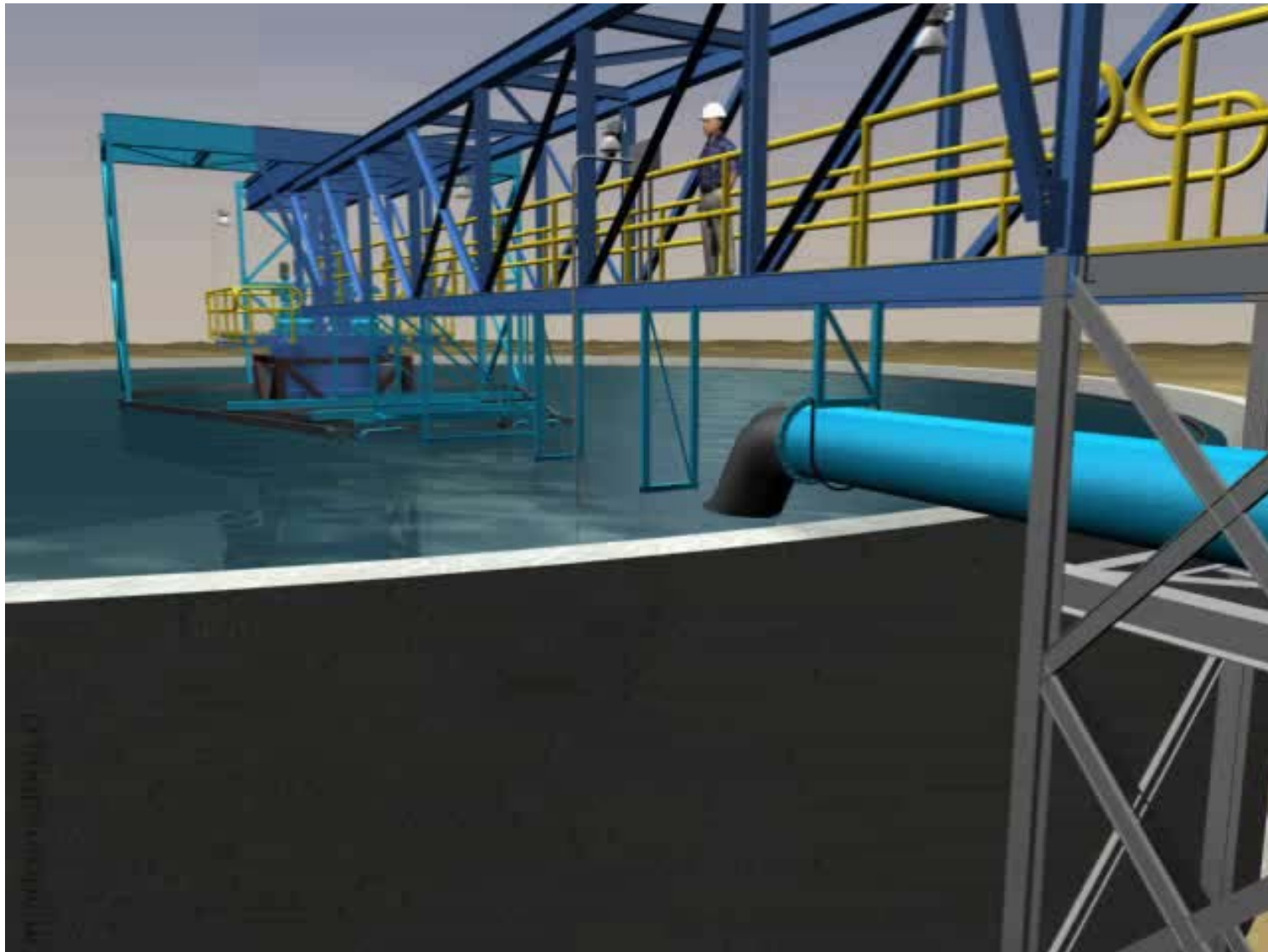


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E-Duc Advantages



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The E-Duc feed dilution system:

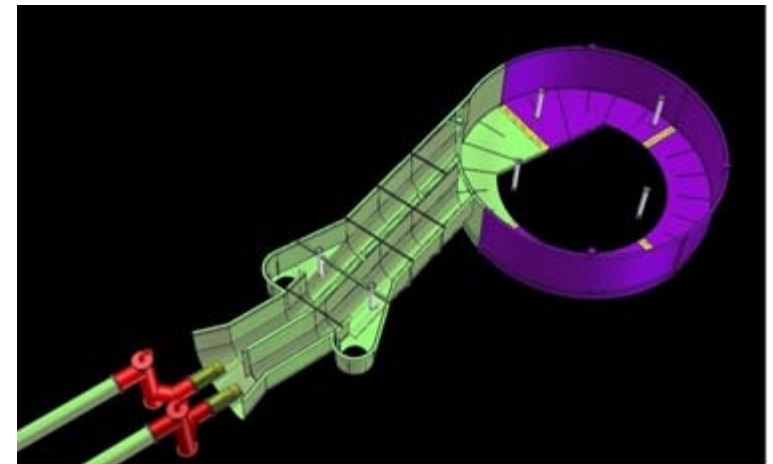


- Separates dilution, mixing, flocculation and distribution
- Allows dilution prior to flocculation
- Provides optimal shear for flash mixing and excellent flocculent distribution
- Low shear aggregate growth and distribution
- Continuing development including spinning the feed stream for improved mixing, solids suspension and retention (Patent applied for)
- Minimizes flocculent consumption – typically within 10% of lab dosage

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The E-Duc feed dilution system:

- Allows dilution to very low solids concentrations
- Is not limited by specific gravity differential
- Keeps a consistent ratio of dilution to feed flow to maintain the target feed concentration
- Minimal area for surface protection, corrosion
- Extensive CFD optimization
- No moving parts
- Simple, elegant design



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P-Duc Variable Feed Dilution

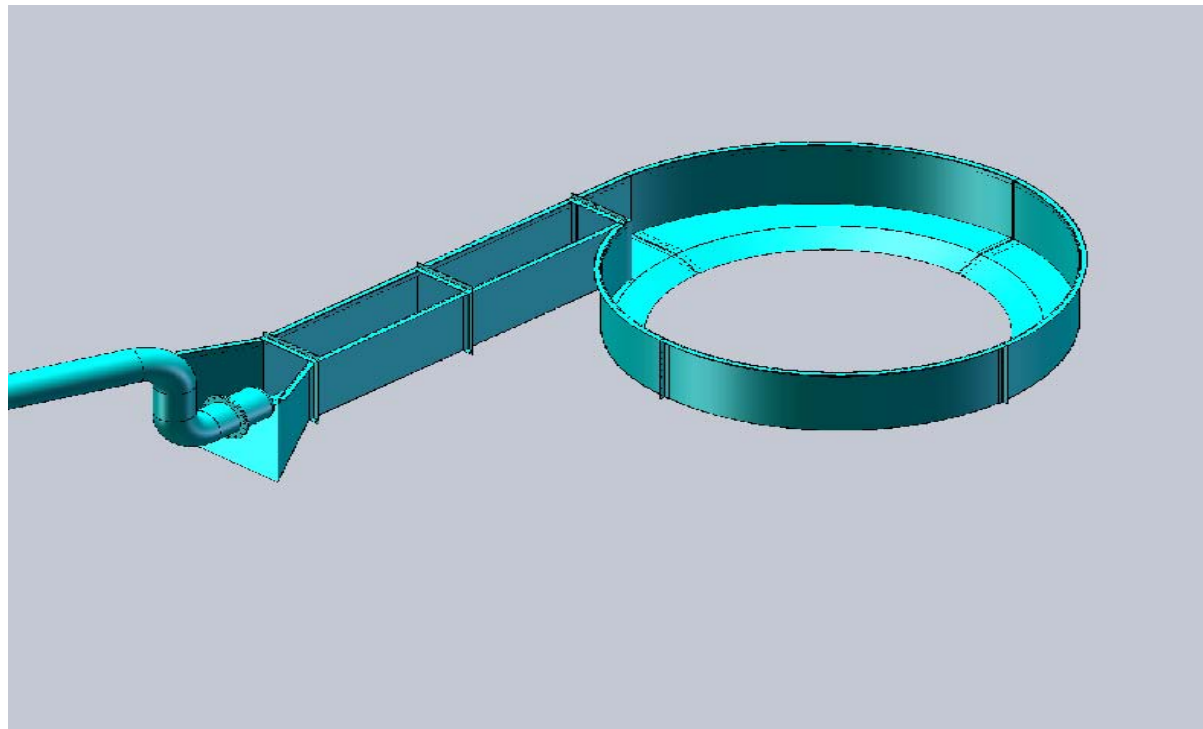


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E-Volute Next Generation Feedwell

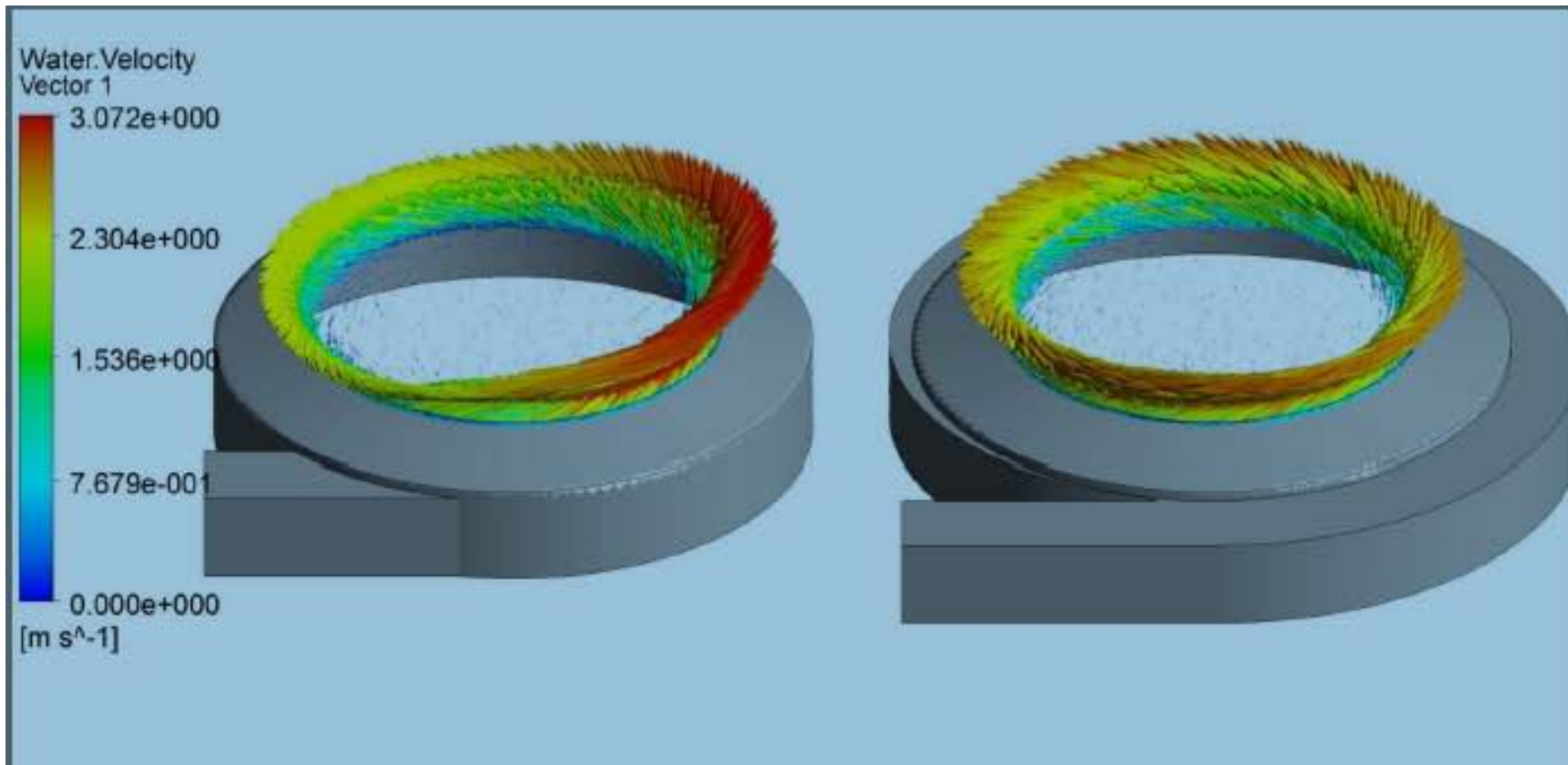


- Uses market-leading E-Duc feed dilution technology
- Even feed distribution
- Reduces average shear rates and minimizes floc shear
- Patent pending



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E-Volute Next Generation Feedwell



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Design for the raking efficiency needed



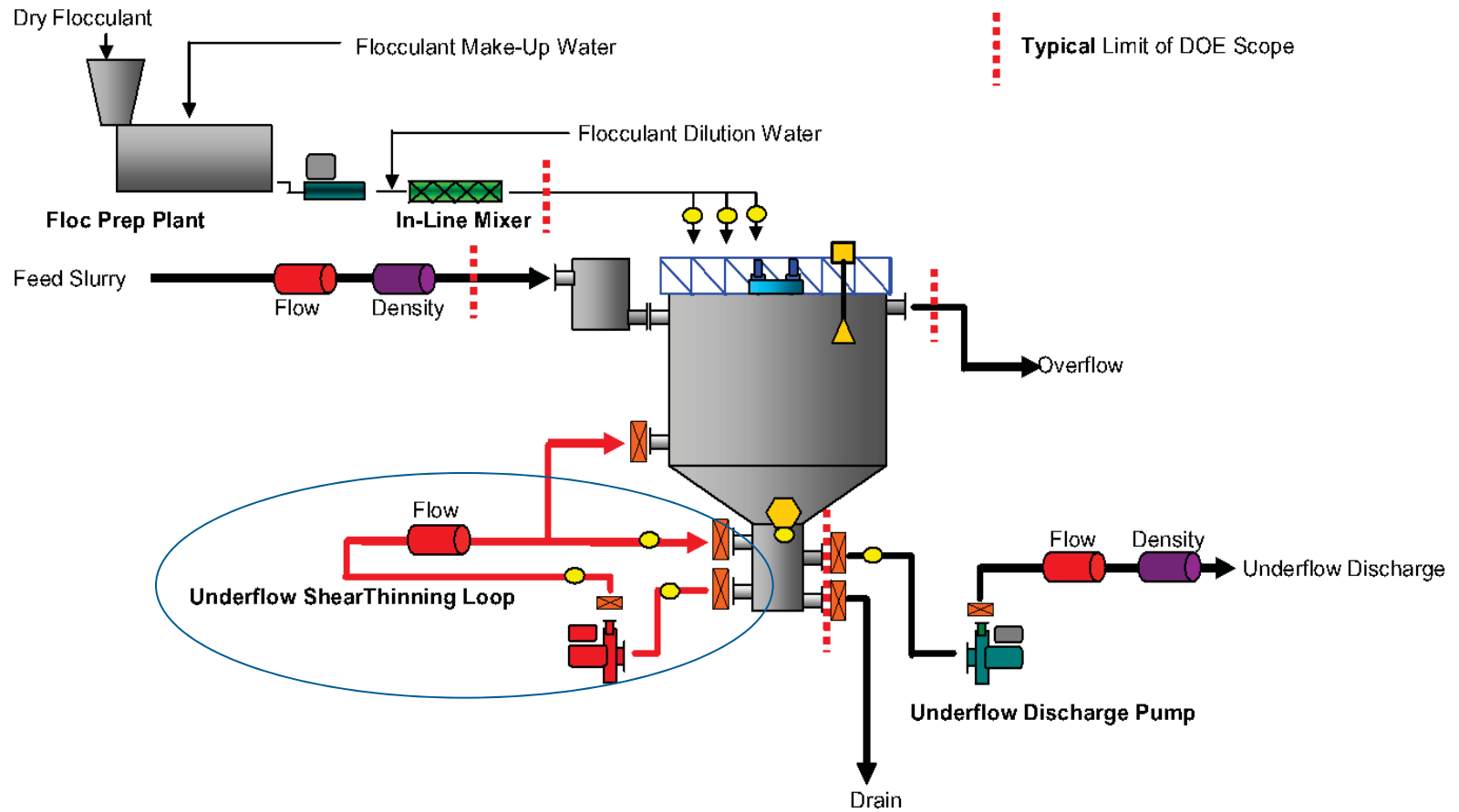
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Unsheared versus Sheared



- 69 wt%, 2006 Escondida pilot testing

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Discharge Cylinder/Shear Thinning Loop



Benefits of Rio Tinto Alcan patented Shear Thinning Design

- Reduces torque in the discharge cylinder
- Can recycle shear thinned mud to the tank knuckle and reduce the rake torque during shutdowns and upsets
- Thinned material in the discharge cylinder helps in getting the thick mud out of the thickener
- Thinned material in the discharge cylinder keeps things fluid and mixed during times when the discharge pumps are off

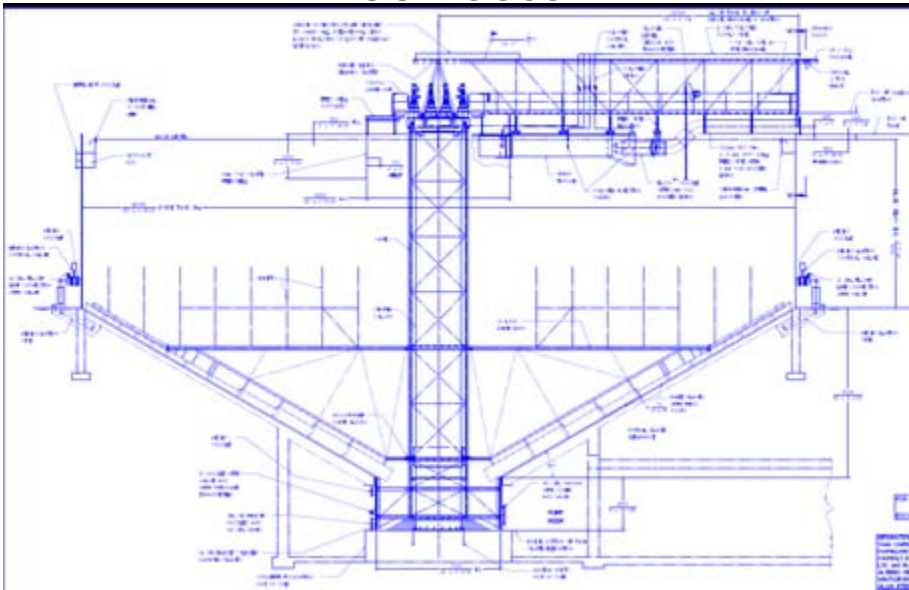
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Case Study : 300,000 tpd

- (12) x 50 m DCT
 - 0.08 m²/tpd
 - C140P-6 drive
 - 10,000,000 ft lbs
 - K = 370
 - 10 m sidewall
 - Target Density 70 wt%
 - 200 Pascal



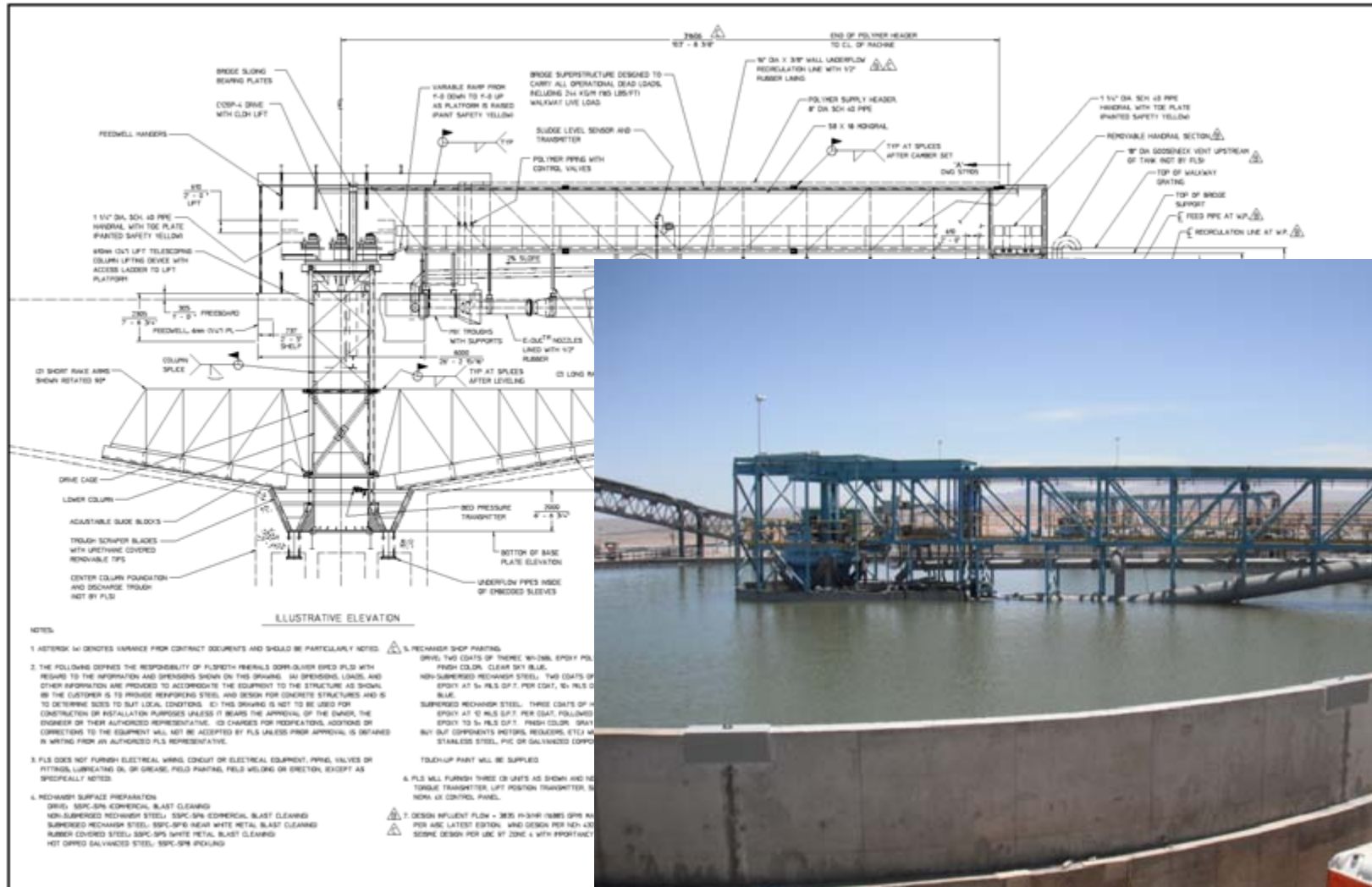
Chilean Applications

- Enami Delta – (1) 12 m DCT – Copper, operating
- Esperanza – (3) 60 m HDT – Copper, operating
- Coemin – (1) 22 m DCT – Copper, in construction
- Andina – (1) 43 m HDT – Copper, operating
- Minera Florida – (2) 17 m HDT – Gold, in engineering
- Las Cenizas – (1) 17 m DCT – Copper, operating
- Cerro Negro – (2) 40 m HDT – Iron, in engineering
- Caserones – (3) 45 m HDT – Copper, in construction



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Esperanza 60 m High Density Tailings



Thickener Background:

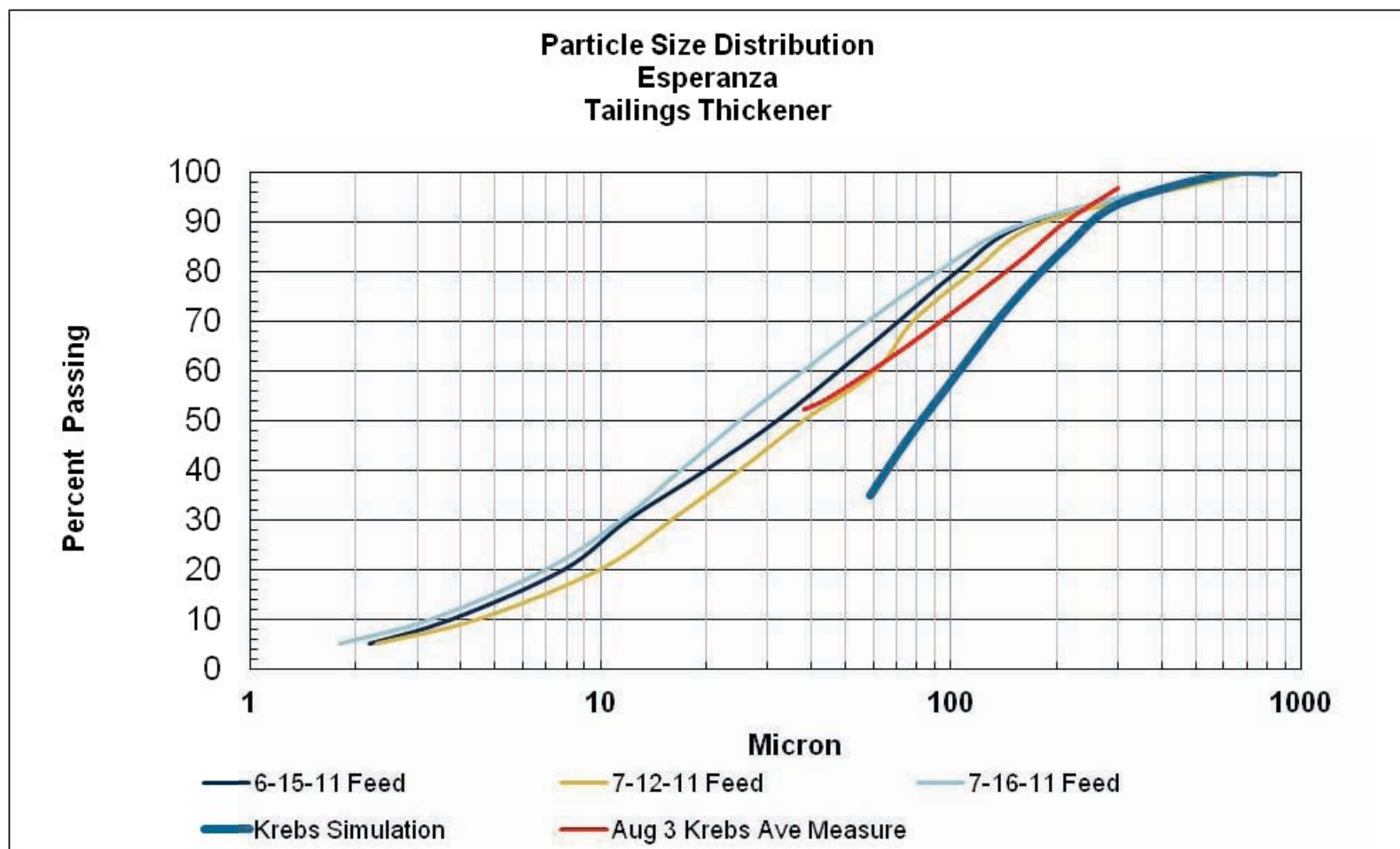
Design Basis

- **(3) 60 m Diameter HIGH DENSITY**
- **4,622 mtph Total (1540 mtph each)**
- **0.076 m²/mtpd**

Process Guarantee

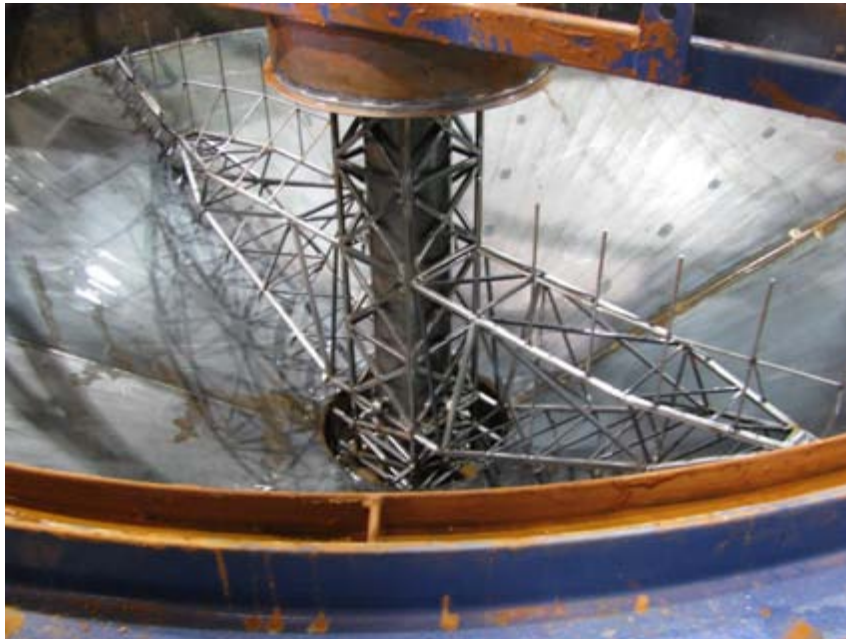
- **Minimum Average Underflow Density of 67 wt% if:**
 - An effective flocculant is applied, and
 - The feed is properly flocculated with the required dosage of flocculant, and
 - The feedwell dilution system is operated to give the required feed dilution to promote effective flocculation as feed characteristics change, and
 - The average particle size distribution is P80 210 micron, and
 - The solids specific gravity averages 2.7

Particle Size, Expected vs Actual



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Comparative Pilot Testing, Modified Truss vs Tubular Arm



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4 m mud flow



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4 m mud flow

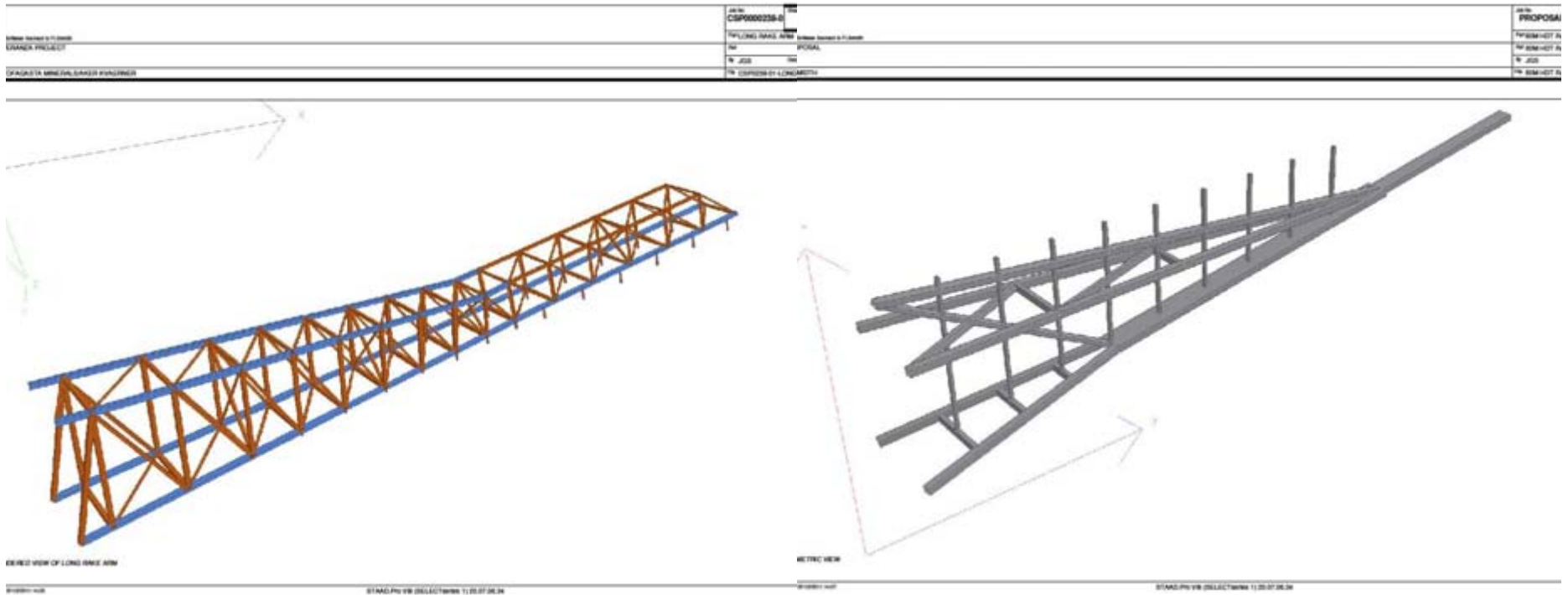


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In Progress – Rake Replacement:

Low Profile Rake Design

Esperanza 60 m - Blades not shown for clarity



Existing Box Truss Design

Low Profile Tubular Design

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Andina 43 m HDT

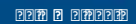


25,000 tpd, 68 wt% underflow
7.1m SWD



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**Enami Delta
83 tph Cu Tails
12 m DCT
72 wt%**

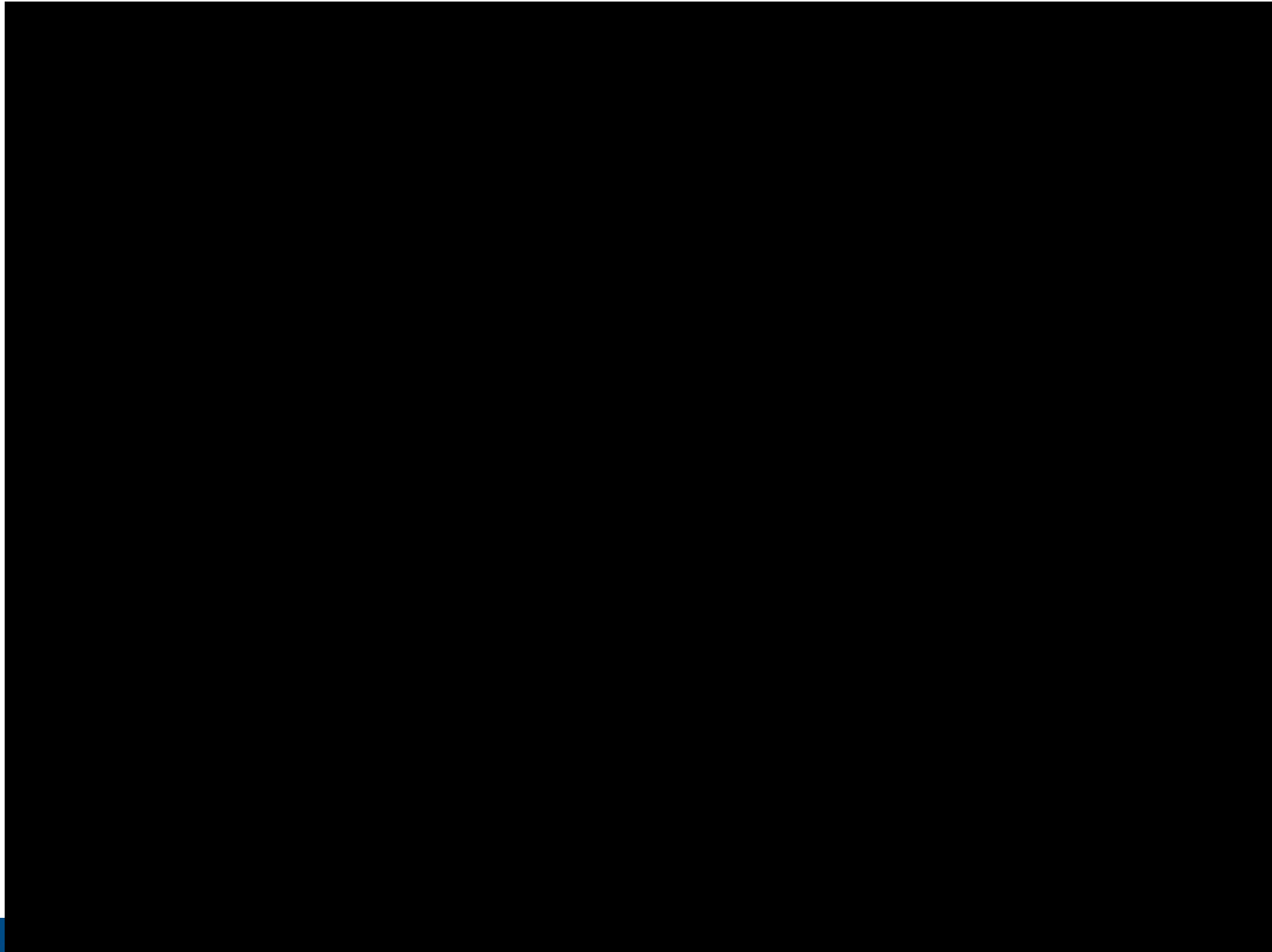


**Chungar
5500 tpd Polymetallic Tails
17 m DCT
72 wt%**



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Chungar



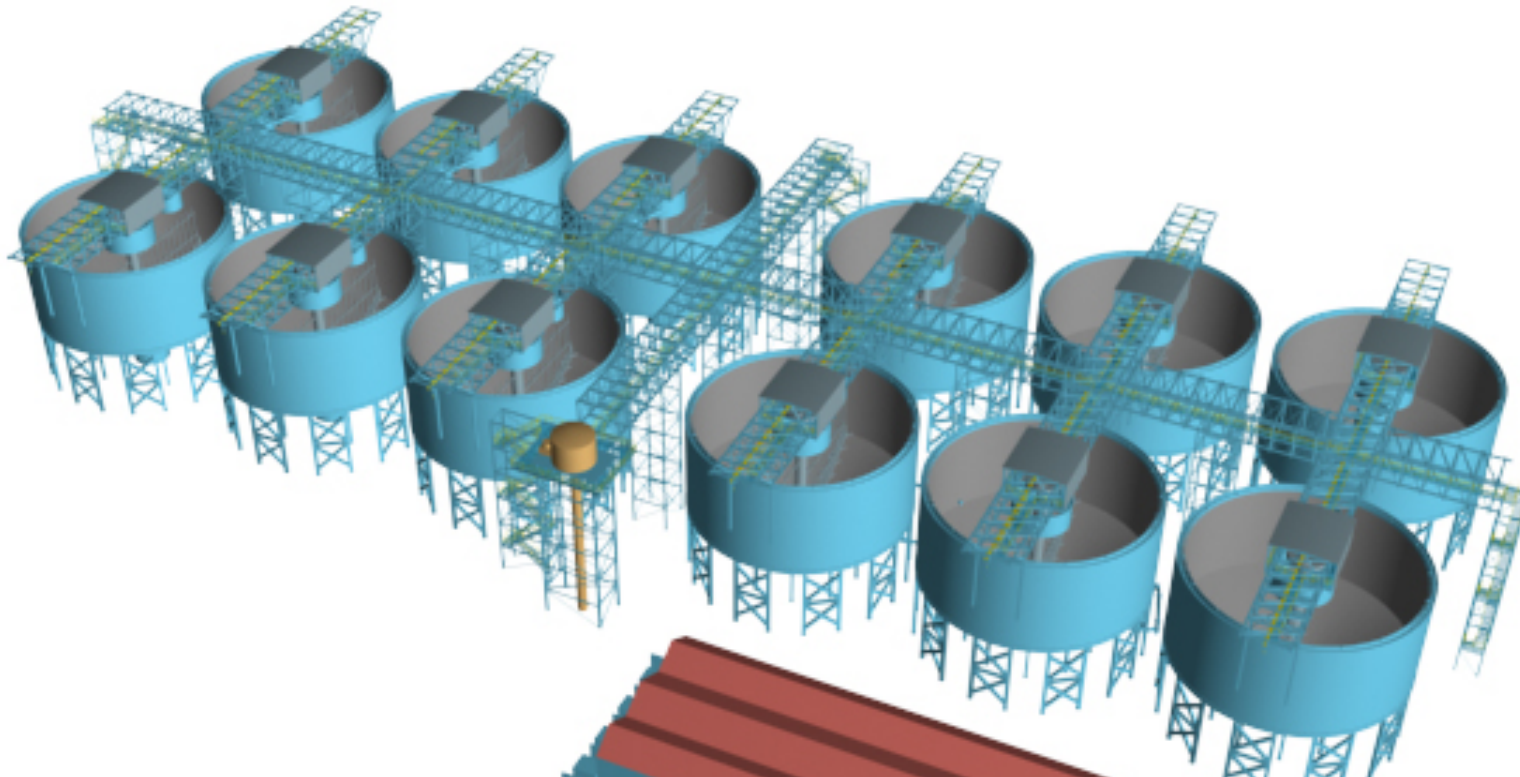
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FLSmidth Paste Thickeners



(12) 24 m DCTs in construction at SCM for 100,000tpd



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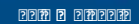


FLSmidth Paste Thickeners



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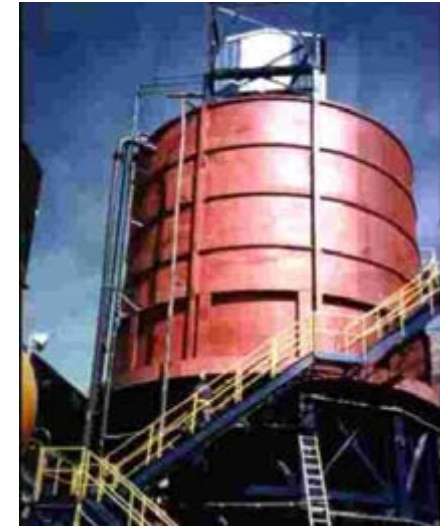


Questions?



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Deep Cone Paste Thickeners



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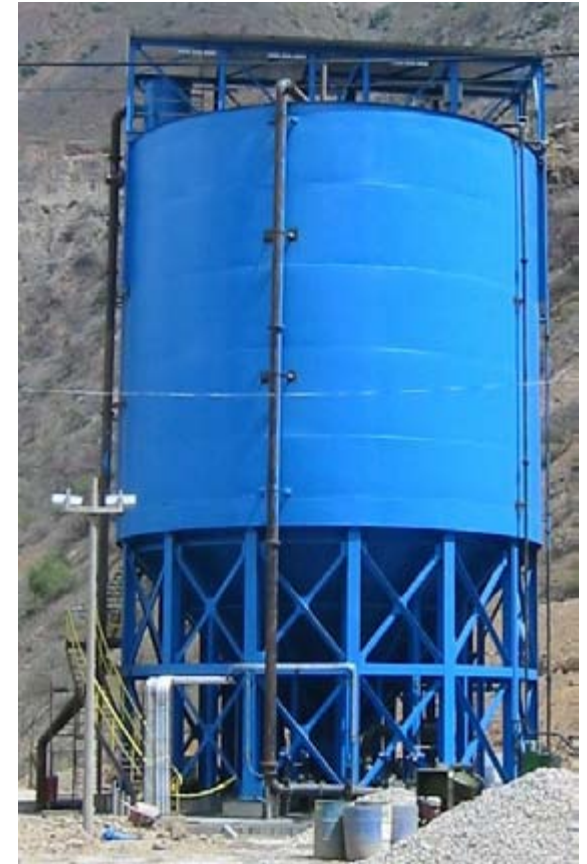


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