Brass Engineering Slurry Pipeline Seminar, Bhubaneswar, day1

Feluwa Presentation:

Piston Diaphragm Pumps for pipeline slurry transfer: When and why to apply piston diaphragm pumps

By: Hein Krimpenfort
Key Account Manager,
Feluwa Pumps

Purpose of this presentation

Piston Diaphragm Pumps for pipeline slurry transfer

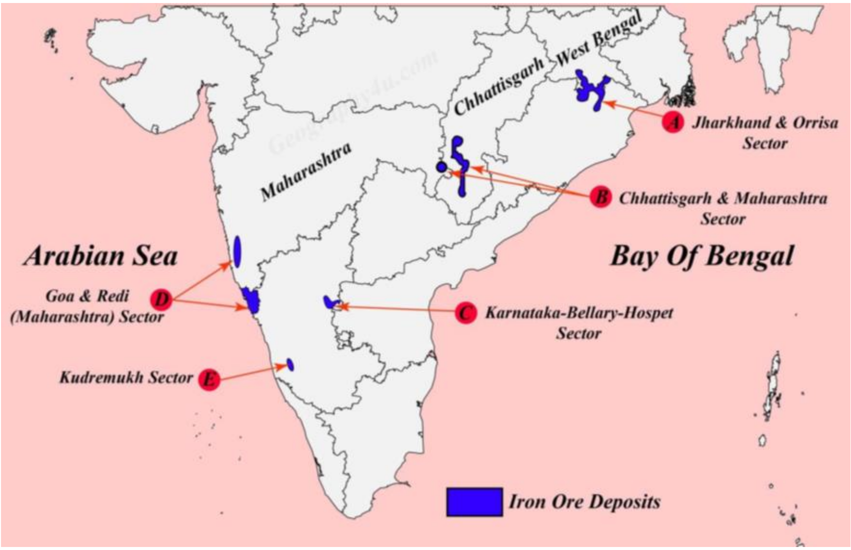
- Purpose of this presentation:

1) Introduce piston diaphragm pump technology
2) Proof that piston diaphragm pumps can be a feasible alternative for multistage centrifugal pumps
3) Present differences pumping concentrate or tailings slurry **(there aren´t any!)**

Iron ore transportation by slurry pipeline

Iron ore transportation by slurry pipeline

- Long distance transportation of iron ore
  - Demand for iron/steel worldwide is booming
    - Around 8% of the world´s total iron ore deposits are located in India
    - Iron ore deposits can be found in Karnataka, Orissa, Chhattisgarh, Goa and Jharkand
    - Enormous quantities of Iron ore needs to be transported from mines to processing plants



Iron ore transportation by slurry pipeline

- Long distance transportation of iron ore
  - Options
    - Truck
      - Approx. 30% of iron ore transport in India
      - High environmental impact
      - Operating cost per ton per km is 7,5 INR
    - Train
      - Approx. 60 to 70% of iron ore transport in India
      - Medium environmental impact
      - Operating cost per ton per km is 4,75 INR
    - Pipeline
      - Approx. 5 to 10% of iron ore transport
      - Low environmental impact
      - Operating cost per ton per km is 0,35 INR

Iron ore transportation by slurry pipeline

- Long distance transportation of iron ore
  - Pipelines:
    - Cheapest way of transporting iron ore
    - Lowest environmental impact
    - Are the preferred transporting method

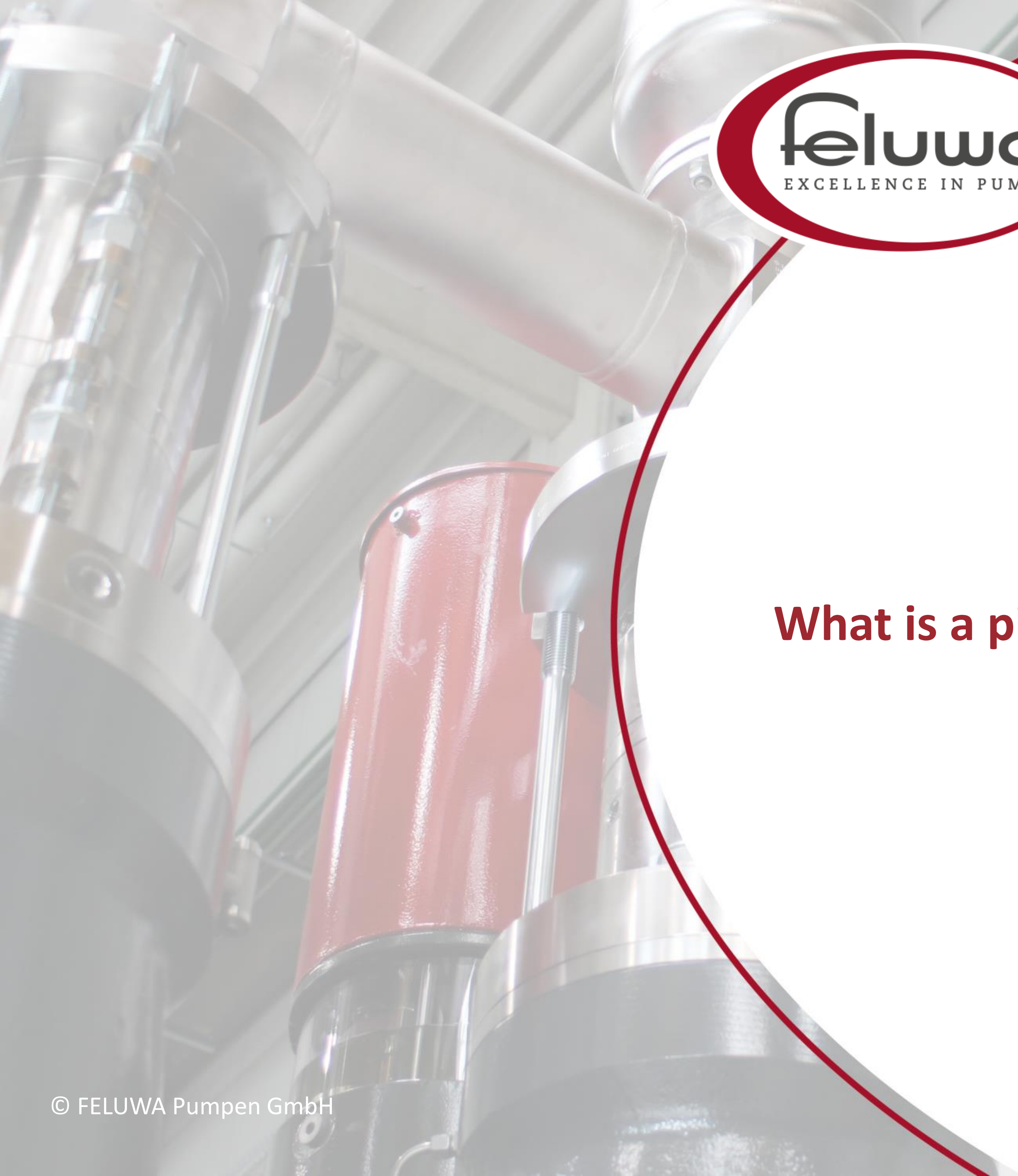
Iron ore transportation by slurry pipeline

- Long distance transportation of iron ore
  - Concentrate pipelines
    - Proven technology
    - Thousands of kilometers of pipelines are in operation, worldwide
    - Hundreds of pumps are in service as prime mover
    - Type of pump is piston diaphragm

Iron ore transportation by slurry pipeline

- Long distance transportation of iron ore

  - Iron ore slurry pipelines in India
    - Number of operating pipelines : 3
    - Number of pipelines under construction : 5
    - Number of pipelines being designed : 15 to 20



What is a piston diaphragm pump

Piston Diaphragm Pumps for pipeline slurry transfer

- What is a piston diaphragm pump:

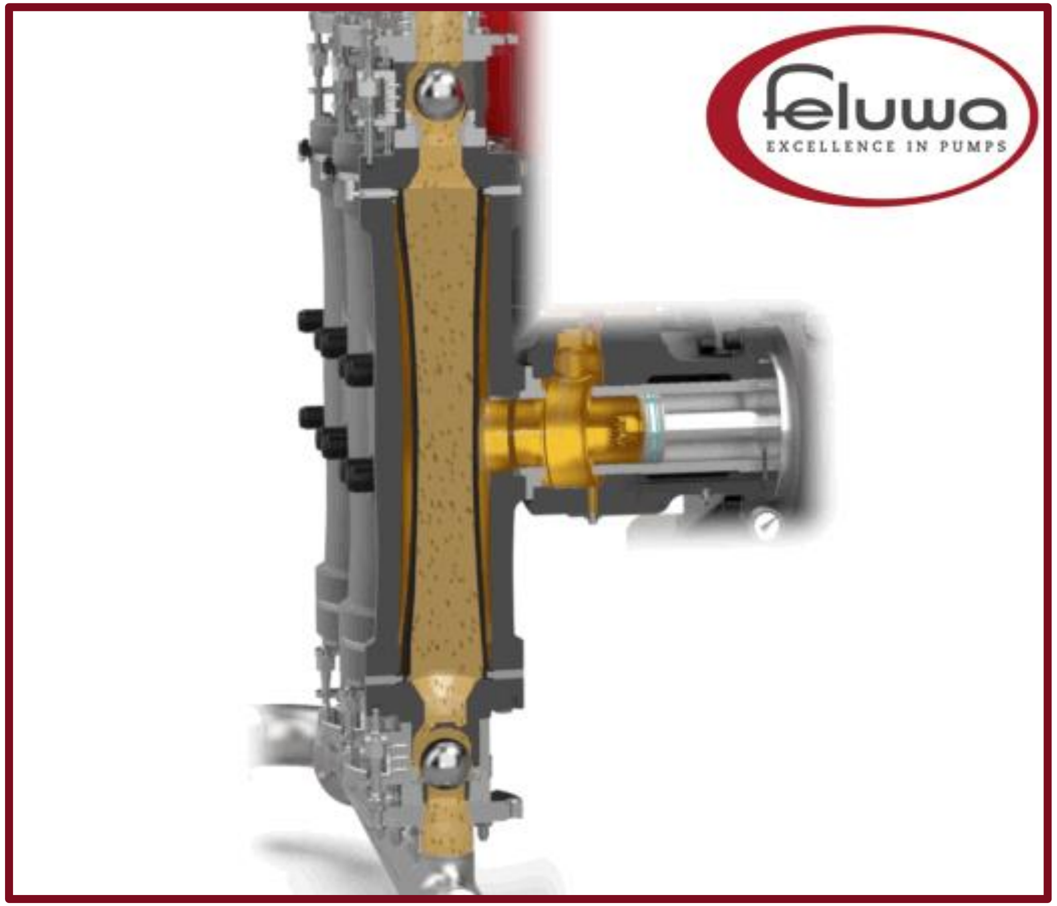
  - A piston diaphragm pump is a positive displacement pump in which the main moving parts run in hydraulic oil and are separated from the fluid by means of an elastomere.
  - The only wearing parts in a piston diaphragm pump are the suction and discharge valves

Piston Diaphragm Pumps for pipeline slurry transfer

- What is a piston diaphragm pump:
  - Piston diaphragm pumps are being used in the mining industry since more than 60 years
  - Thousands of piston diaphragm pumps have been installed for various applications
  - Piston diaphragm pumps are proven technology

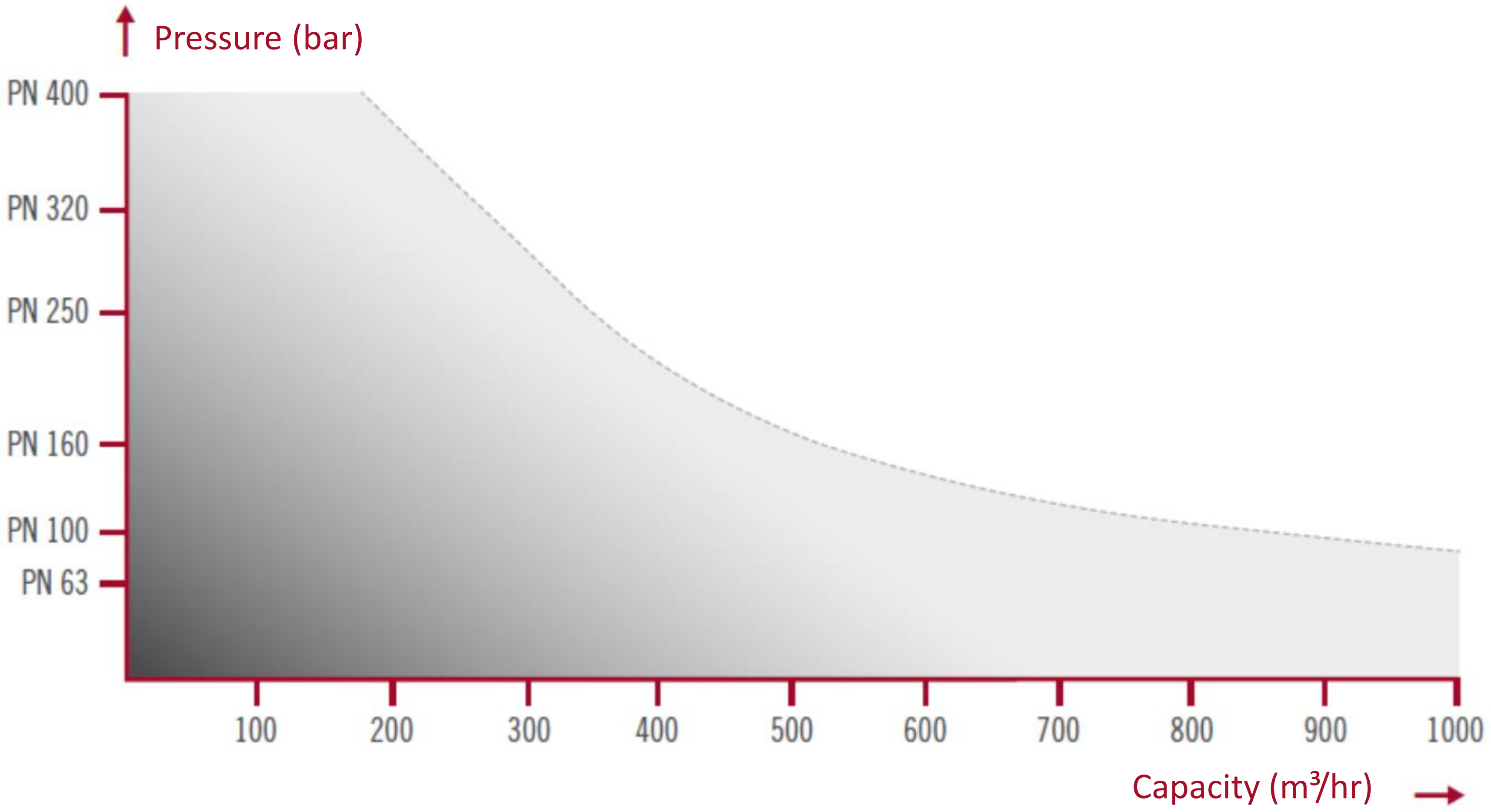
Piston Diaphragm Pumps for pipeline slurry transfer

- What is a piston diaphragm pump:



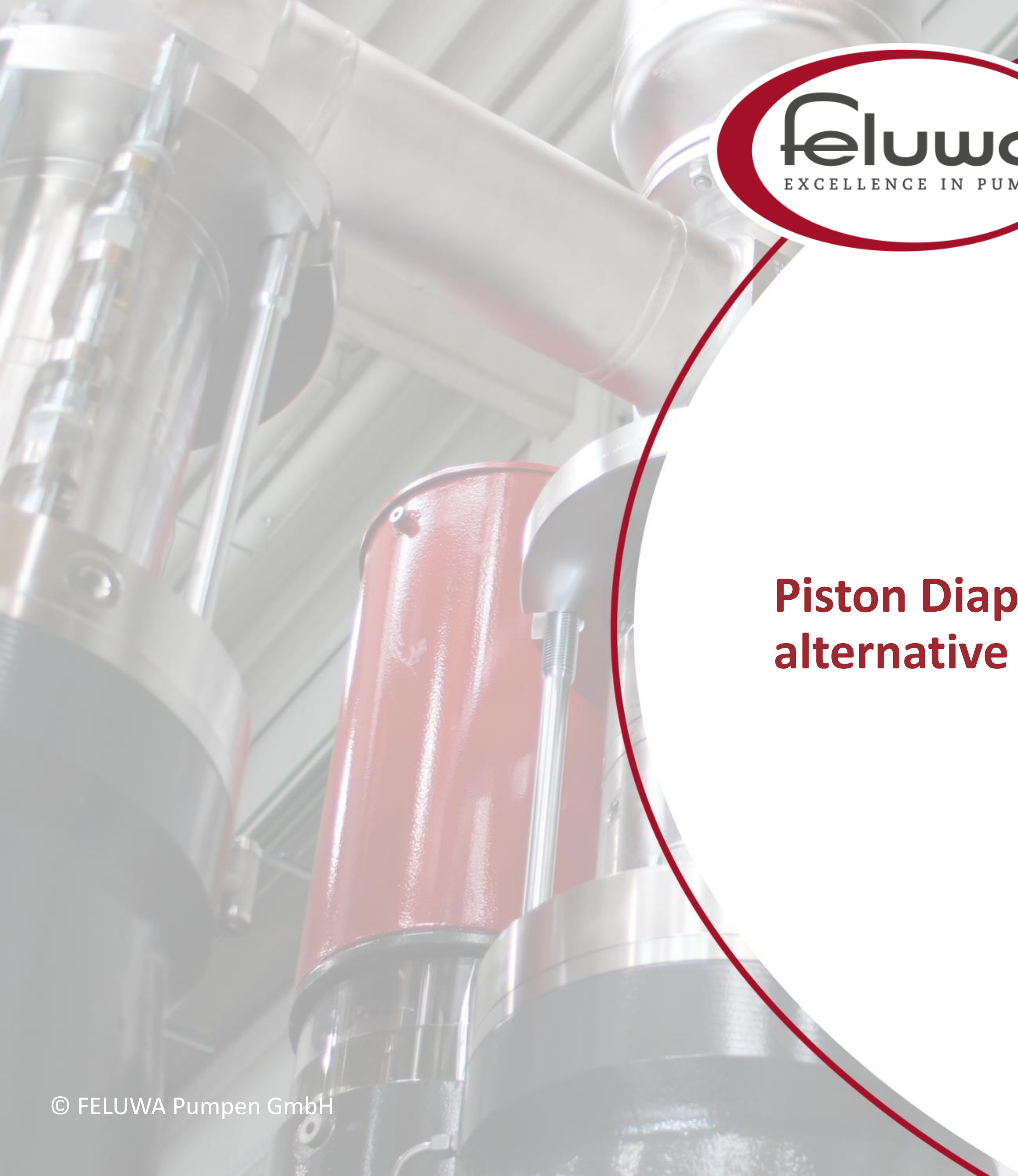
Piston Diaphragm Pumps for pipeline slurry transfer

- Pump range:



Piston Diaphragm Pumps for pipeline slurry transfer

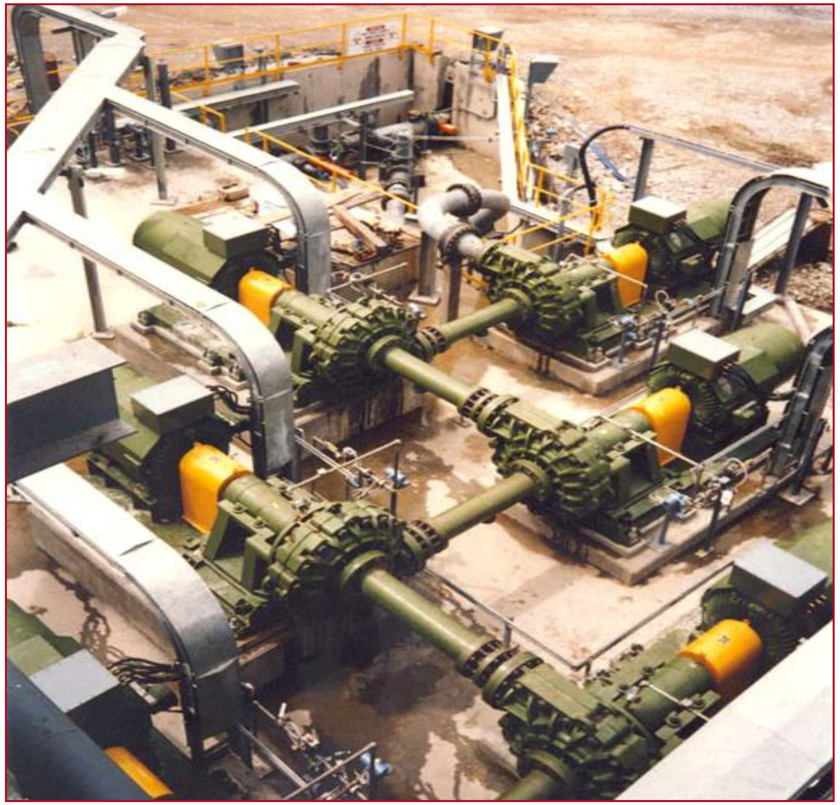
- What is a piston diaphragm pump:



Piston Diaphragm Pumps can be a feasible alternative for multistage centrifugal pumps

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston Diaphragm Pumps can be a feasible alternative for multistage centrifugal pumps:
  - Typical example
    - Pipeline distance : 18 km (irrelevant)
    - Pipeline capacity : 1.000 m^3/hr
    - Discharge pressure : 40 bar
    - Price of power : 6 INR/kWh (US$ 0,08)
    - Number of pumps
      - Centrifugal : 6 + 6 in series



Piston Diaphragm Pumps for pipeline slurry transfer

- Piston Diaphragm Pumps can be a feasible alternative for multistage centrifugal pumps:
  - Typical example
    - Pipeline distance : 18 km (irrelevant)
    - Pipeline capacity : 1.000 m³/hr
    - Discharge pressure : 40 bar
    - Price of power : 6 INR/kWh (US$ 0,08)
    - Number of pumps
      - Piston diaphragm : 2 + 1

Piston Diaphragm Pumps for pipeline slurry transfer

- Feasibility comparison
  - Investment/CAPEX

Investment			
		Centrifugal	**PD Pump**
Required data		Metso:Ototec	DGK400
Number of required operating + standby pumps		12	3
Price per pump	in $	150.000,00	1.000.000,00
Calculation			
Total system price	in $	1.800.000,00	3.000.000,00
Difference in investment	**in $**		**- 1.200.000,00**

Piston Diaphragm Pumps for pipeline slurry transfer

- Feasibility comparison
  - Power/OPEX

Power consumption			
Required data		6 + 6 **Centrifugal**	2 + 1 **PD Pump**
Pressure	**bar**	**40**	**40**
Capacity	**m³/hr**	**1000**	**1000**
Price per kW hr (6 Rupees per kWh)	in $	0,08	0,08
Operating hours	per year	8700	8700
Mechanical efficiency	in %	65	95
Calculation			
Absorbed power	in kW	1709	1170
Hourly power cost	in $	136,75	93,57
Annual power cost	in $	1.189.743,59	814.035,09
Difference in power consumption	**in $**		**375.708,50**

Piston Diaphragm Pumps for pipeline slurry transfer

- Feasibility comparison
    - Wearing parts/OPEX

Spare parts costs			
Required data		**Centrifugal**	**PD Pump**
Parts consumption in % of purchase price (assumed)	in %	50	5
Calculation			
Annual pump spare parts cost operating pumps	in $	450.000,00	99.000,00
Difference in spare parts costs	**in $**		**351.000,00**

Piston Diaphragm Pumps for pipeline slurry transfer

- Feasibility comparison
  - Labour/OPEX

Labour costs			
Required data		**Centrifugal**	**PD Pump**
Number of required pumps		12	3
Maintenance man hours per year per pump (assumed)	hrs	100	50
Labour costs per hours (assumed)	in $	30	30
Calculation			
Labour maintenance costs per year for system	hrs	36.000,00	4.500,00
Difference in maintenance cost	**in $**		**31.500,00**

Piston Diaphragm Pumps for pipeline slurry transfer

- Feasibility comparison
    - Summary

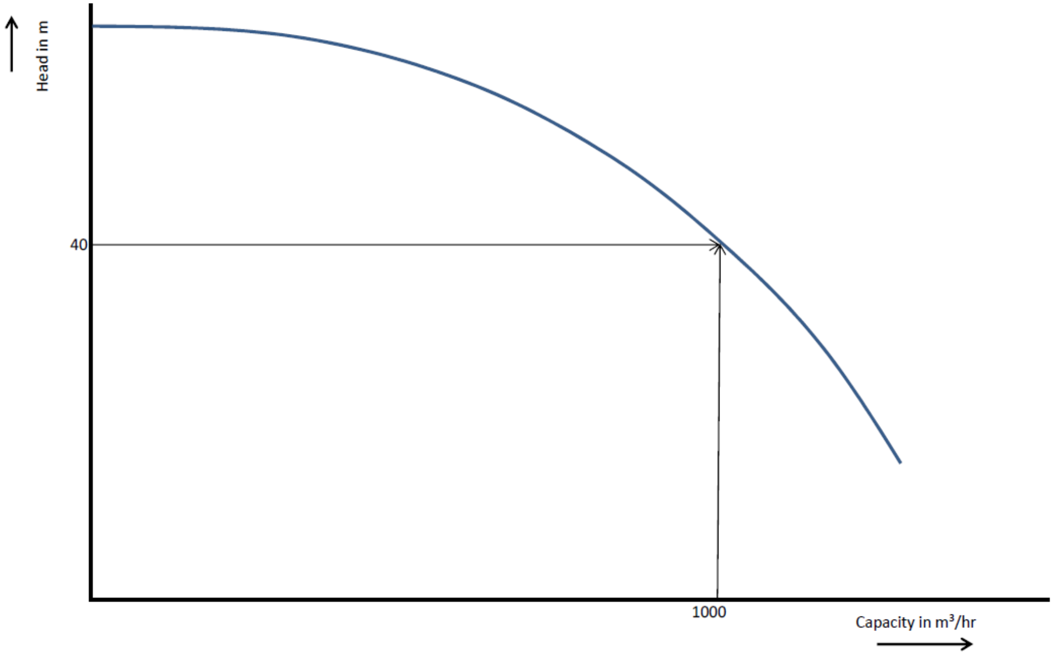
Summary			
		Centrifugal	**PD Pump**
Annual power consumption		**1.189.743,59**	**814.035,09**
Spare parts costs	in $	450.000,00	99.000,00
Labour costs	in $	36.000,00	4.500,00
Total operating costs	in $	1.675.743,59	917.535,09
Difference of total operating costs per month	in $	63.184,04	
Total investment	**in $**	**1.800.000,00**	**3.000.000,00**
Amortization period of diffence in investment	in months		**18,99**
	in years		**1,58**

Piston Diaphragm Pumps for pipeline slurry transfer

- Feasibility comparison
  - Conclusion
    - Depending on
      - Pressure
      - Price of power
      - Abrasivity of the slurry
    - Piston diaphragm pumps can be a feasible alternative for centrifugal pumps

Piston Diaphragm Pumps for pipeline slurry transfer

- Technical comparison
  - In a centrifugal pump capacity is pressure dependent
    - If the pressure increases
    - The capacity decreases

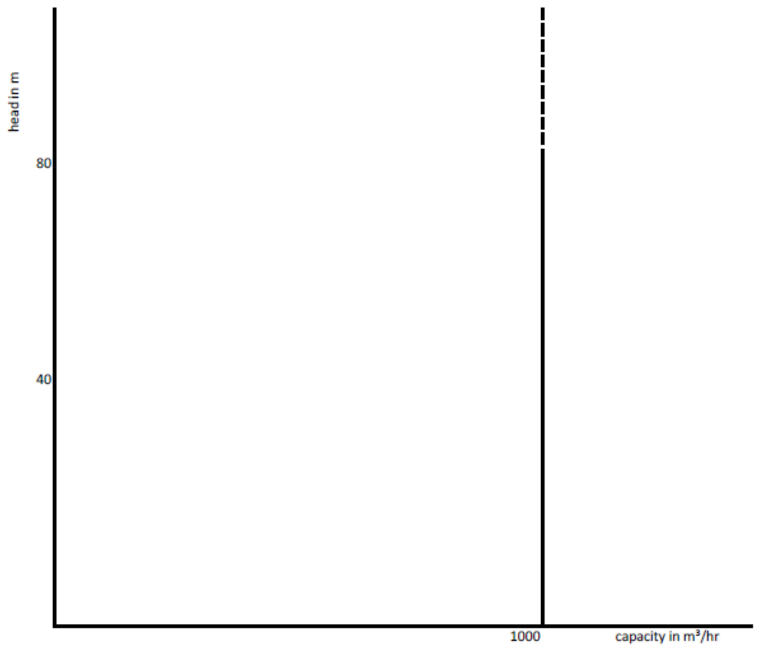


Piston Diaphragm Pumps for pipeline slurry transfer

- Technical comparison
  - In a centrifugal pump capacity is pressure dependent
    - If the pressure increases
    - The capacity decreases
    - There is a considerable risk of clogging the pipeline

Piston Diaphragm Pumps for pipeline slurry transfer

- Technical comparison
  - In a piston diaphragm pump capacity is not pressure dependent
    - If the pressure increases
    - The capacity remains the same



Piston Diaphragm Pumps for pipeline slurry transfer

- Technical comparison
  - In a piston diaphragm pump capacity is not pressure dependent
    - If the pressure increases
    - The capacity remains the same
    - The risk of clogging a pipeline is minimal

Where does pressure come from

Piston Diaphragm Pumps for pipeline slurry transfer

- NOTE:

A pump does not generate/create/make pressure, it does not

A pump merely overcomes a back pressure

Piston Diaphragm Pumps for pipeline slurry transfer

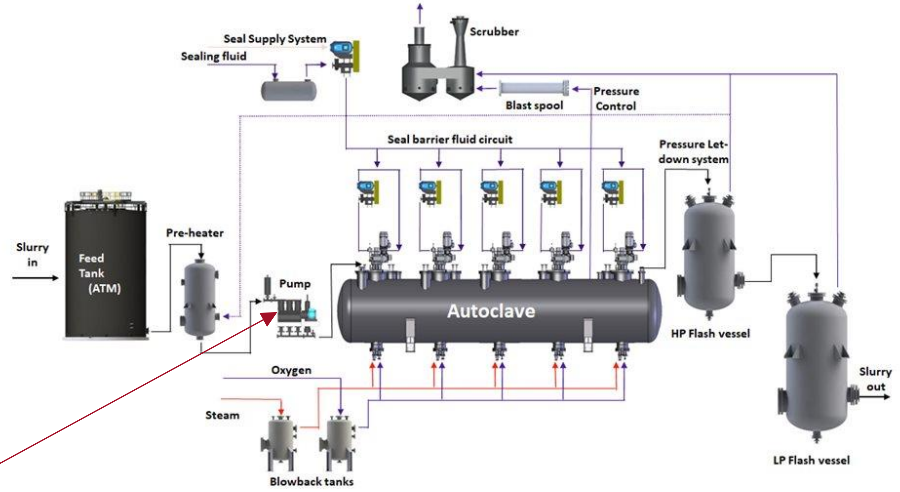
- A pump does not generate/create/make pressure
  - Applications for piston diaphragm pumps in the mining and metallurgical industry
    - Pressure vessel feed
      - Autoclaves in gold, copper, nickel, etc
      - Digesters in bauxite
    - Mine dewatering
      - Clean water + sludge
      - Dirty water
    - Pipeline transfer
      - Tailings
      - Concentrate

Piston Diaphragm Pumps for pipeline slurry transfer

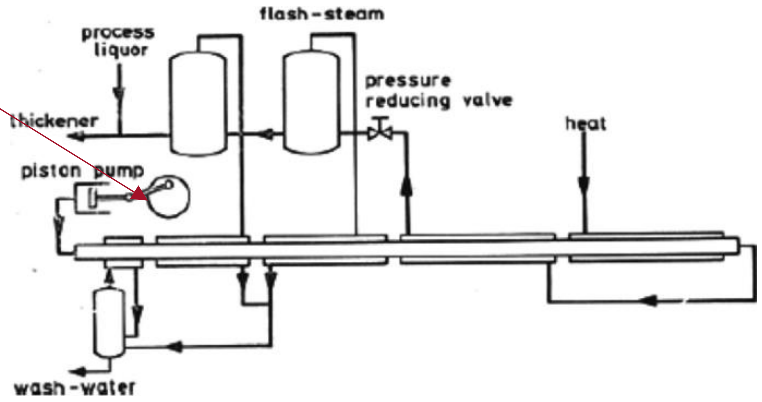
- Where does pressure come from
  - Pressure vessel feed
    - A vessel is pressurized in order to create an atmosphere in which the concentrate is liberated from the ore (in addition to high temperatures, high acidity)
      - In order to transfer ore into the vessel, the pump has to be able to overcome the pressure in the vessel

Piston Diaphragm Pumps for pipeline slurry transfer

- Where does pressure come from
  - Pressure vessel feed
    - Autoclaves (typical pressure 20 to 40 bar)



Feed pump



- Digesters (typical pressure 80 to 100 bar)

Piston Diaphragm Pumps for pipeline slurry transfer

- Where does pressure come from
  - Pressure vessel feed
    - Note:
      - If the pressure in the vessel is 30 bar, the pump will deliver a pressure of slightly more than 30 bar, even if the pump is designed for 40 bar (or more)
      - The pump will produce pressure to overcome the back pressure from the vessel, not more

Piston Diaphragm Pumps for pipeline slurry transfer

- Where does pressure come from
  - Pressure vessel feed, example
    - Location : Russia
    - Customer : Petrapavlovsk
    - Type and qty of pumps : 8 x Feluwa TGK135
    - Capacity per pump : 17 m³/hr
    - Type of slurry : Gold ore
    - SG of solids : 3,2 kg/dm³
    - Solids concentration : 20%
    - Length of pipeline : NA
    - Static head : NA
    - Slurry velocity : NA
    - Discharge pressure : 38 bar (autoclave pressure)

Piston Diaphragm Pumps for pipeline slurry transfer

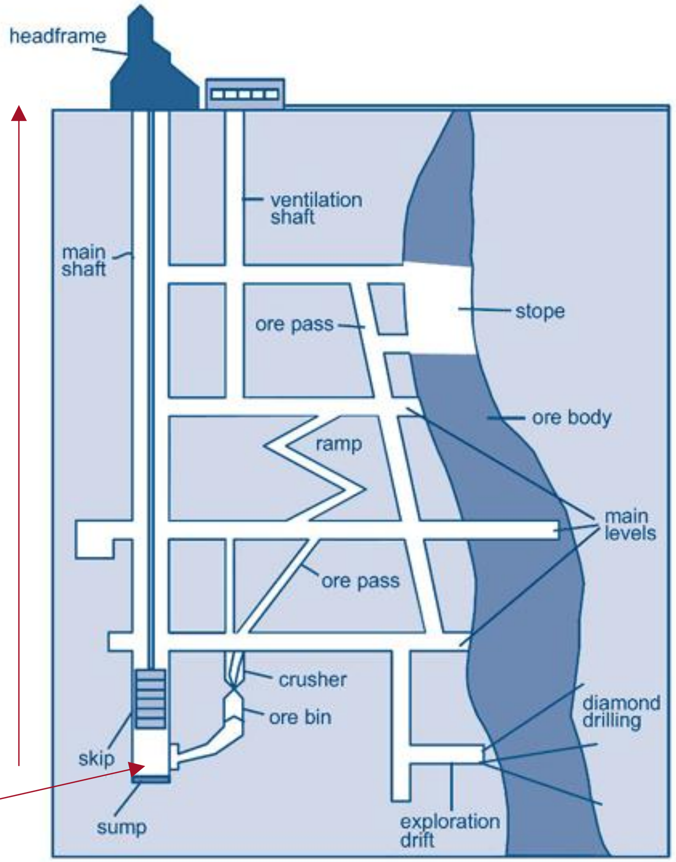
- Where does pressure come from
  - Mine dewatering
    - In an underground mine, process and groundwater needs to be pumped to surface
      - The dewatering pump has to be able to overcome the static back pressure created by the column of water from the pump to surface (multiplied by the SG of the slurry)

Piston Diaphragm Pumps for pipeline slurry transfer

- Where does pressure come from
  - Mine dewatering

Static head = pressure

Dewatering pump



Static head = 500 m
SG of mine water = 1,1 kg/dm³
Required pressure = 55 bar

Static head = 300 m
SG of mine water = 1,0 kg/dm³
Required pressure = 30 bar

Piston Diaphragm Pumps for pipeline slurry transfer

- Where does pressure come from
  - Mine dewatering
    - Note:
      - If static head is 300 meters (@ SG of 1,0 kg/dm³), required discharge pressure will be 30 bar, (even if the pump is designed for 40 bar, or more)
      - The pump will produce pressure to overcome the back pressure from static head, not more

Piston Diaphragm Pumps for pipeline slurry transfer

- Where does pressure come from
  - Mine dewatering, example
    - Location : Turkey
    - Customer : Esan
    - Type and qty of pumps : Feluwa DGK400
    - Capacity per pump : 250 m³/hr
    - Type of slurry : Dirty mine water
    - SG of solids : 1,05 kg/dm³
    - Solids concentration : 5%
    - Length of pipeline : 800 m (vertical)
    - Static head : 85 bar
    - Slurry velocity : 2,5 m/sec
    - Design pump pressure : 100 bar (only static head)

feluwa EXCELLENCE IN PUMPS

Piston Diaphragm Pumps for pipeline slurry transfer

- Where does pressure come from
  - Slurry pipeline transfer
    - In a pipeline, the pump has to overcome back pressure created by
      - Static head
        - If the difference in elevation between the start and the end of the pipeline
      - Friction losses
        - Friction losses created by the slurry/meter need to be multiplied by the pipeline length
    - In order to transfer the slurry from the beginning of the pipeline to the end, the pump needs to overcome the total back pressure created by the pipeline (static head + friction losses)

Piston Diaphragm Pumps for pipeline slurry transfer

- Where does pressure come from
  - Slurry pipeline transfer
    - Static head :
      - In case difference in altitude from start till the end of the pipeline is 300 meters, the back pressure that the pump needs to overcome is 300 x the SG of the slurry
      - In case SG of slurry is 1,6 kg/dm³, static head will be 48 bar

Piston Diaphragm Pumps for pipeline slurry transfer

- Where does pressure come from
  - Slurry pipeline transfer
    - Friction losses:
      - Depend on various factors and need to be determined by specialized slurry pipeline engineering companies

Piston Diaphragm Pumps for pipeline slurry transfer

- Where does pressure come from
  - Slurry pipeline transfer
    - Friction losses are determined by
      - SG of solids
      - Concentration
      - Capacity
      - Pipe diameter (ID)
      - Yield stress
      - Viscosity
      - Pipe wall roughness
      - Particle Size Distribution
      - Number of bends, valves, etc
      - Much more **(just ask Brass)**

SG of slurry

Slurry velocity

Friction loss per m of pipeline

Piston Diaphragm Pumps for pipeline slurry transfer

- Slurry pipeline transfer
  - Note 1:
    - Pressure
      - Type of slurry (concentrate or tailings) is not a criteria
      - For friction loss calculation, “slurry is slurry”
      - For a piston diaphragm pump, “slurry is slurry”

Piston Diaphragm Pumps for pipeline slurry transfer

- Slurry pipeline transfer
  - Note 2:
    - Pressure
      - In case pipeline goes down hill, static head is negative
      - In case friction losses exceed negative static head, additional pump pressure is required to transfer slurry down hill

Piston Diaphragm Pumps for pipeline slurry transfer

- Slurry pipeline transfer
  - Note 3
    - Significance of SG of solids for piston diaphragm pumps:
      - Typically, SG of solids of tailings is 2,3 to 3,0 kg/dm³
        - Typically, the SG of tailings slurry is 1,3 to 2,0 kg/dm³ (depending on solids concentration)
      - Typically, SG of solids of concentrate is 2,5 to 5,5 kg/dm³
        - Typically, the SG of concentrate slurry is 1,7 to 2,3 kg/dm³ (depending on solids concentration)
    - For a piston diaphragm pump the SG of the slurry determines the NPSH required
      - A high SG of slurry, requires a higher NPSHr

Piston Diaphragm Pumps for pipeline slurry transfer

- Slurry pipeline transfer
  - Note 3
    - Significance of SG of solids:
      - A high SG of slurry, requires a higher NPSHr

Data Sheet

Performance Curve SI units [bar]

Project	Brass Seminar_REVA00		
Type of Pump	TGK 500 - 3 DS 350	SAP#:	D000219

Note	Operating Conditions		Note	Performance		Rev
1	**Operating Conditions**			**Performance**		
2	Discharge Pressure	150,0 bar(g)		Rated Capacity	349,55 m^3/h	
3	Suction Pressure (reqired for water)	0,0 bar(g)		Minimum Capacity	111,56 m^3/h	
4	**Fluid**			NPSHr (water column)	8,5 m	
5	Density	1,10 g/cm^3		Mean Piston Speed	0,78 m/s	
6	Viscosity	500,0 cP		Mechanical Efficiency	94,7 %	
7	Particle Size	0,50 mm		Volumetric Efficiency	91,0 %	
8	Temperature	20 °C		Maximum Power Consumption	1538,4 kW	
9	**Construction**			Motor Torque	9795,0 Nm	
10		Size & Rating		Minimum Speed	15 spm	
11	Suction Nozzle	16" Cl.150-RF		Maximum Speed	47 spm	
12	Discharge Nozzle	16" Cl.1500-RTJ		Differential Pressure	150,0 bar	
13	Flush Nozzle (S + D)	4" Cl.150-RF + 4" Cl.1500-RTJ		Piston Displacement	45,40 liter	

Data Sheet

Performance Curve SI units [bar]

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Note	Operating Conditions		Note	Performance		Rev
1	**Operating Conditions**			**Performance**		
2	Discharge Pressure	150,0 bar(g)		Rated Capacity	349,55 m^3/h	
3	Suction Pressure (reqired for water)	0,4 bar(g)		Minimum Capacity	111,56 m^3/h	
4	**Fluid**			NPSHr (water column)	13,3 m	
5	Density	2,00 g/cm^3		Mean Piston Speed	0,78 m/s	
6	Viscosity	500,0 cP		Mechanical Efficiency	94,7 %	
7	Particle Size	0,50 mm		Volumetric Efficiency	91,0 %	
8	Temperature	20 °C		Maximum Power Consumption	1538,4 kW	
9	**Construction**			Motor Torque	9795,0 Nm	
10		Size & Rating		Minimum Speed	15 spm	
11	Suction Nozzle	16" Cl.150-RF		Maximum Speed	47 spm	
12	Discharge Nozzle	16" Cl.1500-RTJ		Differential Pressure	149,6 bar	
13	Flush Nozzle (S + D)	4" Cl.150-RF + 4" Cl.1500-RTJ		Piston Displacement	45,40 liter	

Piston Diaphragm Pumps for pipeline slurry transfer

- Slurry pipeline transfer
  - Note 4
    - Critical velocity:
      - SG of solids determines the critical/precipitation velocity of a slurry in the pipeline
      - Particle Size Distribution plays an important role in determining the critical velocity
      - The higher the SG of solids is, the higher the slurry velocity in the pipeline (to prevent settling of these solids
      - In order to achieve a higher velocity, the diameter of the pipeline needs to be decreased
      - The higher the slurry velocity in the pipeline, the higher the friction losses will be

Piston Diaphragm Pumps for pipeline slurry transfer

- Slurry pipeline transfer
  - Slurry pipeline transfer, example tailings
    - Location : Mexico
    - Customer : Minera Boleo
    - Type and qty of pumps : 4 x Feluwa QGK500
    - Capacity per pump : 750 m^3/hr
    - SG of slurry : 1,7 kg/dm^3
    - Length of pipeline : 6 km
    - Static head : 200 m
    - Slurry velocity : 1,8 m/sec
    - Static head : 3.400 kPa
    - Friction losses : 1.100 kPa
    - **Design pump pressure : 4.500 kPa**

Piston Diaphragm Pumps for pipeline slurry transfer

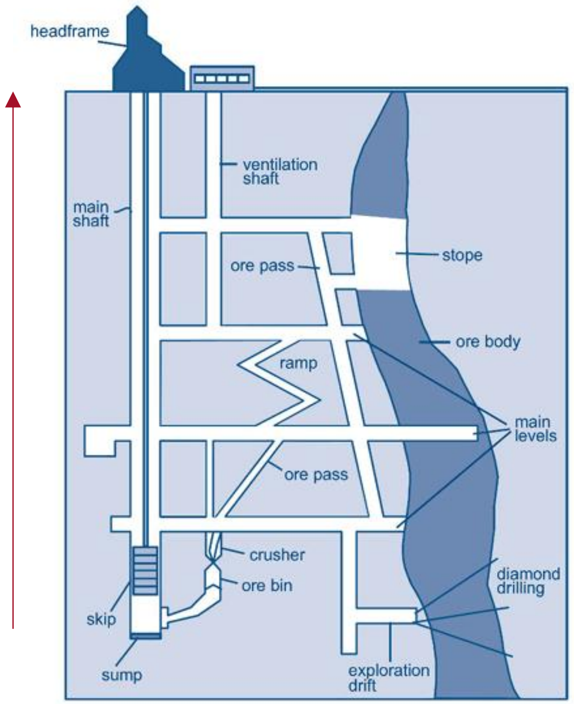
- Slurry pipeline transfer
  - Slurry pipeline transfer, example concentrate
    - Location : Mozambique
    - Customer : Kenmare
    - Type and qty of pumps : 3 x Feluwa TGK400
    - Capacity per pump : 68 m^3/hr
    - SG of solids : 5,2 kg/dm^3
    - Length of pipeline : 15 km
    - Static head : 0 m
    - Slurry velocity : 5 m/sec
    - Static head : 0,0 kPa
    - Friction losses : 27.000 kPa
    - **Design pump pressure : 27.000 kPa**

Piston Diaphragm Pumps for pipeline slurry transfer

- Slurry pipeline transfer
  - Pressure
    - Pipeline length is converted into pressure
    - **For a piston diaphragm pump, length of a pipeline is irrelevant**
    - **A pump does not know how long the pipeline is (and it does not care)**
    - **A pump does not know what kind of slurry it pumps (and it does not care)**

Piston Diaphragm Pumps for pipeline slurry transfer

- Slurry pipeline transfer
  - Pressure



Vertical pipeline (only static head),
length 1,8 km, horizontal length is 0, pressure is 20.000 kPa

Length of a pipeline is irrelevant!!!

Horizontal pipeline (only friction losses),
length 200 km, is pressure is 20.000 kPa

Piston diaphragm pump selection

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Main criteria for pump size selection:
    - Capacity in m^3/hr or GPM
    - Pressure in bar, kPa or PSI

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Main criteria for pump size selection:
    - Capacity in m^3/hr or GPM

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Piston volume
    - Number of cylinders
    - Number of pump chambers
    - Pressure/volumetric efficiency
    - Stroke rate
    - Available installed power

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Piston volume
      - Determined by
        - Surface area of piston
        - Stroke length
        - Formula : ((0,25 x π x D²) x stroke length)
        - Example :
          - Piston diameter : 3,4 dm
          - Piston stroke : 5,0 dm
          - Piston volume : 45,4 dm³

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Number of cylinders and pump chambers
      - Piston diaphragm pumps are available in various configurations:
        - Simplex single acting (1 cylinder, 1 pump chamber)
        - Simplex double acting (1 cylinder, 2 pump chambers)
        - Duplex double acting (2 cylinders, 4 pump chambers)
        - Triplex single acting (3 cylinders, 3 pump chambers)
        - Quintuplex single acting (5 cylinders, 5 pump chambers)

Piston Diaphragm Pumps for pipeline slurry transfer

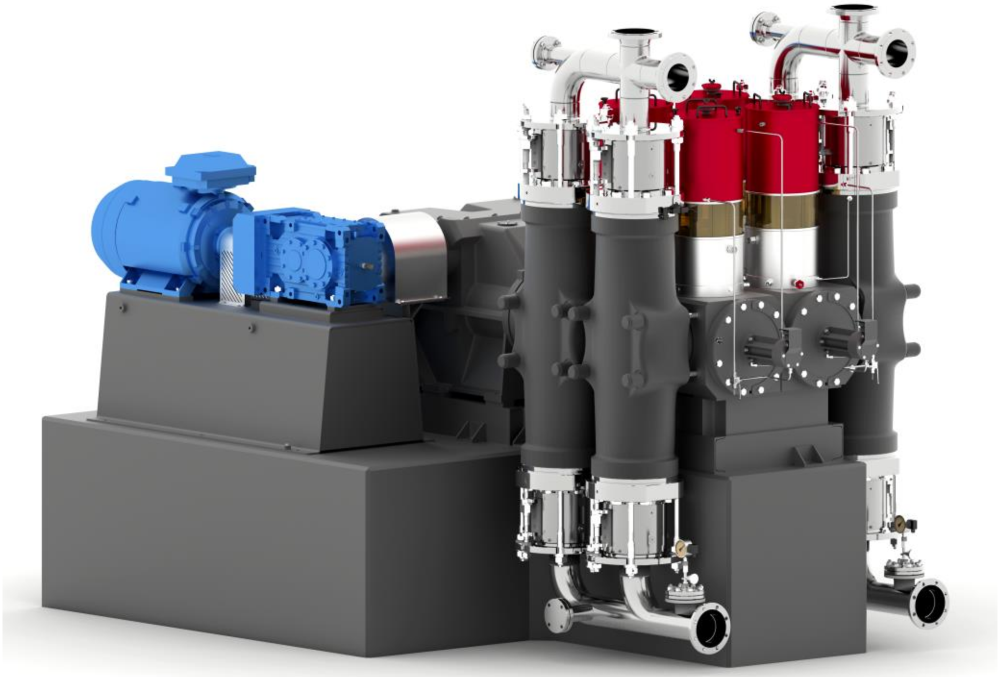
- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Simplex single acting (1 cylinder, 1 pump chamber)
    - Feluwa SG

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Simplex double acting (1 cylinder, 2 pump chambers)
    - Feluwa SG

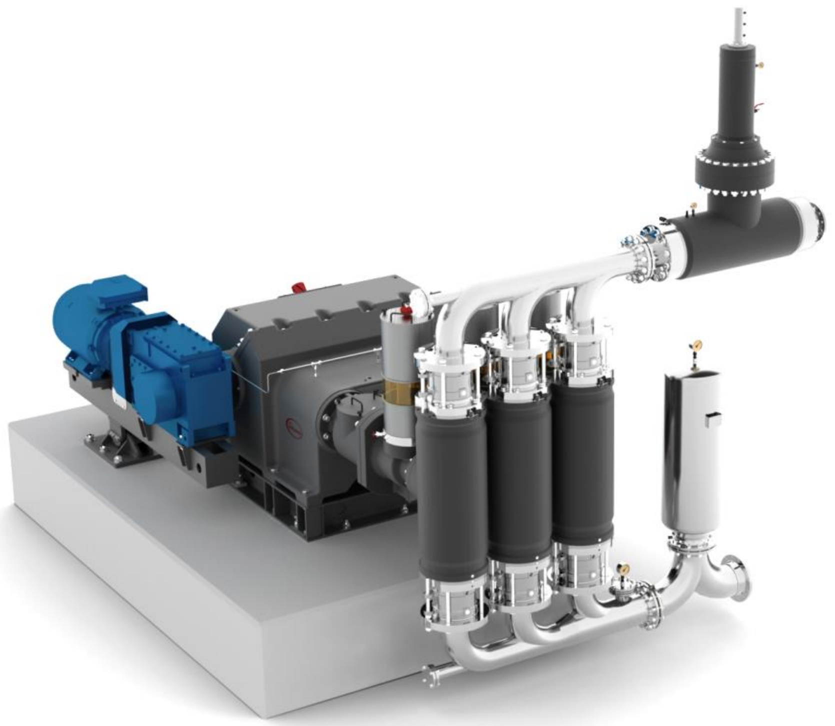
Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Duplex double acting (2 cylinders, 4 pump chambers)
    - Feluwa DGK



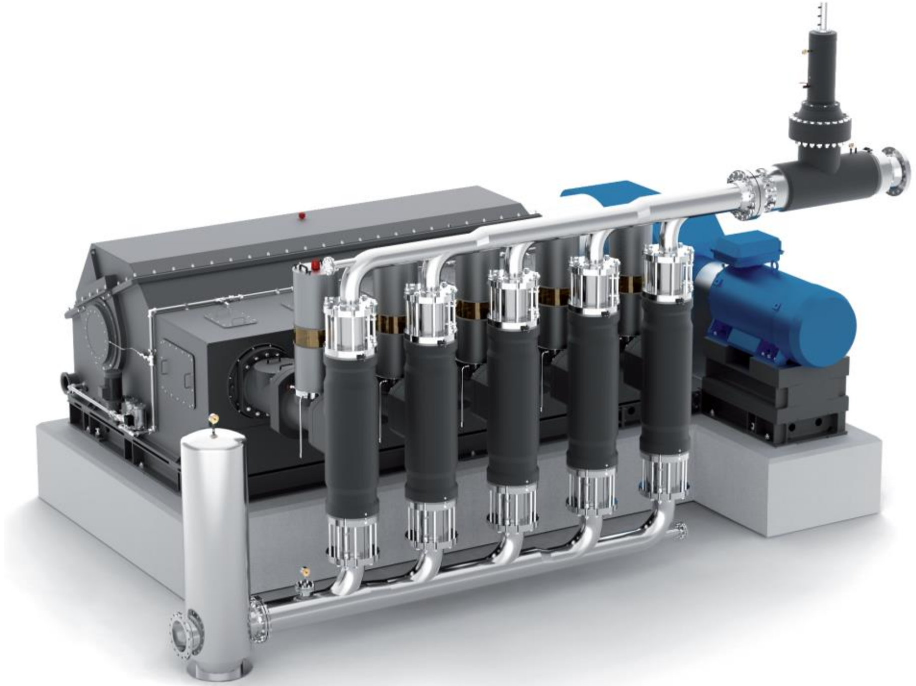
Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Triplex single acting (3 cylinders, 3 pump chambers)
    - Feluwa TGK



Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Quintuplex single acting (5 cylinders, 5 pump chambers)
    - Feluwa QGK



Piston Diaphragm Pumps for pipeline slurry transfer

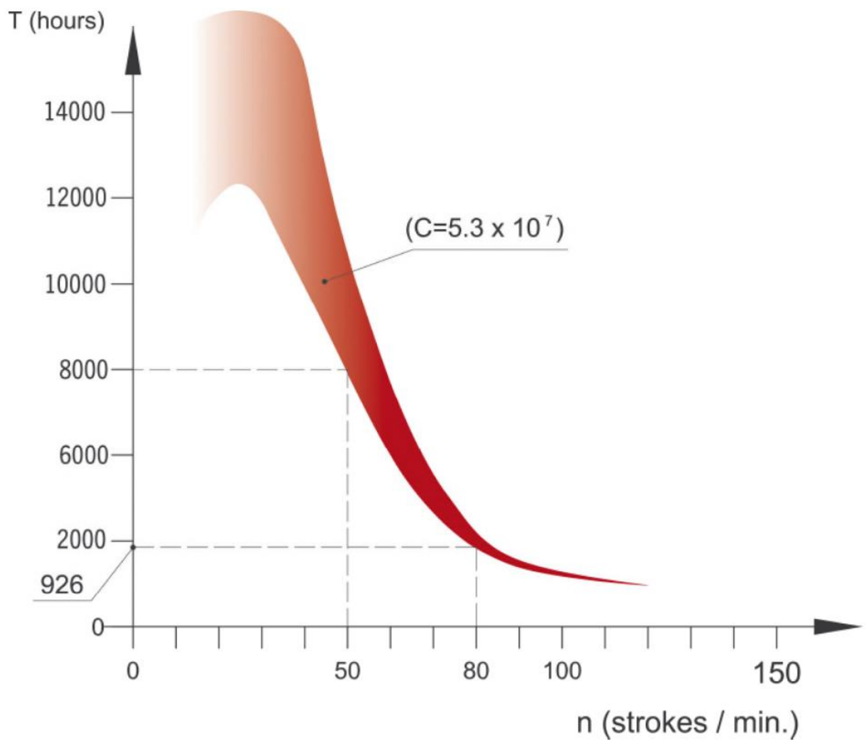
- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Pressure/volumetric efficiency
      - Pressure determines the volumetric efficiency
      - The higher the discharge pressure, the lower the volumetric efficiency
      - Criteria
        - Air content (compressibility) in propelling liquid
        - Air content (compressibility) in slurry
        - “Elasticity” of pressure bearing pump components
      - Depending on pressure, volumetric efficiency can be as low as 90%!

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Stroke rate (per minute)
      - For large pumps, stroke rate should be limited to 50 per minute
      - Stroke rate determines
        - Lifetime of valve components
        - NPSHr
        - Smooth and quiet operation
        - Less noise
        - Longer lifetime of pump

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Relationship between stroke rate and valve life



Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Relationship between stroke rate and valve life
      - Relation is not linear but exponential
      - In case stroke rate increases by 10%, valve life is not decreased by 10% but could be 20 or 25% shorter (example)

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Available installed power (in kW)
      - Required power is a function of capacity and pressure
      - Relationship between capacity and pressure is linear
      - If capacity increases by 50% – required power will increase by 50% (at the same pressure)
      - Sufficient power has to be installed to handle capacity and pressure

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pump capacity depends on:
    - Formula for capacity
    - (Piston volume x number of cylinders x stroke rate x volumetric efficiency x 60)/1000 = capacity in m^3/hr
    - Example : (45,3 x 3 x 50 x 90% x 60)/1000 = 367 m^3/hr

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Main criteria for pump size selection:
    - Pressure in bar, kPa or PSI

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pressure depends on:
    - Rod load of power end
    - Design of pressure bearing components
    - Available installed power

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pressure depends on:
    - Rod load of power end
      - Road load/force is the mechanical capability of the pump to create a force (in kN)
        - The pump power-end is designed with a specific rod load
        - The road load of large slurry transfer pumps is typically 1.000 kN of more
        - The available rod load has to exceed the required rod load, created by the back pressure of the pipeline, pressure vessel, etc.

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pressure depends on:
    - Required road load of power end
      - Determined by
        - Surface area of piston
        - Discharge pressure

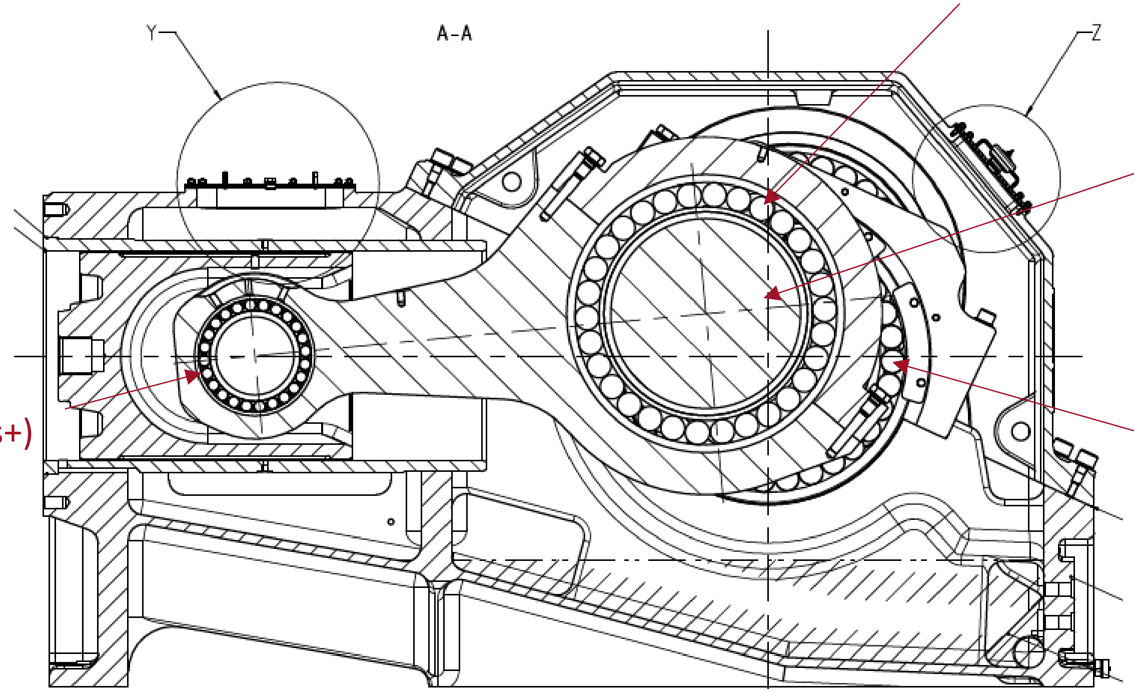
        - Formula: ((0,25 x π x D²) x discharge pressure)
        - Example :
          - Piston diameter : 3,4 dm
          - Required pressure : 150 bar
          - Required rod load : 1.361 kN

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pressure depends on:
    - Required rod road load of power end

Main bearings
Lifetime 100.000 hrs+

Crankshaft (forged steel)



Cross head bearings
(lifetime 100.000 hrs+)

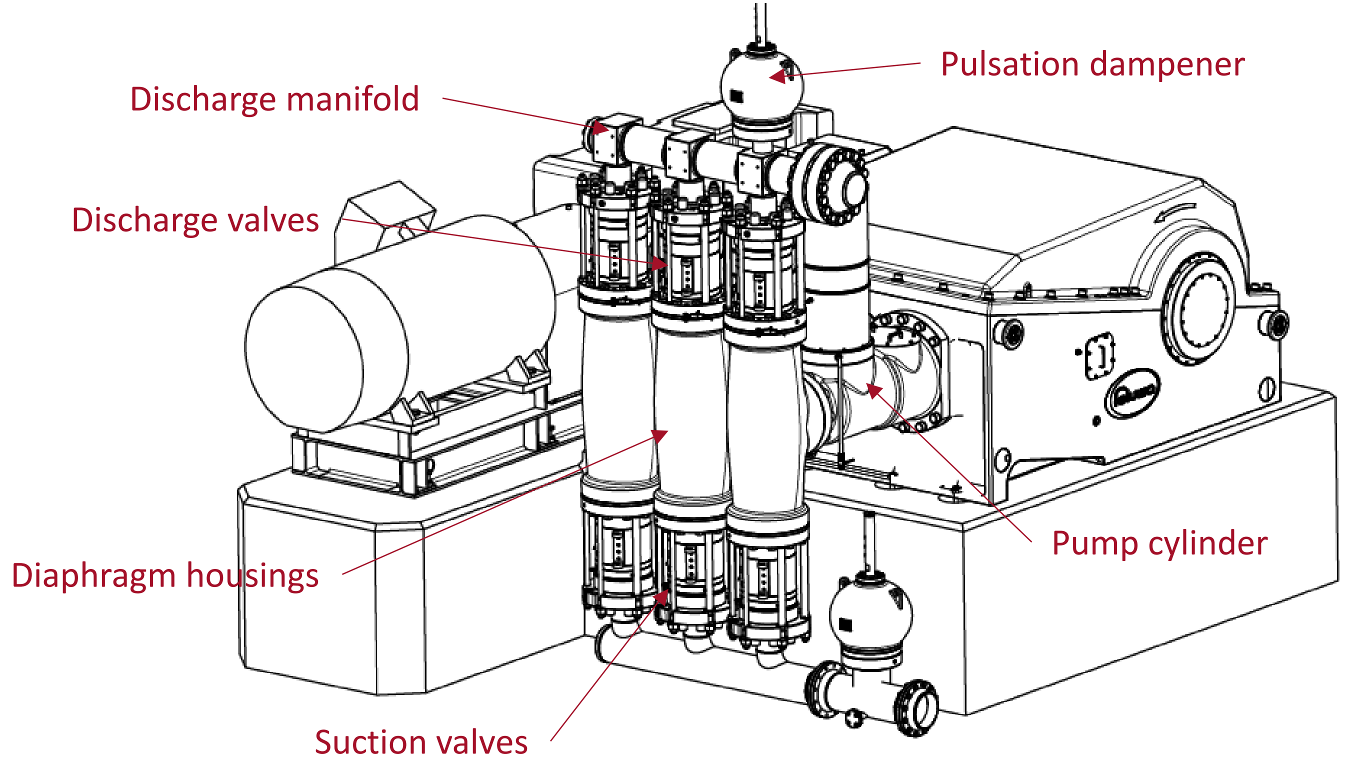
Connecting rod bearings
(lifetime 100.000 hrs+)

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pressure depends on:
    - Design of pressure bearing components
      - Pressure bearing components in a piston diaphragm pump are
        - Pump cylinder (in which piston moves back and forward)
        - Suction valves
        - Diaphragm housings
        - Discharge valves
        - Discharge manifold
        - Discharge pulsation dampeners

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Pressure depends on:
    - Pressure bearing components in a piston diaphragm pump are



Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Installed power:
    - Available installed power (in kW)
      - Required power is a function of capacity and pressure
      - Relationship between capacity and pressure is linear
      - If pressure increases by 50% – required power will increase by 50% (at the same capacity)
      - Sufficient power has to be installed to handle capacity and pressure

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Installed power:
    - Installed power has to exceed required power, depending on:
      - Capacity
      - Pressure
      - Mechanical efficiency
        - Pump (typical 95%)
        - External gearbox (typical 98%)
        - Motor (typical 98 to 95%
      - Altitude (above 1.000 m derating applies)
      - Ambient temperature
      - Service factor (1,0 to 1,25)

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Example pump selection process:
    - Pipeline capacity : 1.400 m^3/hr
    - Discharge pressure : 150 bar
    - Number of operating pumps : 4
    - Capacity per pump : 350 m^3/hr

      1) Select most likely pump : TGK500 (triplex single acting)
      2) Review volumetric efficiency at 150 bar : 92%
      3) Select piston diameter : 340 mm
      4) Check rod load at maximum pressure : 1.361 kN (is below design rod load)
      5) Required capacity : 350 m^3/hr
      6) Calculate required stroke rate : 47/min (is below acceptable maximum)
      7) Confirmation of selected pump : TGK500

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - TGK500

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Example pump selection process:
    - Other selection criteria
      - SG of slurry : for NPSHr
      - Viscosity : for NPSHr
      - Altitude : for installed power
      - Type of valve : cone or ball
      - Valve size : slurry velocity through valve should not exceed 2 m/sec
      - Suction dampener size : peak to peak pulsations should not exceed 3%
      - Discharge dampener size : peak to peak pulsations should not exceed 3%

Piston Diaphragm Pumps for pipeline slurry transfer

- Piston diaphragm pump selection
  - Example pump selection process:
    - Other selection criteria
      - **Type of slurry (concentrate or tailings) is not a selection criteria!!!**

Differences between tailings and concentrate slurry

Piston Diaphragm Pumps for pipeline slurry transfer

- Differences between tailings and concentrate slurry pipelines
  - Concentrate slurry:
    - Destination is refinery (valuable product)
    - Constant solids concentration
    - Constant particle sizes
    - Long pipelines
    - High pressures
    - Lower capacity
  - Tailings slurry:
    - Destination is dumpsite (TSF) (valueless product)
    - Varying solids concentration
    - Varying particle sizes
    - Short pipelines
    - Low pressure
    - Higher capacity

Piston Diaphragm Pumps for pipeline slurry transfer

- Differences between tailings and concentrate slurry pipelines
  - Concentrate slurry:
    - Controlled properties
  - Tailings slurry:
    - Less controlled properties
  - **Tailing slurry is much more demanding and challenging on pumps than concentrate slurry**

Piston Diaphragm Pumps for pipeline slurry transfer

- ArcelorMittal/Nippon Steel

  - Customer : AMNS, Dabuna, India
  - Number of pumps : 2
  - Application : Iron ore tailings slurry transfer
  - Capacity : 636 m^3/hr
  - Pressure : 6.300 kPa
  - In operation : 2024

Piston Diaphragm Pumps for pipeline slurry transfer

- Nalco

  - Customer : Nalco, India
  - Number of pumps : 2
  - Application : Red mud transfer
  - Capacity : 250 m^3/hr
  - Pressure : 13.000 kPa
  - In operation : 2024

Piston Diaphragm Pumps for pipeline slurry transfer

- Summary
  - N.D. Rao (President Amalgam Steel):

    "For a pump it does not matter if it handles concentrate or tailings, slurry is slurry" ©

Conclusion

Piston Diaphragm Pumps for pipeline slurry transfer

- Conclusion:
  - A reference in tailings is as good as a reference in concentrate
  - A reference in concentrate is as good as a reference in tailings
  - **Tailing slurry is much more demanding and challenging on pumps than concentrate slurry**
  - **For a piston diaphragm pump it does not matter if it handles concentrate or tailings, slurry is slurry**

  - **Remember**

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Questions?

Thank you!

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