Session 11 –
“Vertical Pumps (VS1, VS2, VS3)”
Session 12 –
“Vertical Pumps (VS4, VS6, VS7)”

Aimed at Process and Mechanical Engineers, and Consultant Engineers who specify pumping equipment as well as Applications & Sales Engineers selecting and quoting them.
While engineers generally have a good understanding of horizontal pumps, their exposure to vertical pumps is more limited and as a result they are frequently misunderstood and under-utilised.
This course will look to put that right and explain the features and benefits of vertical pumps and how they can frequently be problem solvers.

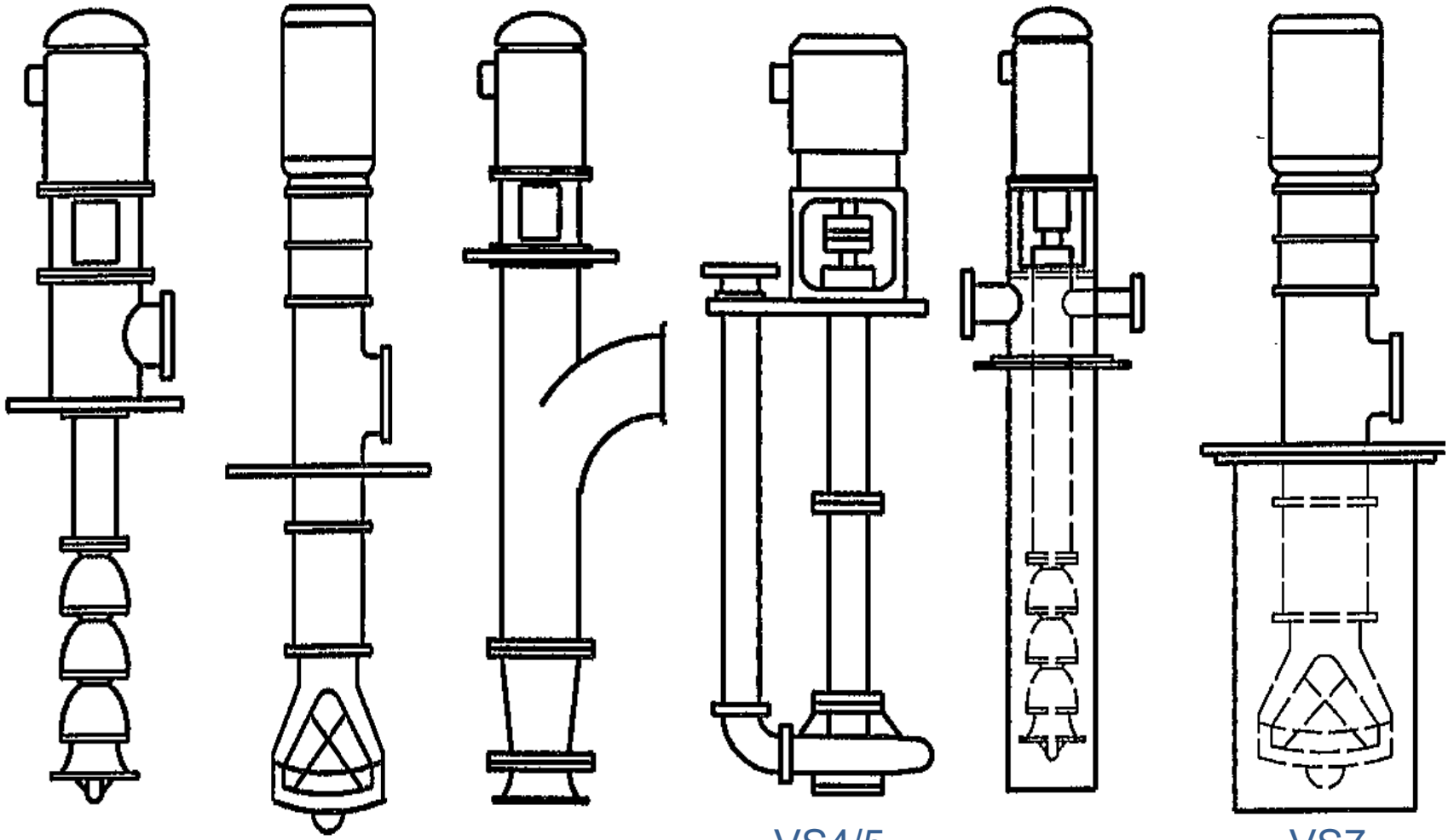
VERTICAL PUMPS INTRODUCTION

RUHRPUMPEN PRODUCT RANGE

- Ruhrpumpen has a complete selection of vertically suspended pumps, axial flow, mixed flow and radial products to meet a huge range of duties and services.
- VS1, VS2, VS3, VS4, VS6, VS7 designs available
- One of the widest range of hydraulics available in the Marketplace.
- Flows up to 320,000 USGPM / 73,000 m3/hr
- Head up to 3,500 ft / 1,067 m
- Can be provided according to API 610 or Hydraulic Institute construction

VERTICAL PUMP CONFIGURATIONS

API 610 CONFIGURATIONS



RUHRPUMPEN VERTICAL PRODUCTS

VS1

VS1

VS2

VS3

VS4/5

VS6

VS6

PUMP THEORY

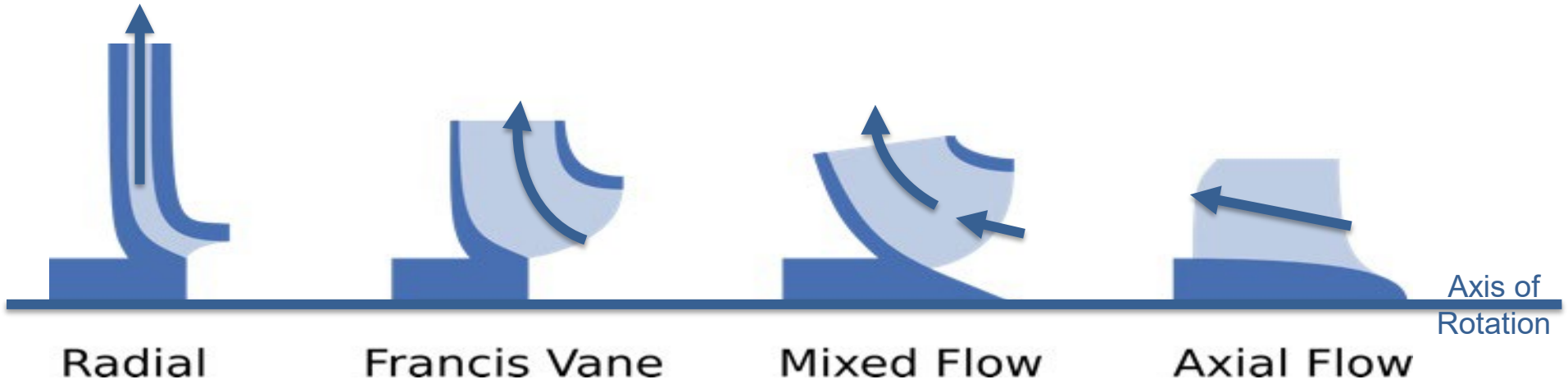
IMPELLER TYPES

- There are 4 major impeller types

- Below illustration shows each type of impeller and how it handles the fluid flow

Radial flow	flow exit through impeller is radial (perpendicular to shaft)
Francis vane	modified radial flow (smoother transition from entrance to exit)
Mixed flow	combination of radial and axial
Axial flow	flow exit through impeller is parallel to shaft

- The result of these different physical characteristics is different hydraulic ranges (radial flow – higher head, axial flow – high flow)



www.neutrium.net

SPECIFIC SPEED, Ns

- Ns is a single number that allows us to easily describe the impeller head/flow performance

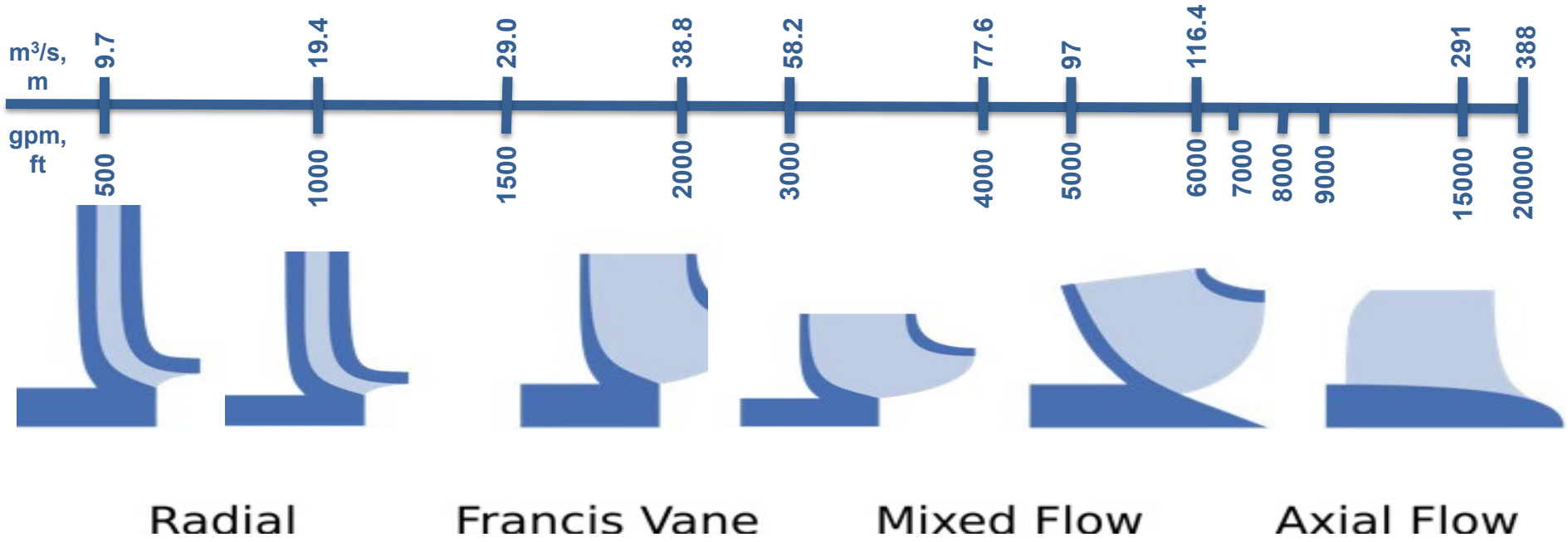
$$Ns = n \bullet \frac{\sqrt{Q}}{Head^{0.75}}$$

- Ns is specific speed
- n is pump rotational speed
- Q is flowrate (m^3/s or usgpm) at the point of best efficiency
- Head total head (m or ft) per stage at the point of best efficiency

- speed in revolutions per minute at which a geometrically similar impeller would operate if it were of such a size as to deliver one gallon per minute against one foot of hydraulic head.

- Since impellers of similar type have similar specific speeds – we can also predict impeller type from Ns

SPECIFIC SPEED, Ns



(Specific Speed in $m^3/s,m$, rpm X 51.6 = Specific Speed in usgpm, ft, rpm

CURVE SHAPE

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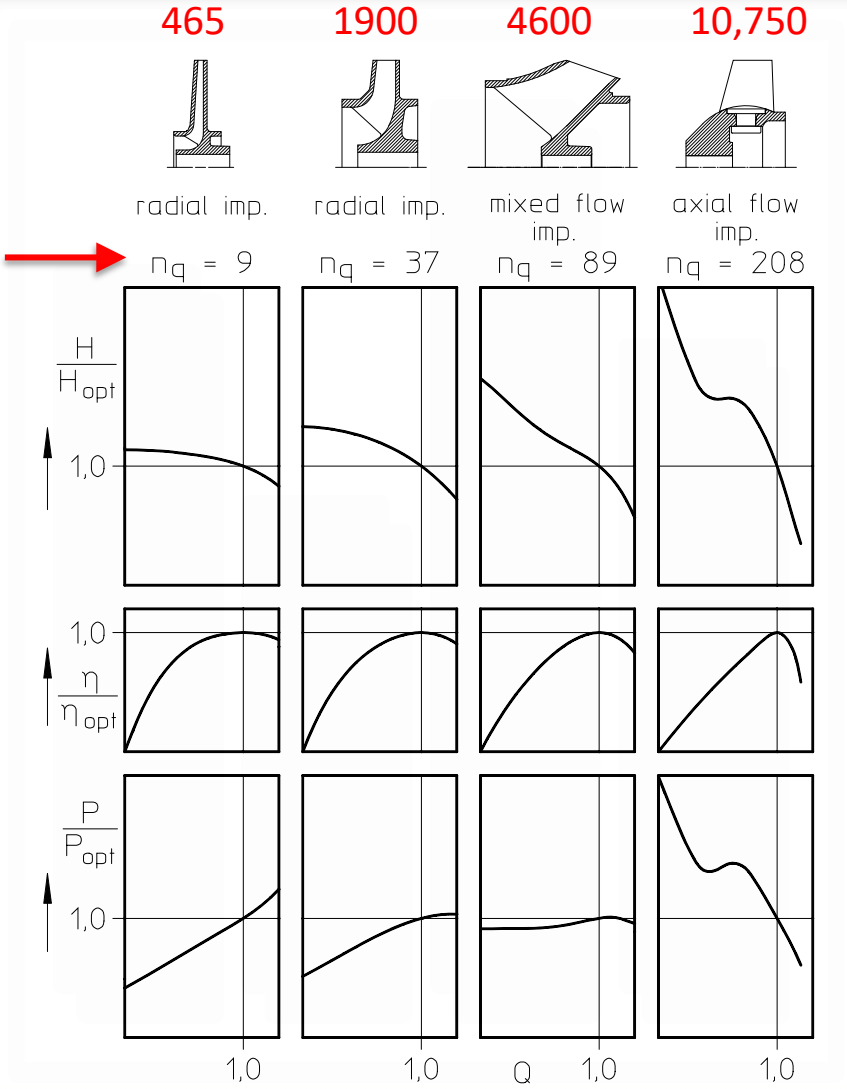
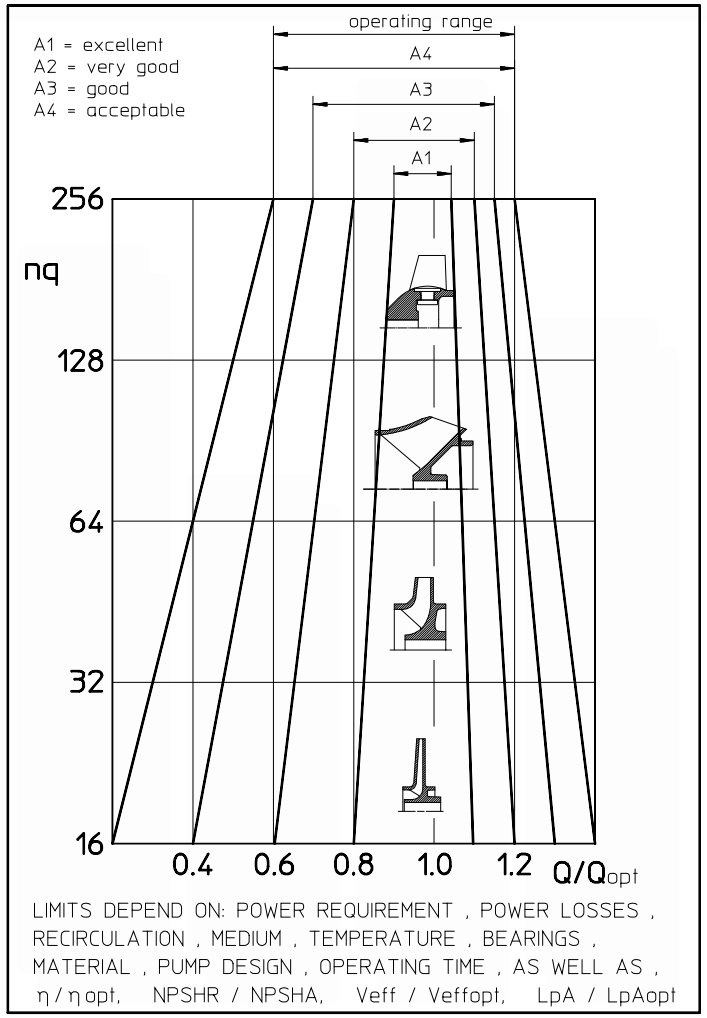
N_s metric units



N_s US Units

- Pumps with similar specific speeds have similar shapes of curve
- Axial flow impellers have steep curves (around 300% head rise)
- Radial flows impellers have very flat curves
- Rule of thumb for steepness (BEP to shut-off) of ALL centrifugal pumps (not just Ruhrpumpen pumps): 100 + ns (metric) = steepness (%)
- Example: ns = 45 => head rise about 145%
- This means that often the specification requirements for 120 % steepness is not possible to fullfil.
- (Specific speed in $m^3/s,m$, rpm) X 51.6 = usgpm, ft, rpm

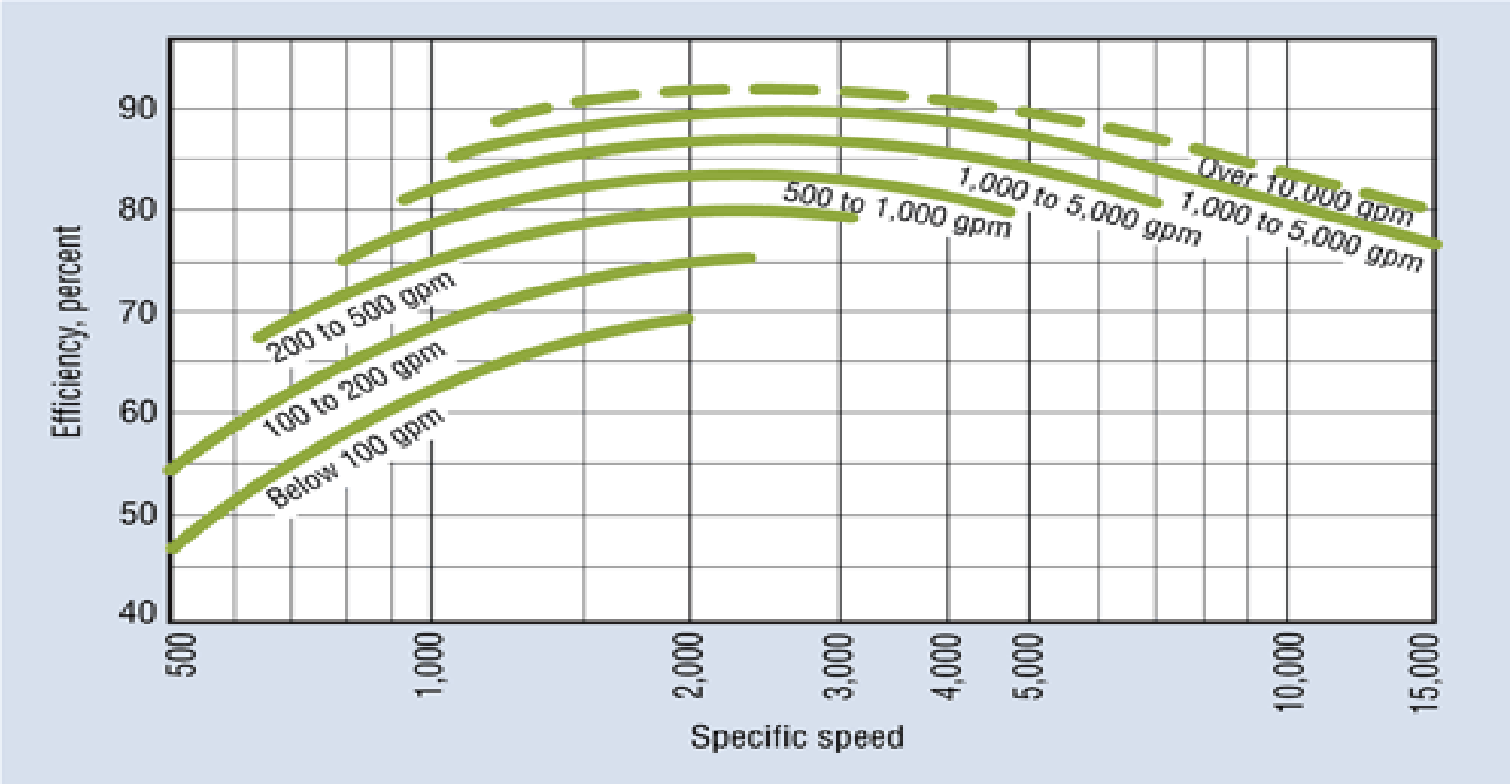
OPERATING REGION



- Radial impellers tend to have wider operating range than axial types

EFFICIENCY

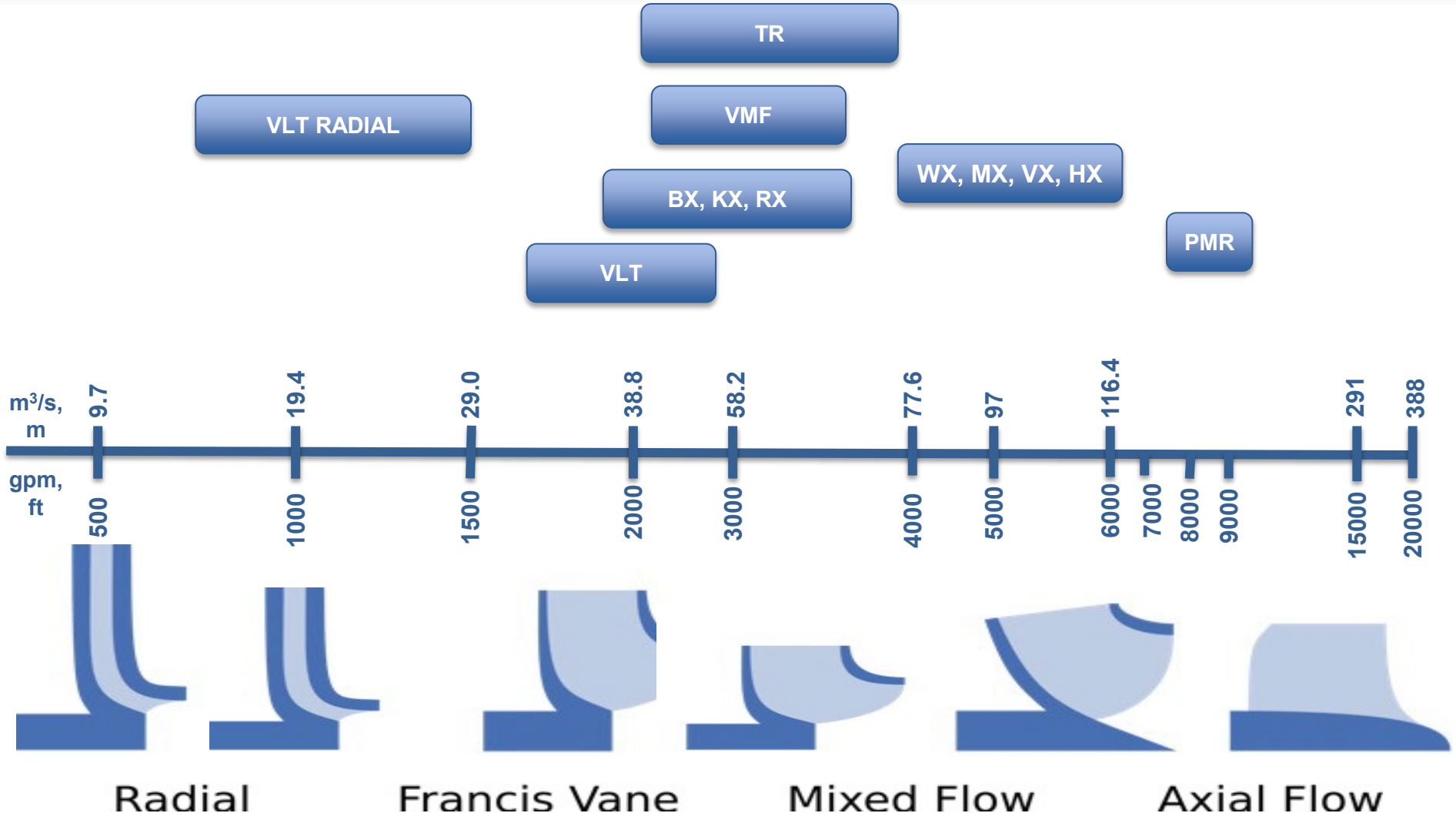
- Optimum specific speed for highest efficiency is between 2000-3000 US / 40-60 Metric



Hydraulic Institute specific-speed chart.

www.hpac.com

SPECIFIC SPEED, Ns



CLOSED vs OPEN vs SEMI OPEN

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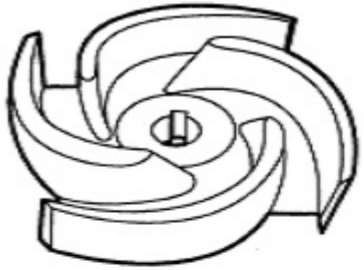
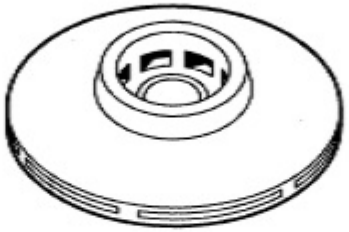
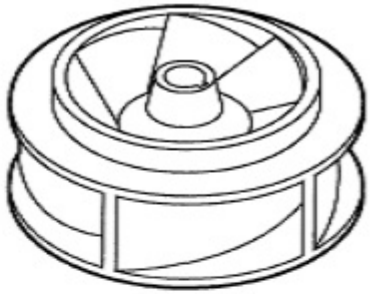


OPEN IMPELLER

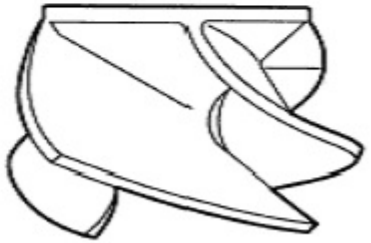
SEMI-OPEN IMPELLER



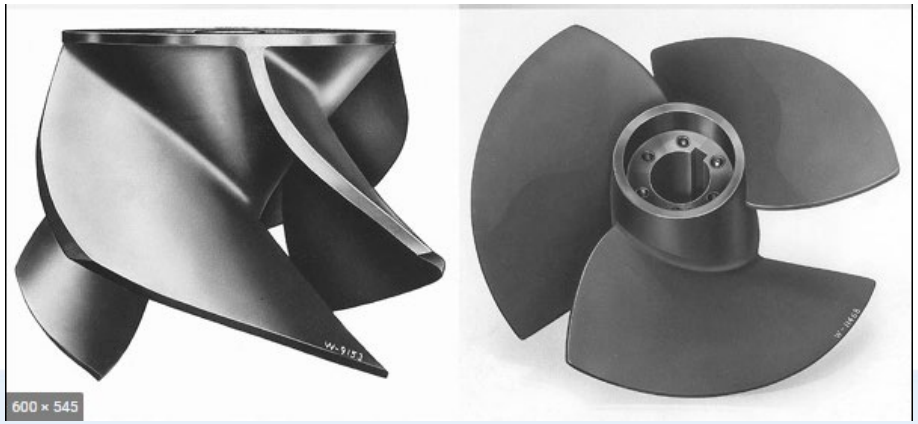
SINGLE-SUCTION
CLOSED IMPELLER



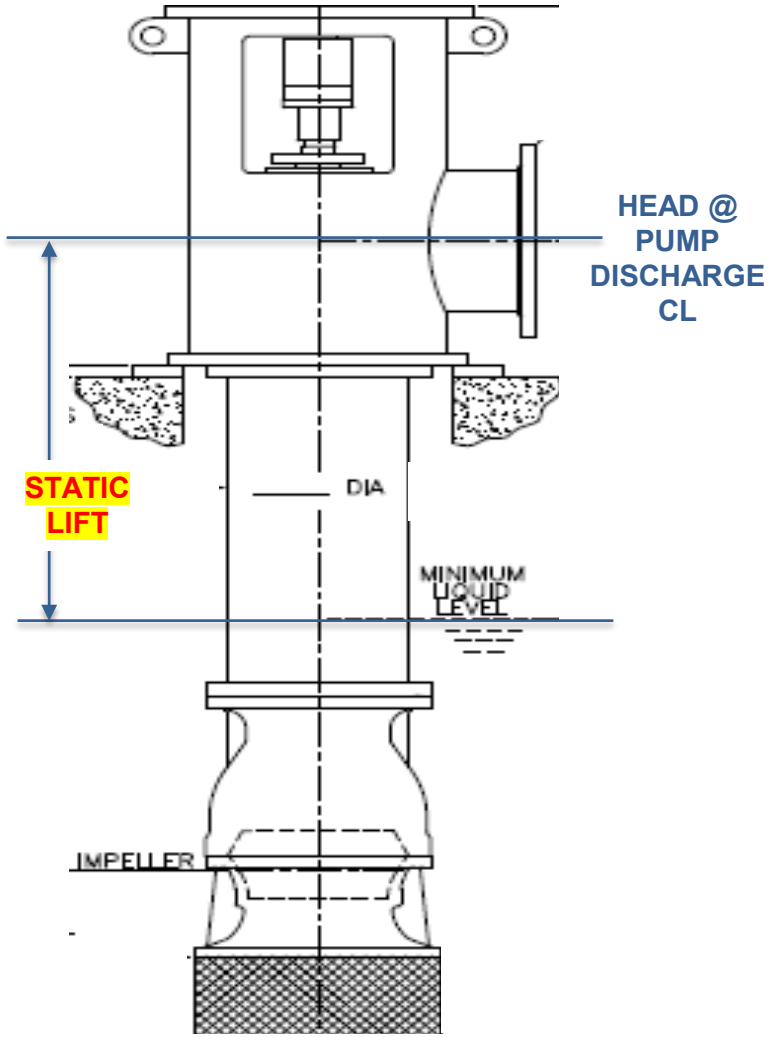
DOUBLE-SUCTION
IMPELLER



MIXED-FLOW
IMPELLER



STATIC LIFT (VS1,2,3,4,5 Types)



- For a pump in open pit/sump configuration (in a river, lake or sump) it is crucial to take into account the Static Lift from sump liquid level to the discharge flange
- Bowl assembly has to lift the fluid from the sump liquid level to discharge flange (static lift) AND produce customer required head at discharge flange
- Head can be specified by the customer at several different points:
  - Low liquid level (minimum)
  - Normal Liquid Level
  - Centerline of discharge nozzle
- In case the head is specified by customer at CL discharge nozzle, the static lift can be included by customer in the head stated in datasheet or it can be added by the vendor when selecting the pump. It needs to be clear on the data sheet which approach is being considered.

VS1

VCT/VLT
TR/VLT-TR
VMF

Vertical Turbine Pumps

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Characteristics
- API 610 latest edition construction (VS1 type)
- Multistage vertical centrifugal pumps with diffuser type bowl
- Semi-Open / enclosed impellers
- Counterclockwise rotation viewed from coupling end
- Basket or conical strainer, according to pump requirements
- Product or oil lubricated
- Oversized bowl shaft sizing for longer life
- Epoxy coated bowls
- Collet mounted impellers
- Integral cast wear surfaces with optional wear rings in bronze or SS

Materials

Bowls
- Cast iron bowls
- Bronze impellers
- 416 SS shafting
- Optional materials on request

Columns
- Carbon steel pipe – threaded or flanged
- AISI–1045 carbon steel or 416 SS line shafting
- Optional materials on request

Discharge Head
- Cast Iron with 125# ANSI FF flanges
- Fabricated steel with 150# or 300#

Bearing Material
- Bronze as standard
- Other materials and configurations

Options
- ANSI flanges
- Custom fabricated discharge head to meet your criteria

Applications
- Deep Well
- Irrigation
- Sump
- Condensate
- Can pump requirements
- Fire service
- Municipal

VTP / HQ

Capacity	13,636 m^3/h	60,000 U.S. gpm
Head	762 m	2,500 ft
Temperature	121°C	250°F
Pressure	74 bar	1,080 psi

Vertical Circulator and Mixed Flow Pumps

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Characteristics

- API 610 latest edition construction (VS3 type)
- Vertical space saving construction
- Integral bearing retainer
- Wide range of impeller designs and specific speeds (1,800-14,000) for optimum hydraulic coverage
- Engineered to customer specifications
- Oil, fresh water or self-lube column construction
- Open, semi-open and closed impellers
- Threaded or flanged column (depending on its size), with water or oil lubrication
- Packed stuffing box or mechanical seal
- Above or below ground discharge
- Sizes 20 cm (8 in) to 305 cm (120 in)

Options

- Pull-out design for ease in maintenance (except VMF and TR)
- Pump mounted thrust bearings
- Rotor 'Pull-Out' design

Applications

- Power generation
- Condenser cooling water service
- Cooling tower service
- Flood service
- Storm water disposal
- Water treatment
- Primary water supply
- Waste treatment plants
- Industrial service
- Sump drainage

TR / HX / KX / MX / RX
SX / VX / WX / VMF

Capacity	50,000 m^3/h	220,000 U.S. gpm
Head	175 m	575 ft
Temperature	-30 to 135°C	-20 to 275°F
Pressure	10 bar	156 psi

Vertical Axial Flow Pumps

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Characteristics
- API 610 latest edition construction (VS3 type)
- Multi-stage vertical centrifugal pump, diffuser type bowl
- Axial flow impeller, high efficiency
- Handles solids up to 23 cm diameter (9 in)
- Counterclockwise rotation viewed from shaft coupling
- Discharge elbows designed to reduce friction losses, diffusers designed to minimize turbulence and increase efficiency
- Product, oil, or fresh water lubrication
- Above or below base discharge

Materials
- Bowls: Cast iron with bronze impeller
- Column: Carbon steel with AISI-1045 shaft
- Discharge head: Fabricated steel
- Other materials of construction

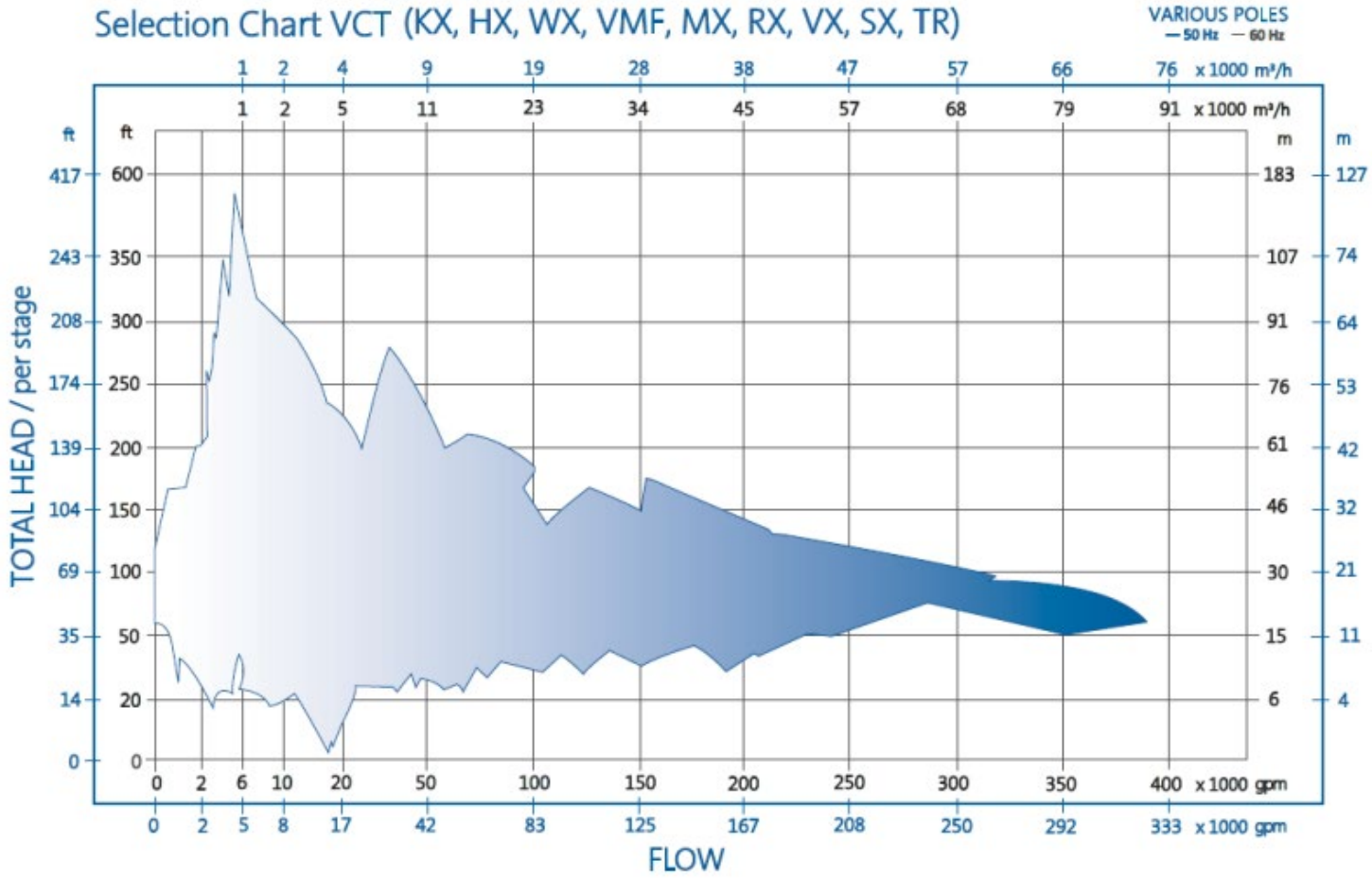
Options
- Rotor 'Pull-Out' design
- Basket type strainer
- Extended Suction bell to minimize vortices

Applications
- Drainage
- Wastewater
- Flood control
- Irrigation
- Waste treatment plants
- Underpass drainage
- Condenser cooling
- Construction dewatering
- Ditch pumps
- Raw water intakes

VAF / POV / PV
PMR / VPO / PVD

Capacity	72,680 m^3/h	320,000 U.S. gpm
Head	27 m	90 ft
Temperature	95°C	230°F
Pressure	5 bar	75 psi

RANGE


Selection Chart VCT (KX, HX, WX, VMF, MX, RX, VX, SX, TR)
VARIOUS POLES
— 50 Hz — 60 Hz
1 2 4 9 19 28 38 47 57 66 76 x 1000 m³/h
1 2 5 11 23 34 45 57 68 79 91 x 1000 m³/h
ft
ft
m
m
417 600 183 127
243 350 107 74
208 300 91 64
174 250 76 53
139 200 61 42
104 150 46 32
69 100 30 21
35 50 15 11
14 20 6 4
0 0
TOTAL HEAD / per stage
0 2 6 10 20 50 100 150 200 250 300 350 400 x 1000 gpm
0 2 5 8 17 42 83 125 167 208 250 292 333 x 1000 gpm
FLOW

VERTICAL PUMPS

Vertical pumps consist of a bowl assembly (3), single stage or multistage, suspended on a discharge head (1) from baseplate at the mounting floor. The column (2) length is dictated by the application and installation site

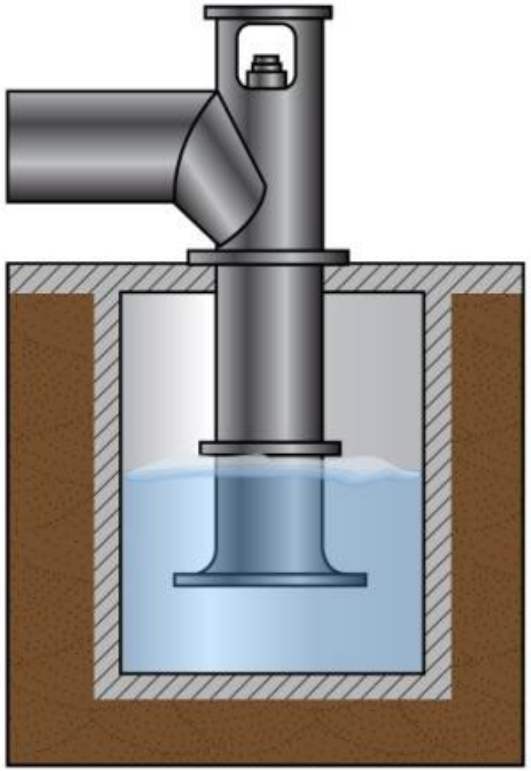
1.Discharge head

2. Column

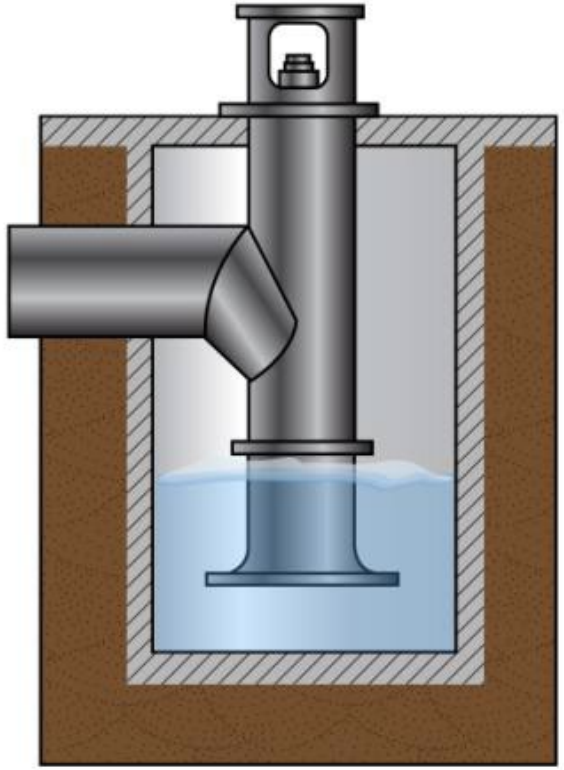
3.Bowl Assembly

FEATURES AND BENEFITS
DISCHARGE HEAD OPTIONS

Above Ground Discharge



Below Ground Discharge



VS1
(L HEAD AND BELOW GRADE DISCHARGE)

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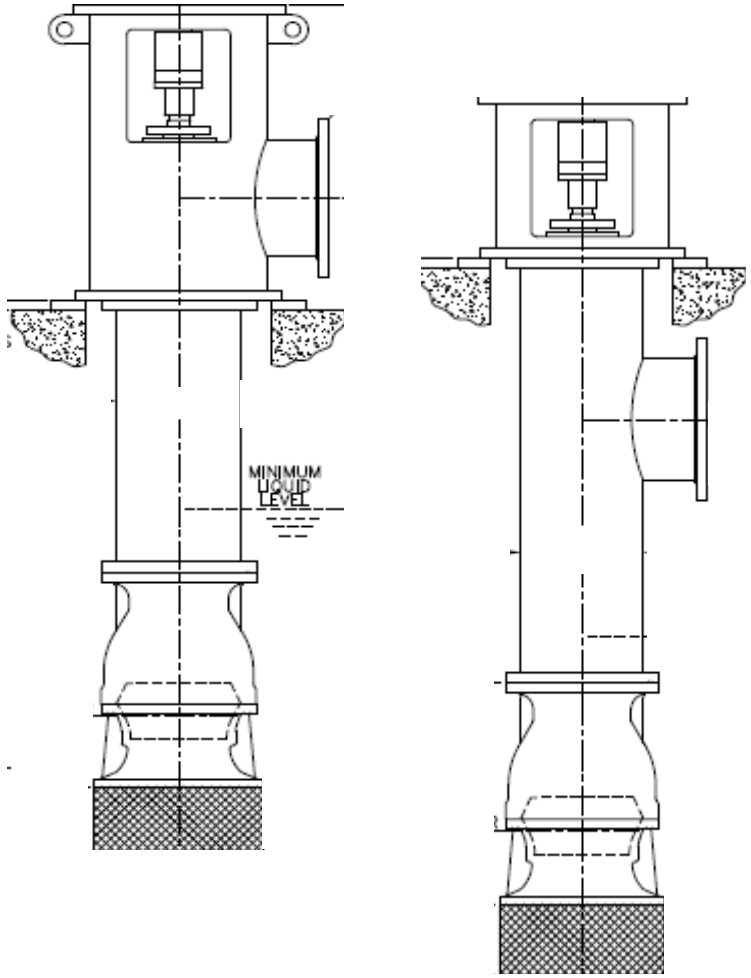

- Use in sump (open system) or tank (closed system) type applications
- Pressure boundary is Head, Bowls and Column
- Configuration chosen to meet customer pipework requirements

FEATURES AND BENEFITS
DISCHARGE HEAD

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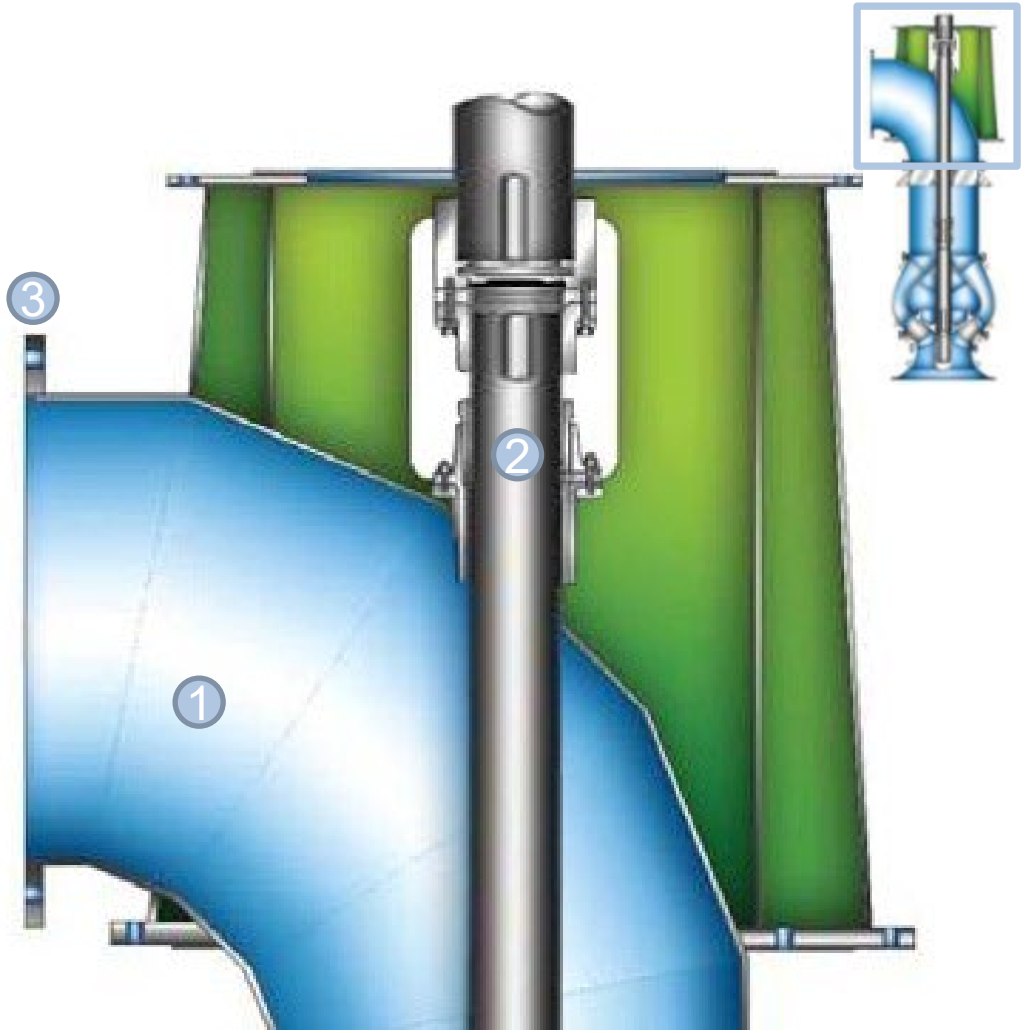
1. **Most commonly T or L fabricated head. Mitered head may be used in some applications. Some options for cast heads**

2. **Large stuffing box -** TR pump is standard with packing but can be equipped with mechanical seals (split seal is preferred). VCT and VMT pumps can be supplied with mechanical seal or packing

3. **Heavy duty flanges** – Positive and registered fit alignment



FEATURES AND BENEFITS
COUPLING

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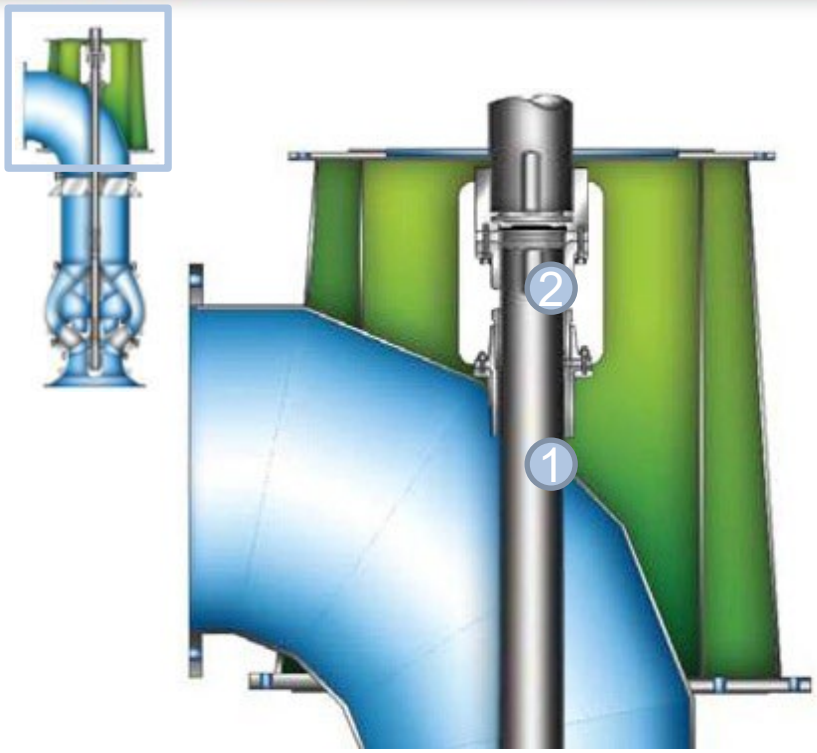


VMT

All metal **three piece adjustable coupling** – Ensures positive, foolproof shaft alignment.

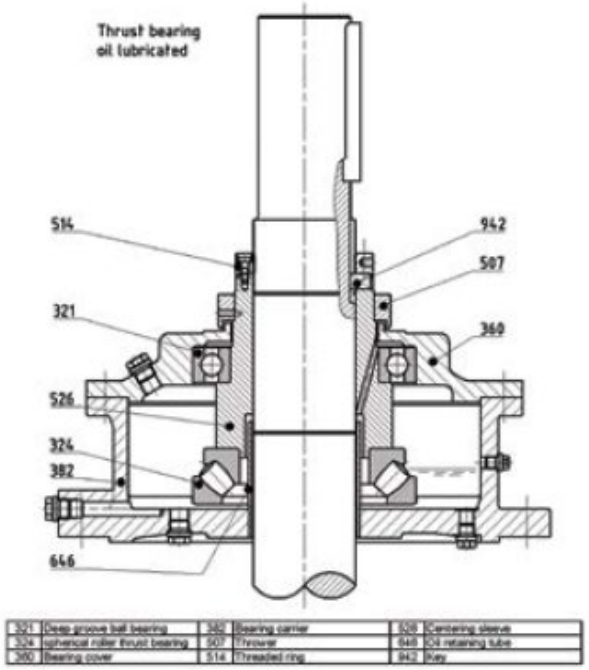
All metal **Ruhrpumpen four piece coupling** when mechanical seal is used. Coupling has removable spacer that allows a mechanical seal to be replaced without removing the motor. The spacer is not needed when packing is used.

In case of using an external thrust pot 4 piece spacer coupling (Ruhrpumpen manufacture) used between pump and thrust pot. Flexible non spacer coupling between thrust bearing and motor

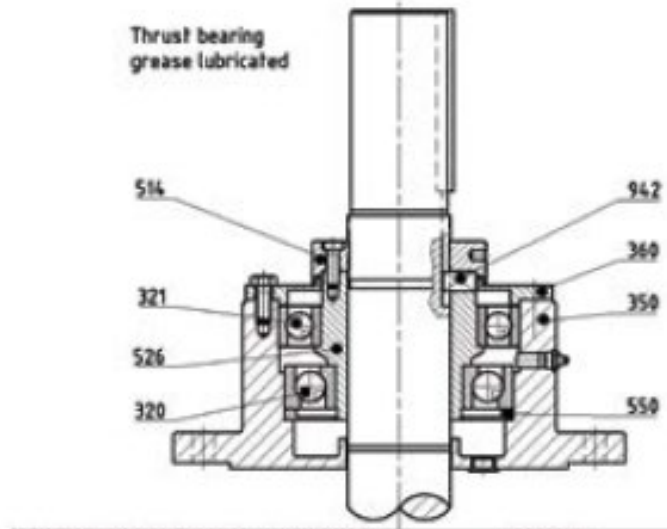
TR Flexible coupling with rubber or steel elements manufactured to high accuracy are standard. The coupling guard is in the scope of supply and conforms to appropriate safety standards. The TR can also be equipped with spacer couplings on request. For information on spacer length consult engineering

THRUST HANDLING

- Thrust bearing in the pump



321	Deep groove ball bearing	382	Bearing carrier	526	Centering sleeve
324	spherical roller thrust bearing	507	Thrower	646	Oil retaining tube
360	Bearing cover	514	Threaded ring	942	Key



320	Angular contact ball bearing	360	Bearing cover	550	Disc
321	Deep groove ball bearing	514	Threaded ring	942	Key
350	Bearing housing	526	Centering sleeve		

5-PIECE ELBOW NOZZLE HEAD WITH DUAL-MATERIALS

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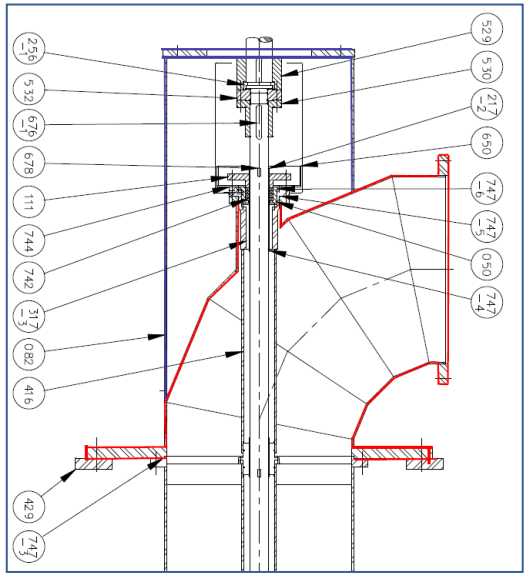
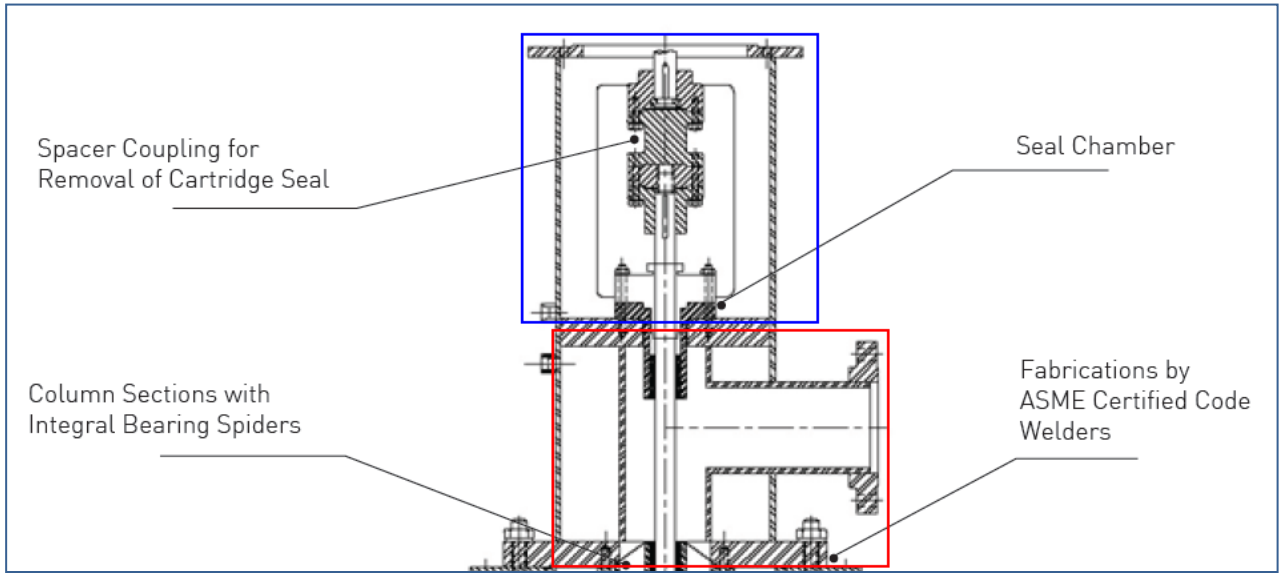
- Where the application requires high alloy wetted parts Ruhrpumpen is able to save cost and offer reduced price to customer by offering the nozzle head with alloy wetted areas and non-wetted/structural parts in carbon steel

- This is a standard construction nozzle head for us – the design is not changed. The only thing we do differently is that we use different weld procedures as needed for each seam.

- Alloy wetted areas (shown in red) and non-wetted/structural parts in carbon steel (shown in blue) in below examples





FEATURES AND BENEFITS COLUMN

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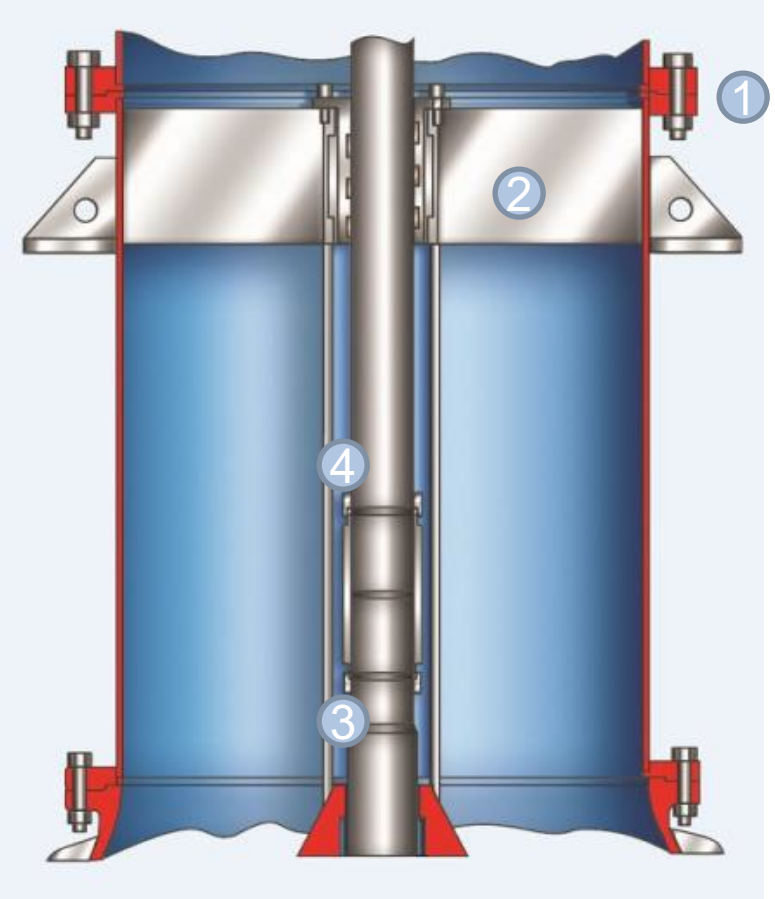


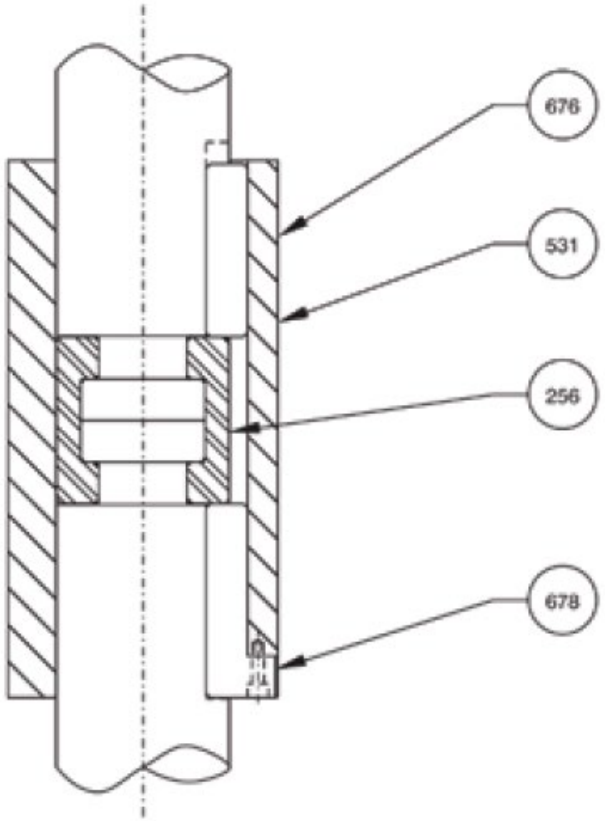
1. **Heavy duty flanges** – Positive and registered fit alignment

2. **Bearings –** product lubricated (open line shaft) or externally lubricated (closed line shaft)

3. **Sleeve type coupling** is standard on VMT. Ensures proper alignment and fast assembly/disassembly. Sleeve coupling is keyed. Threaded coupling is possible but unusual on this product.

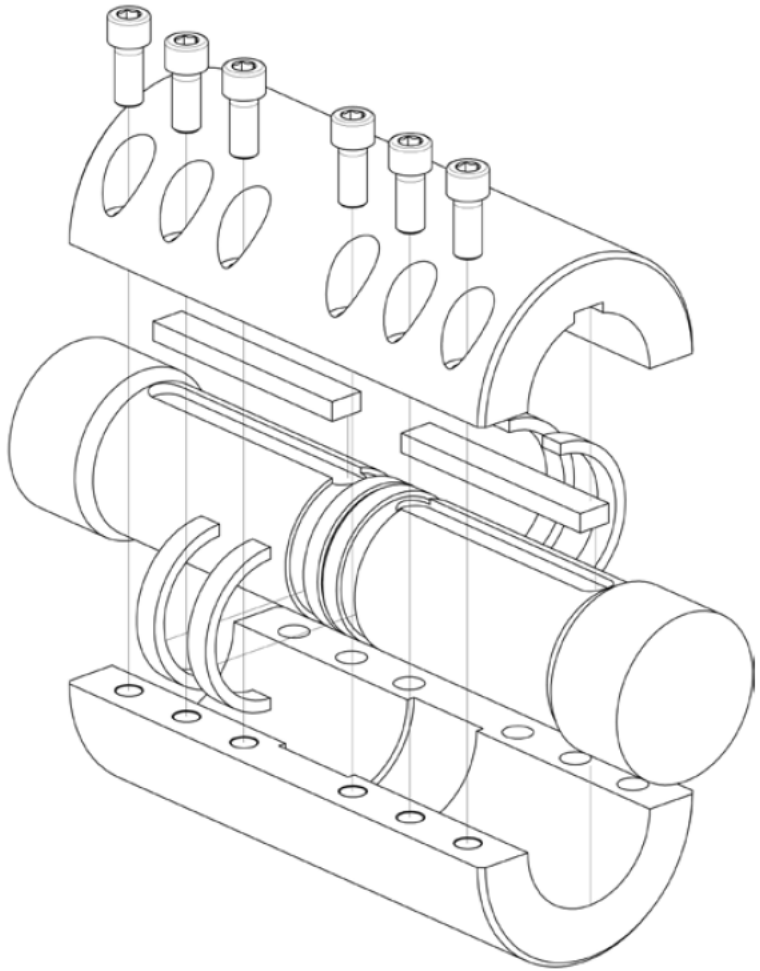
   Split muff type coupling on TR

4. **Integral Spider** (welded spider) as standard. (Not drop-in type)



Sleeve (keyed) coupling

Split Muff Coupling



LINE SHAFT BEARING LUBRICATION

- Enclosed Line shaft

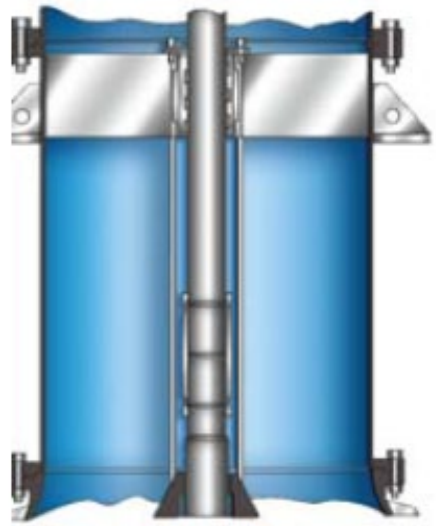
- Inner column isolates bearings from process fluid. Normally used for applications where customer requests it (for example fluid with high levels of abrasives) or for applications with more than 50ft length of line shaft above LLL (to prevent top bearings running dry during startup)

- Pressurized and non pressurized configurations are available

  - In pressurized version the enclosing tube is filled with fluid (normally water) supplied at a connection on the nozzle head and lubricates line shaft bearings and top bowl bearings

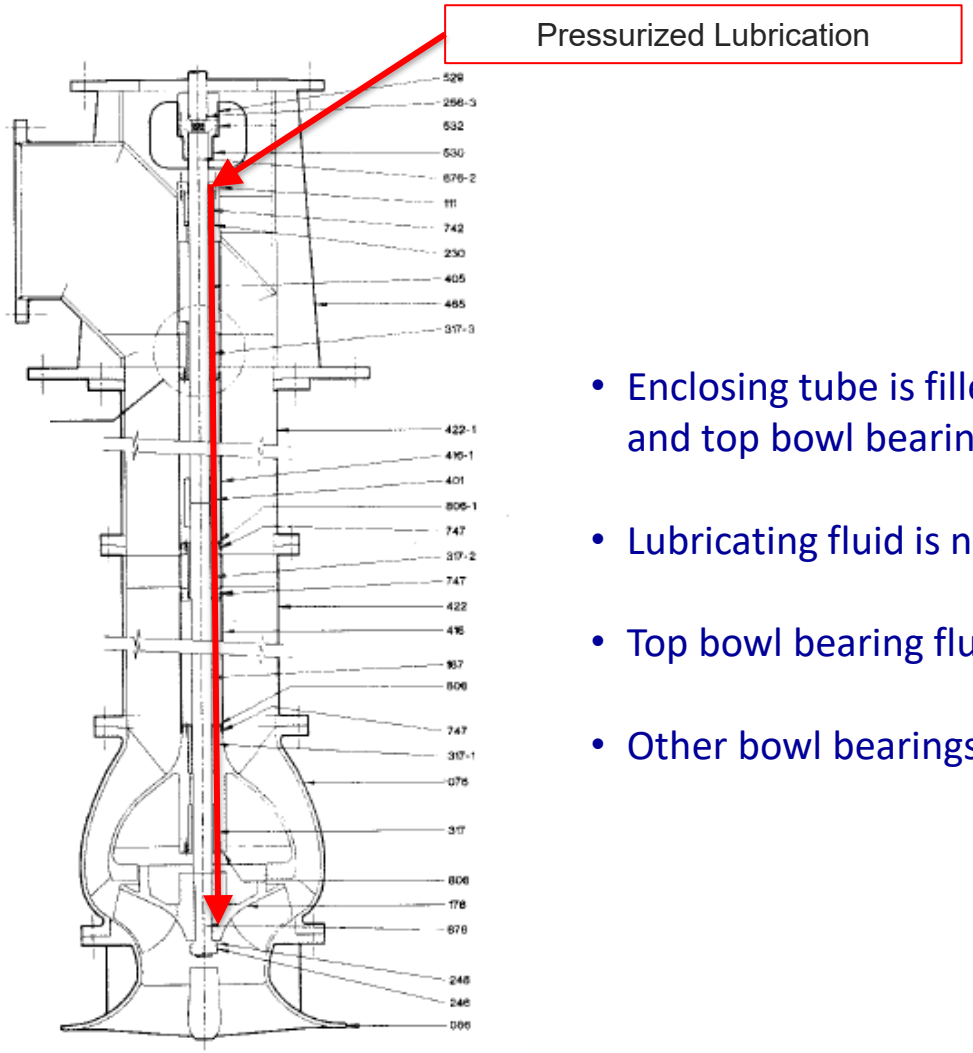
  - In non-pressurized configuration it is usual that a small flow rate of oil (approximately 0.1 sup flow) is supplied from external source and injected at the nozzle head normally below packing/seal. Can be supplied by customer from an external source or a small tank can be supplied by RP and mounted on nozzle head (see illustration on following slides)

- This is a more expensive solution than product lubricated bearings and Ruhrpumpen. In case of product containing some particles RP experienced engineers will determine whether upgraded bearing materials or enclosed line shaft would the optimum solution



ENCLOSED LINESHAFT

ENCLOSED LINE SHAFT PRESSURISED LUBRICATION



- Enclosing tube is filled with fluid and lubricates line shaft bearings and top bowl bearings
- Lubricating fluid is normally water
- Top bowl bearing flush water lubricated
- Other bowl bearings are product lubricated

CLOSED LINE SHAFT
NON PRESSURISED LUBRICATION

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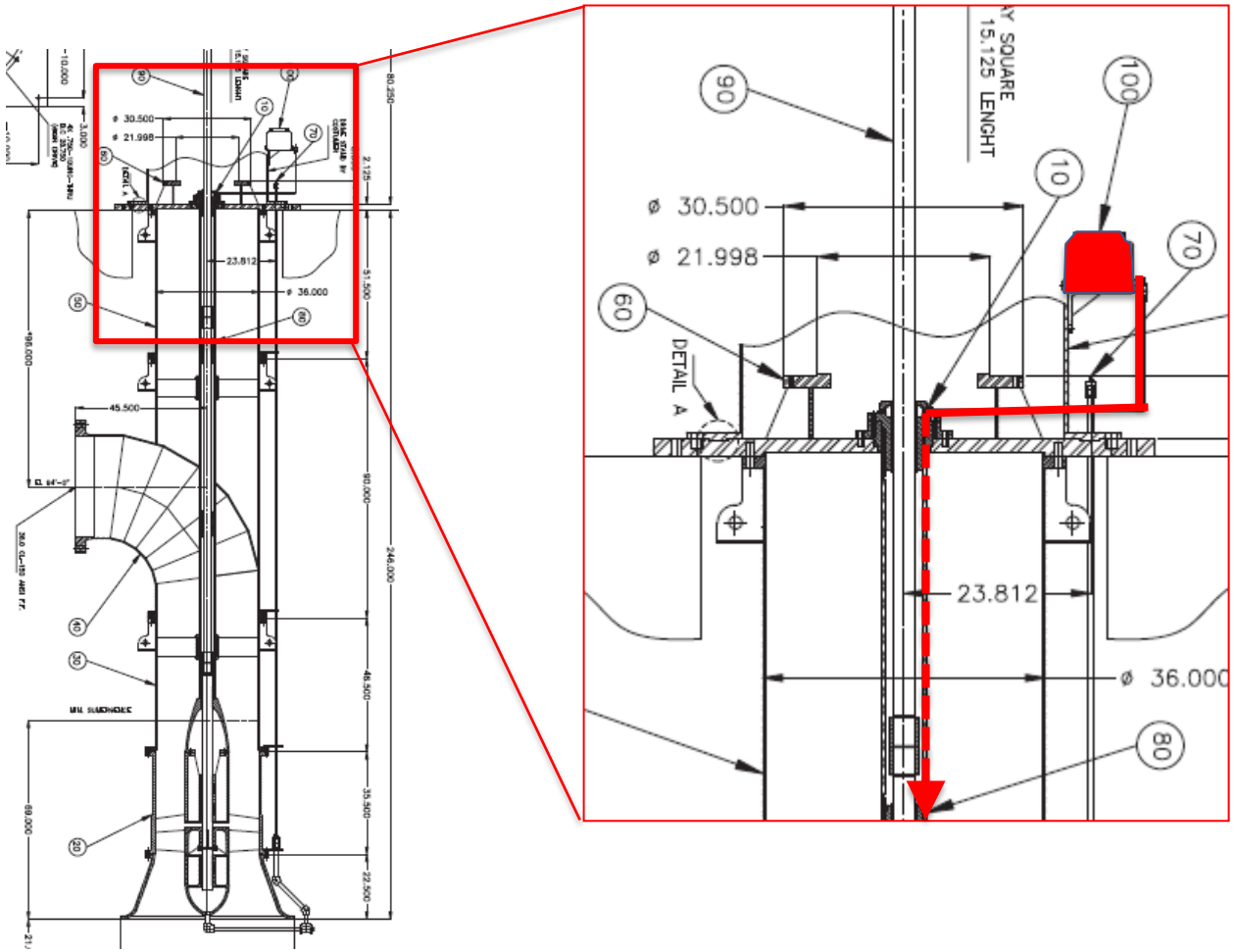
- Illustration of optional oil supply tank



- 100 = Oil Supply Tank
- Mounted by a steel stand on pump mounting plate
- 10 = ¼” lubrication port

FEATURES AND BENEFITS
BOWL ASSEMBLY

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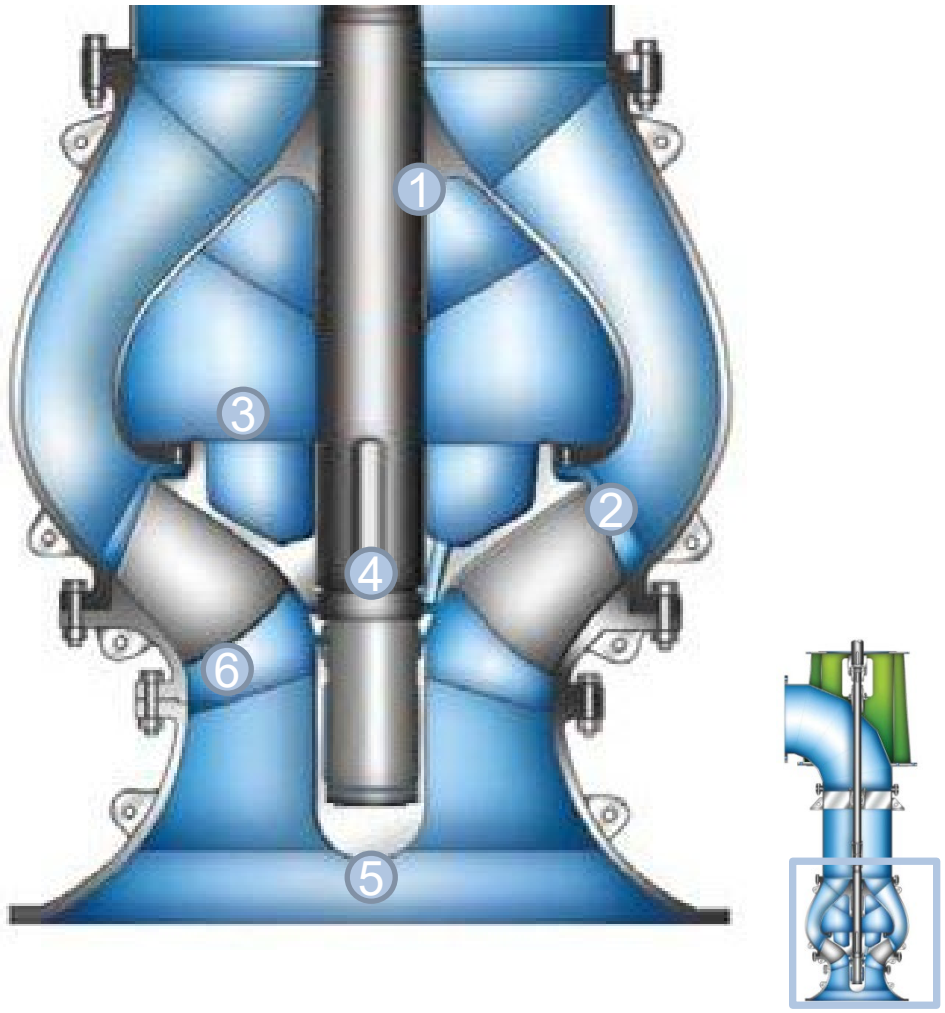
1. **Flanged bearings -** One or more bearings are located on the top case hub to provide maximum support and alignment to the impeller.

2. **Impeller** – Semi open, open or closed according conditions of service, 3 plane dynamically balanced

3. **Secured impeller**

4. **Suction Bell -** Less downtime, Bottom bearing keeps shaft aligned. Self lubed or greased for long service life



CLOSED VERSUS SEMI-OPEN IMPELLER

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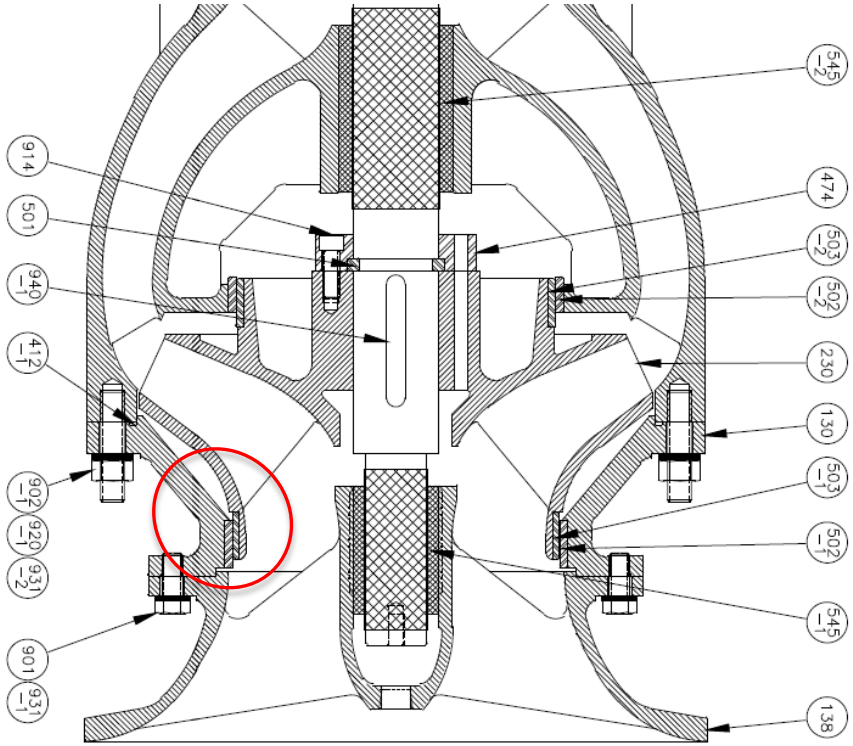
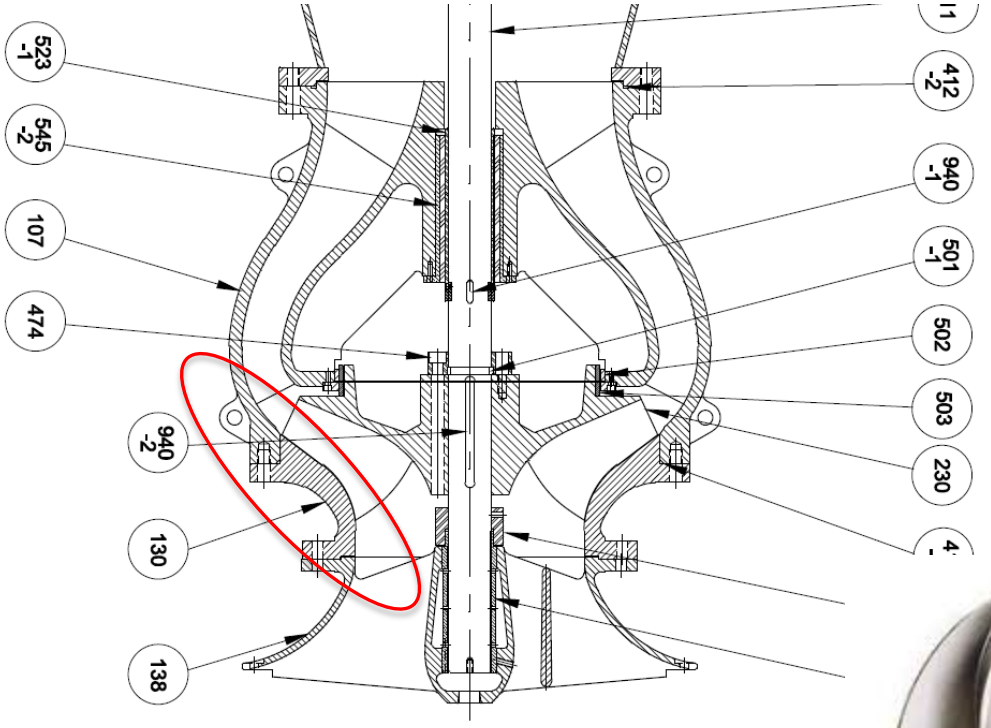
CLOSED IMPELLER



Closed impeller has a lower shroud which has a close-clearance with the bowl

SEMI-OPEN IMPELLER



Semi-impeller has no lower shroud an therefore no close-clearance areas

VS2

DOUBLE SUCTION
DX, DSV

Double Suction Vertical Turbine Pumps

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Specialist for Pumping Technology

Characteristics
- API 610 latest edition construction (VS2 type)
- Above or below base discharge nozzle
- Single stage vertical, centrifugal, double volute
- Double suction enclosed impeller
- Counterclockwise rotation viewed from shaft
- Oil lubricated column, or may be force-lubricated by the pumped liquid

Materials
- Liquid End: cast iron with bronze impellers
- Column: carbon steel pipe and shaft
- Discharge Head: carbon steel with 150 and 300 ANSI flanges
- Other materials on request

Options
- Low NPSH first-stage design
- Enclosed line shaft with external lubrication

Applications
- Cooling towers and other applications requiring large volumes of liquid with relatively high head
- Raw water intake

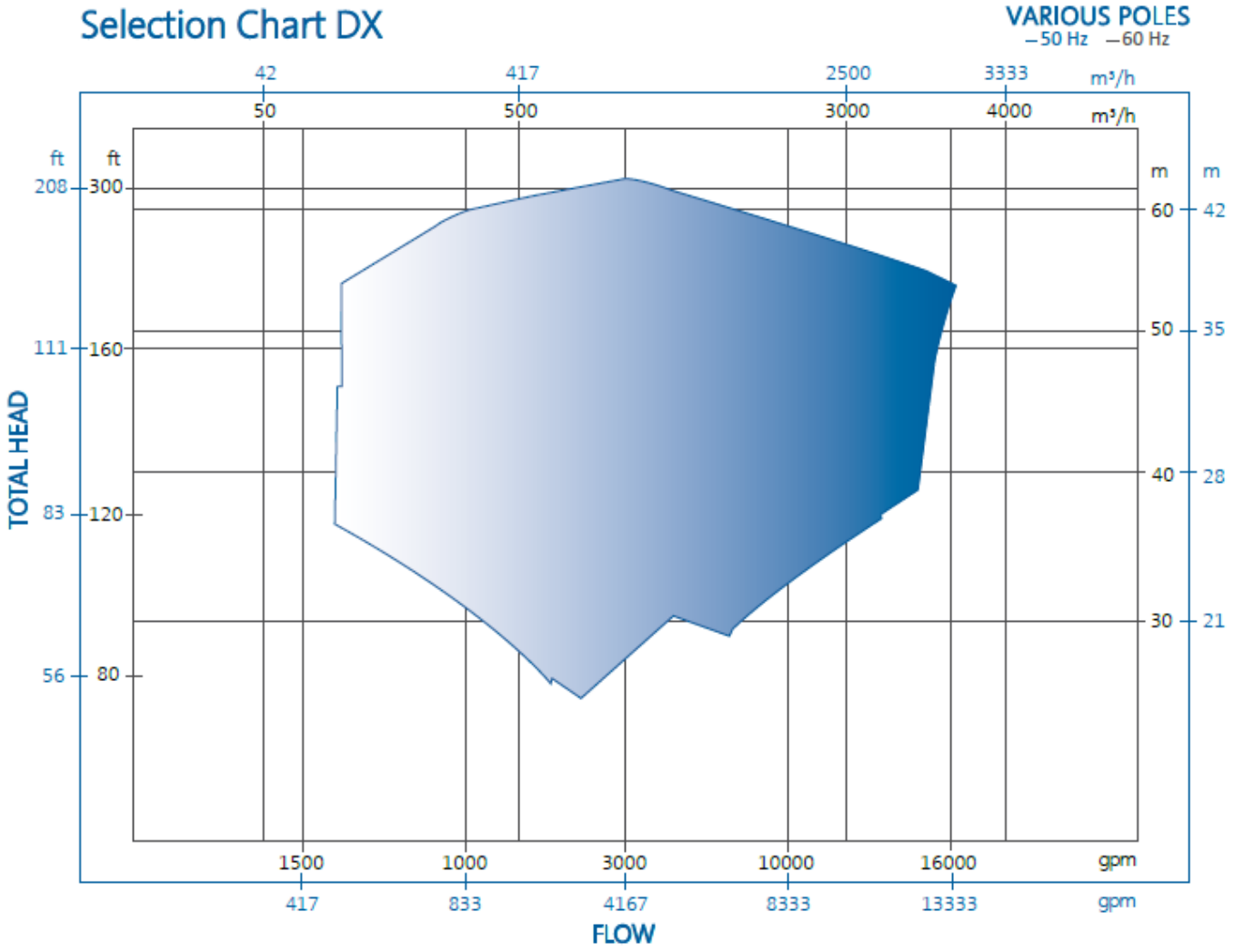
DSV / DX

Capacity	340 to 18,170 m^3/h	1,500 to 80,000 U.S. gpm
Head	12 to 244 m	40 to 800 ft
Temperature	150°C	302°F
Pressure	19 bar	280 psi

FEATURES AND BENEFITS

- DSV is a heavy-duty, vertical double-suction, twin volute, single-stage, centrifugal design.

- The single impeller, volute design develops the higher heads and capacities without the need for additional stages. This minimizes the number of wearing parts, resulting in easier maintenance and positive alignment. Unlike the vertical turbine pump, this completely eliminates the use of intermediate bowl bearings, which are vulnerable when handling abrasive liquids.


Selection Chart DX
VARIOUS POLES
50 Hz 60 Hz
42
417
2500
3333
m³/h
50
500
3000
4000
m³/h
ft
ft
208
300
111
160
83
120
56
80
TOTAL HEAD
m
m
60
42
50
35
40
28
30
21
1500
1000
3000
10000
16000
gpm
417
833
4167
8333
13333
gpm
FLOW

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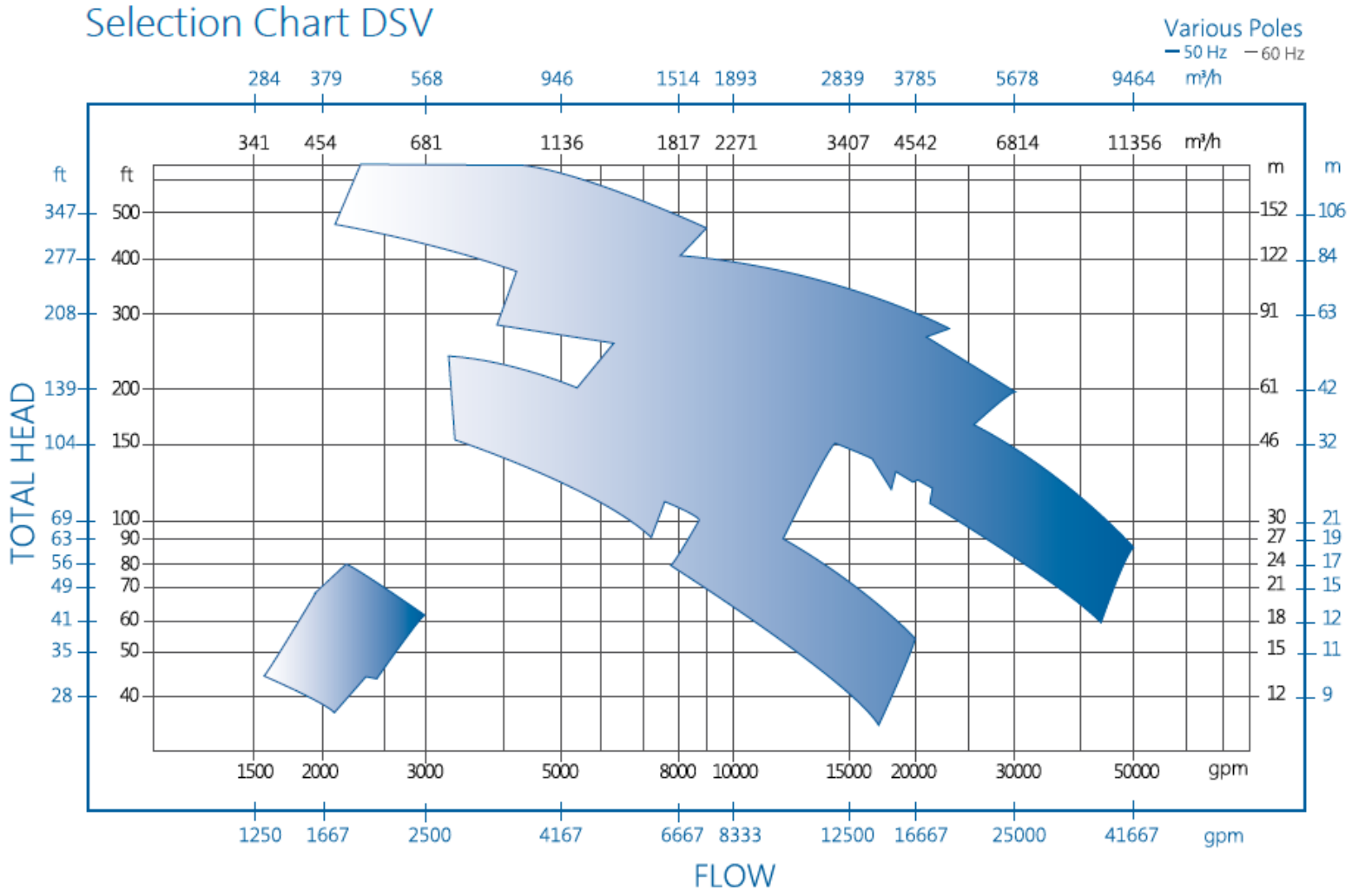
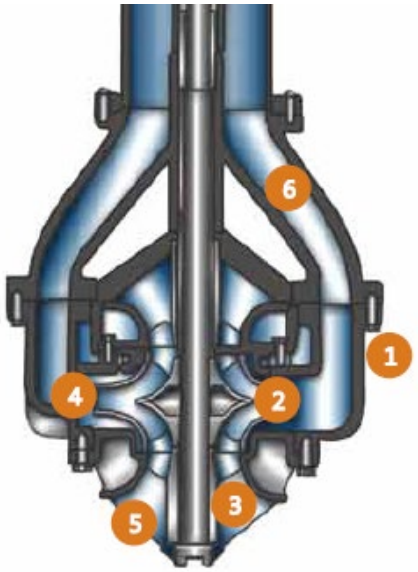


FEATURES AND BENEFITS

Double suction = lower NPSH



1 VOLUTE CASE.
The twin volute case is designed to efficiently convert to pressure the velocity added to the liquid by the impeller. The volute case directs the liquid from the impeller into the transition diffuser with a minimum of hydraulic losses.

2 IMPELLER.
The impeller is an enclosed double-suction centrifugal type which is keyed to the shaft and held in position by corrosion resistant retaining rings. The retaining rings are protected from abrasion by collars that turn with the impeller. The impeller is hydraulically and dynamically balanced to provide smooth operation. When specified, optional renewable impeller wear rings may be provided on both the upper and lower skirts to the impeller or they may be added later to renew the clearances.

3 SUCTION BELL.
The upper and lower flared suction bell directs the liquid into the impeller. It contains four guide vanes to prevent vortexing and provides the housing for the suction bell bearings.

4 CASING WEAR RINGS.
Are provided in the suction bell on both sides of the impeller. The wear rings are closely fitted to minimize the return of liquid from the discharge side of the impeller past the skirt to the suction side due to the pressure differential. The rate of wear depends on the character of the liquid pumped and the materials of construction. Hardened stainless steel wear rings are often used for severe service.

5 BELL BEARINGS.
Are located in the suction bells inmediately adjacent to either side of the impeller. The bell bearings are a sleeve-type and grooved to receive proper lubrication and closely fitted to maintain alignment.

6 TRANSITION DIFFUSER.
The transition diffuser provides a smooth hydraulic flow from the volute to the column pipe. The transition diffuser contains the connector bearing that couples to the bottom section of the shaft tube flanged connections with registered fits are provided for bolting the column pipe.

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Bowl Assembly Options

Double suction enclosed impeller as a first stage can be manufactured in VCT pumps

DX First Stage

CASE STUDIES AND PHOTOGRAPHS

Ruhrpumpen tests its largest ever multistage vertical pump

This 60 CKX model pump features 3 stages, 43,000 GPM/460 ft TDH with a 6100 HP/4000 volt/590 RPM motor, and is undoubtedly one of the largest vertical multistage pumps ever built in North and South America.

The customer, North Texas Municipal Water District, witnessed the test which ran very smoothly.

Testing was conducted at the Ruhrpumpen test lab in Monterrey, Mexico.

Technical Details	
Pump	VCT 67HXH
Application	Circulating Water
Flow	91,500 gpm (20,782 m^3/h)
Head	62 ft (19 m)
Motor	1,750 HP (1,305 kW)

Technical Details	
Pump	43 KX
Application	Hydrocarbon
Flow	28,628 gpm (6,500 m^3/h)
Head	160 ft (49 m)
Motor	750 HP (559 kW)

Technical Details	
Pump	32KXL/H, 2 stages
Application	Crude Oil Blend
Flow	12,988 gpm (2,950 m^3/h)
Head	370 ft (113 m)
Motor	2,300 HP (1,715 kW)

Technical Details	
Pump	32KXH, 2 stages
Application	Diluted Bitumen
Flow	12,703 gpm (2,895 m³/h)
Head	250 ft (76 m)
Motor	1,250 HP (932 kW)

Technical Details	
Pump	34KXH, 3 stages
Application	Synthetic Crude
Flow	15,410 gpm (3,500 m^3/h)
Head	295 ft (90 m)
Motor	1,500 HP (1118 kW)

Technical Details	
Pump	VCT 28KXH, 3 Stage
Application	Petrochemical
Flow	8,911 GPM (2,024 m³/h)
Head	335 ft (102 m)
Motor	1,500 HP (1,119 kW)

Technical Details	
Pump	VCT 60CKXL
Application	Water Transfer
Flow	43,043 GPM (9,857 m^3/h)
Head	1,066 ft (325 m)
Motor	6,100 HP (4,550 kW)

Technical Details	
Pump	VCT 43 WX, 1 Stage
Application	Waste water
Flow	31,700 GPM (7,200 m³/h)
Head	83 ft (25 m)
Engine	959 HP (715 kW)

Technical Details	
Pump	TR 1000/7/1000, 2 stages
Application	Cooling Water
Flow	50,630 GPM (11,500 m^3/h)
Head	213 ft (65 m)
Motor	3,620 HP (2,700 kW)

Technical Details	
Pump	TR 800/ 7/685 x 2
Application	Cooling Water
Flow	30,820 gpm (7,000 m³/h)
Head	223 ft (68 m)
Motor	4000 HP (2700 kW)

Technical Details	
Pump	37KXH, 1 stage
Application	Service Water
Flow	20,165 GPM (4,580 m^3/h)
Head	118 ft (36 m)
Motor	738 HP (550 kW)

* With Vane Grating Flow Modifier

Technical Details	
Pump	VCT 30 KXH/Ho, 2 Stage
Application	Water
Flow	12,073 gpm (2,742 m^3/h)
Head	335 ft (102 m)
Motor	1,500 HP (1,119 kW)

Coming Attractions ☺

"Vertical Pumps Part 2 (VS4/5, VS6, VS7)"

Thurs 27th Jan – 08.00 (UK GMT) (Eastern Hemisphere) & 17.00 (UK GMT) (Western Hemisphere)

Aimed at Process and Mechanical Engineers, and Consultant Engineers who specify pumping equipment as well as Applications & Sales Engineers selecting and quoting them.

While engineers generally have a good understanding of horizontal pumps, their exposure to vertical pumps is more limited and as a result they are frequently misunderstood and under-utilised.

This course will look to put that right and explain the features and benefits of vertical pumps and how they can frequently be problem solvers.

Future sessions : – Subject To Be Advised (I haven't decided yet!)